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Agenda Item 5: Conservation of Species and Habitats

5.2. Updating of the Action Plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic phenomena in the Mediterranean Sea (Dark Habitats Action Plan)

Draft updated Action Plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic phenomena in the Mediterranean Sea (Dark Habitats Action Plan)

Note:

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Note by the Secretariat

With regards to the update of the Action plan, 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.

The assessment of the implementation of the action Plan has considered the SPA/RAC Progress activities achieved during the last biennium's (since 2012) and the activities realized by Contracting Parties as requested by the adopted timetable.

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

The draft updated Action plan is given in this document.

Table of contents

I. Foreword

1. The Action Plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemosynthetic phenomena in the Mediterranean Sea follows a series of eight Action plans adopted by the Mediterranean countries within the framework of the Barcelona Convention, devoted to the conservation of species or groups of species. These Action plans are:

- Action Plan for the management of the monk seal
- Action Plan for the conservation of marine turtles
- Action Plan for the conservation of cetaceans
- Action Plan for the conservation of marine vegetation
- Action Plan for the conservation of bird species registered in annex II of the SPA/BD Protocol
- Action Plan for the conservation of cartilaginous fishes (Chondrichtyans) in the Mediterranean Sea
- Action Plan concerning species introduction and invasive species
- Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea

2. Dark Habitats are considered as fragile and sensitive habitats requiring protection (Directive 92/43/EEC). They constitute veritable reservoirs of biodiversity that, therefore, must be protected and need further attention.

3. This draft Action plan was the result of a Meeting of the ad hoc group of Mediterranean experts, nominated in consultation with the Contracting Parties and relevant partner organizations (Marseilles (France), May 2013). It was reviewed and adopted by the Eleventh Meeting of Focal Points for SPAs (Rabat - Morocco, 2 – 5 July 2013).

4. The Action Plan was adopted in the Eighteenth Ordinary Meeting of the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols (Istanbul - Turkey, 3-6 December 2013). The document of the Action Plan was first published in 2015 under the reference: UNEP-MAP-RAC/SPA, 2015. Action Plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic phenomena in the Mediterranean Sea. Dark Habitats Action Plan. Ed. RAC/SPA, Tunis: 17 pp.

5. This document is the draft update of the Action Plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemo-synthetic phenomena in the Mediterranean Sea as requested by the contracting Parties in their decision IG.24/07 (CoP 21- Naples (Italy), 2-5 December 2019).

II. Presentation

6. Dark habitats are those where either no sunlight arrives or where the light that does arrive is insufficient for the development of plant or algal assemblages. These are known as the aphotic and the disphotic or twilight zones. They are distributed throughout the Mediterranean basin and include both shallow marine dark caves[1] and deep-sea habitats (usually at depths below 150-200 m, Figure 1). However, inventorying and monitoring initiatives focusing on marine caves should consider the cave habitat as a whole. Therefore, this document covers both semi-dark and dark caves. Diverse geomorphological structures such as underwater caves, canyons, slopes, isolated rocks, seamounts, abyssal plains and areas presenting chemosynthetic phenomena, can characterise the dark habitats and can support sensitive habitats and assemblages that are of unique scientific and conservation interest and require special protection.

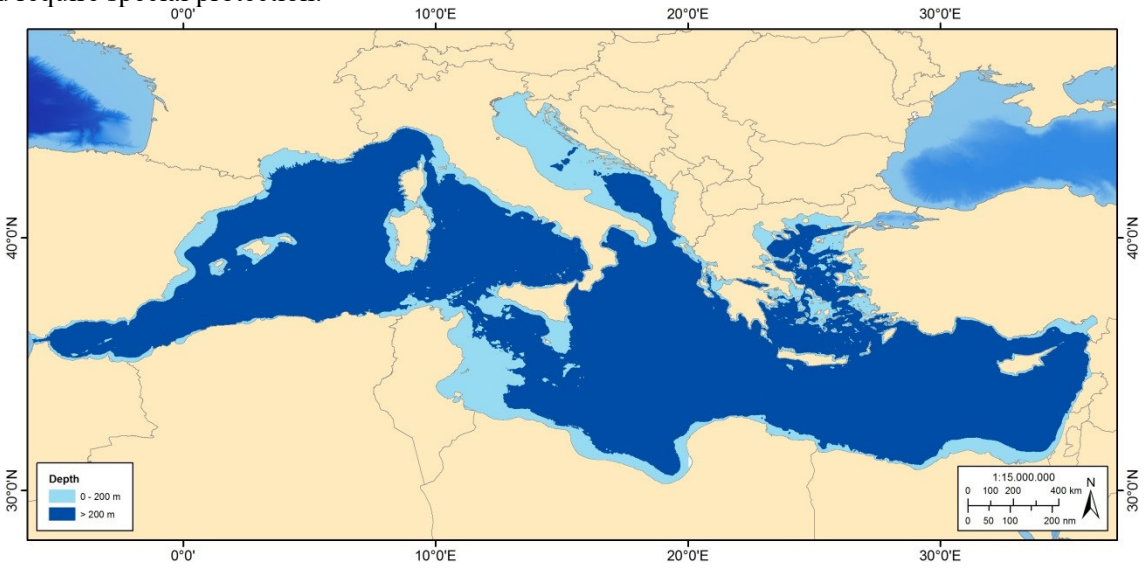

Figure 1:Deep-sea areas in the Mediterranean Sea below 200 m depth (from SPA/RAC-UN Environment/MAP & OCEANA, 2017; compiled by the authors based on data available from different sources)

III. State of knowledge

III.1 Distribution

III.1.1 Marine caves

7. To date approximately 3,000 marine caves have been recorded in the Mediterranean Sea (see Figure 2) (Giakoumi et al., 2013; SPA/RAC-UNEP/MAP, 2020). Most of these caves are located in the North Mediterranean, which encompasses a higher percentage of rocky coasts and has been more extensively studied for this particular habitat. Specifically, the highest numbers of known caves are in the Eastern Adriatic, Aegean, Tyrrhenian, Provencal and Ionian coasts, where they are sometimes densely concentrated on islands and rocky peninsulas (SPA/RAC-UNEP/MAP, 2020). Mapping initiatives have taken place in Italy (Cicogna et al., 2003), Corsica (CREOCEAN-DREAL, 2010), Croatia (Surić et al., 2010) and Greece (Gerovasileiou et al., 2015; Sini et al., 2017). Expeditions in the framework of the research projects MedKeyHabitats, MedMPAnet and LIFE BaĦAR for N2K provided information on the distribution of marine caves in Algeria (PNUE/PAM-CAR/ASP, 2016a), Lebanon (SPA/RAC-UN Environment/MAP, 2017), Montenegro (UNEP-MAP-RAC/SPA, 2016a, b), Morocco (Espinosa et al., 2015; PNUE/PAM-CAR/ASP, 2016b), Malta and Gozo (Evans et al., 2016;

[1] Semi-dark cave communities have been integrated into the Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea (UNEP-MAP-RAC/SPA, 2008).

Borg et al., 2017). The latter studies also extended the bathymetric distribution of the marine cave habitat to the deep sea (between 205 and 795 m). Numerous marine caves from the coasts of Turkey were also described in a recent publication (Öztürk, 2019). However, given the logistic difficulties in the inventorying of underwater caves, and especially the submerged ones, their number is assumed to be much higher than we know (SPA/RAC-UNEP/MAP & OCEANA, 2017). Mapping efforts are required in order to fill current distribution gaps in the Eastern and Southern Mediterranean regions, and in deeper waters.

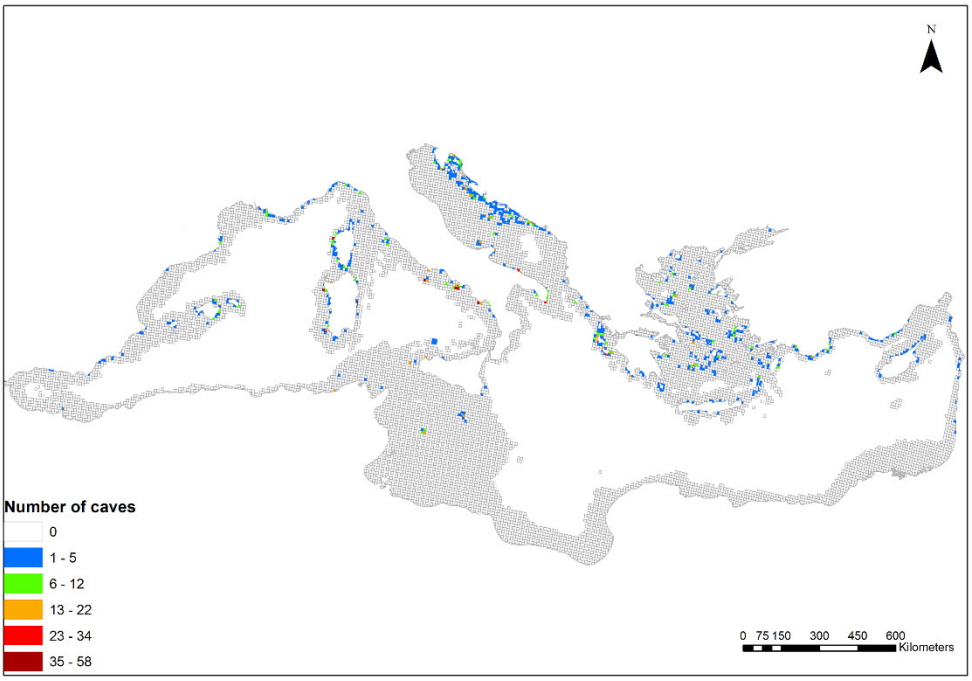

Figure 2: Distribution of marine caves in the Mediterranean Sea. Different colours indicate the number of caves recorded in cells of 10x10 km (from Giakoumi et al., 2013)

III.1.2 Deep sea

8. Geomorphologic structures such as canyons (Figure 3), seamounts (Figure 4) and rocky aphotic escarpments may be localized by the acquisition and study of high-resolution geomorphologic seafloor data. Spatial information on deep-sea geomorphologic structures such as canyons have been compiled at the Mediterranean scale (Würtz, 2012) and have been updated (Harris & Macmillan-Lawler, 2015). The distribution of seamounts and seamount-like structures have also been mapped in the Mediterranean (Würtz & Rovere, 2015).

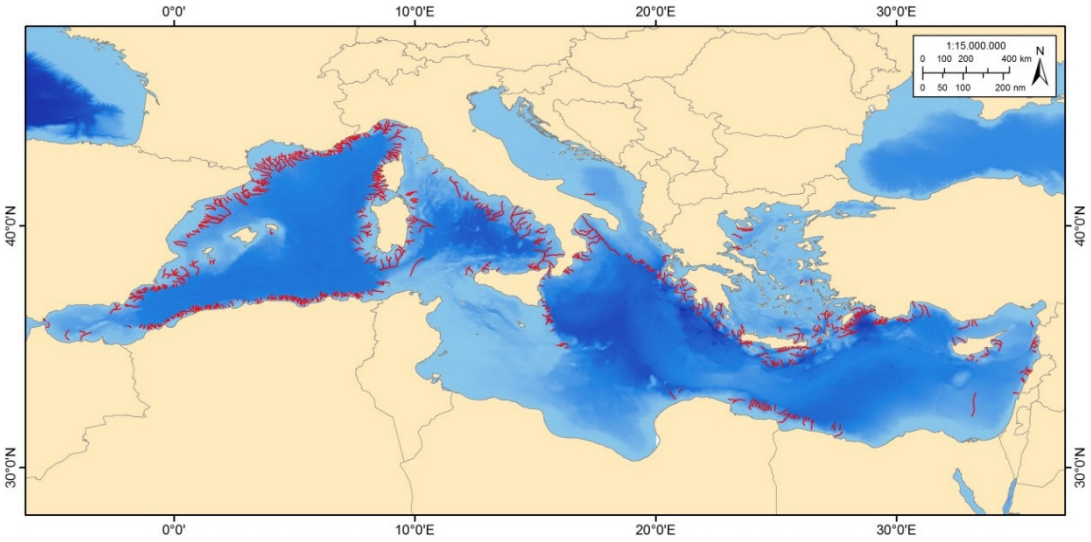

Figure 3: Distribution of Mediterranean submarine canyons (from SPA/RAC-UN Environment/MAP & OCEANA, 2017; compiled by the authors based on data available from different sources)

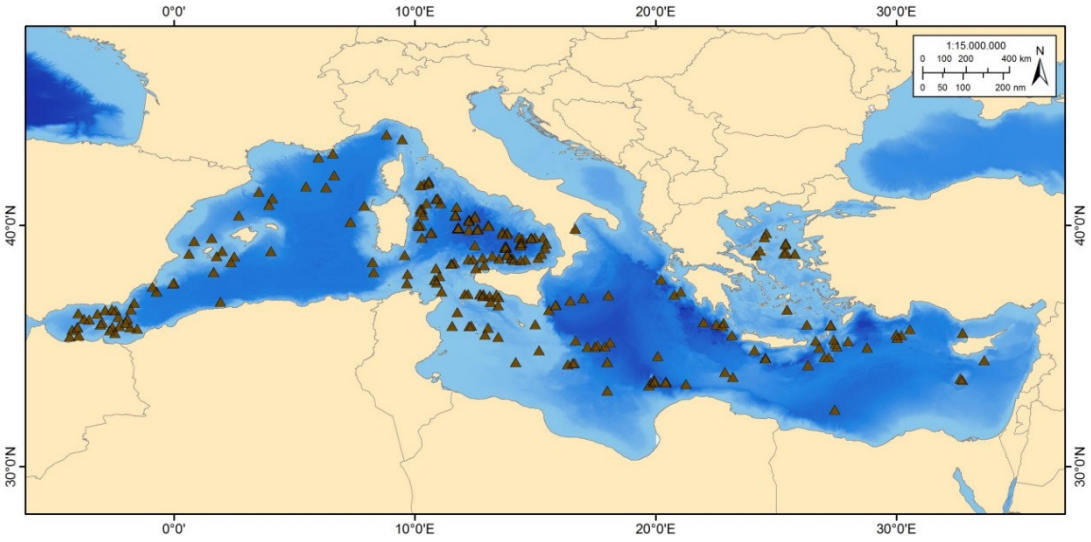

Figure 4: Distribution of Mediterranean seamounts (from SPA/RAC-UN Environment/MAP & OCEANA, 2017; compiled by the authors based on data available from different sources)

9. These structures offer heterogeneous habitats that enhance biodiversity and are considered as hotspots of biodiversity (Danovaro et al., 2010; Würtz & Rovere, 2015). They may harbour slow growing, long-living species, constitutive of sponge aggregations, coral forests and Cold-Water Corals (CWCs) that are considered as Vulnerable Marine Ecosystems (VMEs), according to *The International Guidelines for the Management of Deep-sea Fisheries in the High Seas* (FAO, 2009). Areas with chemosynthetic phenomena (*e.g.* cold seeps, mud volcanoes, hydrothermal fields, pockmarks, brine pools) (Figure 5), represent rare and fragile morphological structures and shelter unique ecosystems and species (*e.g.* Angeletti et al., 2015; Esposito et al., 2015; Beccari et al., 2020).

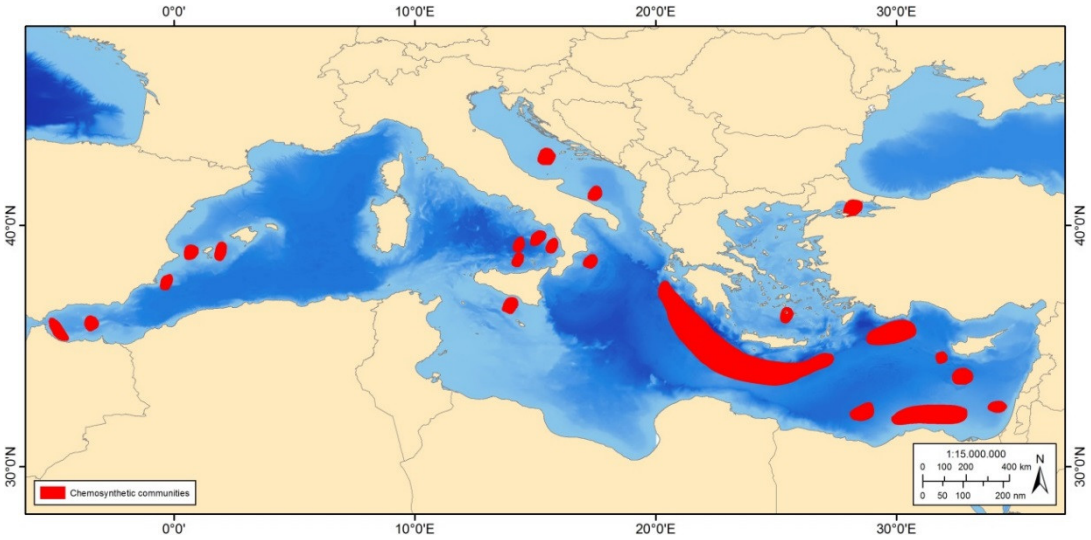

Figure 5: Identified areas with chemosynthetic assemblages (from SPA/RAC-UN Environment/MAP & OCEANA, 2017; compiled by the authors based on data available from different sources)

10. The distribution of one of the most emblematic and fragile Mediterranean deep-sea assemblages, the Cold-Water Corals (CWCs), has been mapped at the Mediterranean scale (see Figure 6 from Chimienti et al., 2019).

Figure 6: The actual information on the distribution of the Cold-Water Corals (CWCs) in the Mediterranean (Chimienti et al., 2019)

11. A recent book reviews the cold and deep coral habitats known to date in the Mediterranean Basin (see Orejas & Jiménez, 2019). The known distribution of the black coral *Leiopathes glaberrima* (Massi et al., 2018) as well as the scleractinian *Dendrophyllia cornigera* (Castellan et al., 2019) have also been published at the Mediterranean scale. These species are present in the Alboran, Ligurian and Tyrrhenian Sea, the Algero-Provençal Basin, the Sicily channel, the Ionian Sea, the Southern Adriatic, the Aegean Sea and the North Levantine (near Rhodes Island).

12. The spatial distributions of some other deep-sea benthic species have been published but they are limited to an area or a country (*e.g.* distribution of the bamboo coral *Isidella elongata* in the Aegean Sea (Gerovasileiou et al., 2019), 130 taxa from the French Mediterranean canyons and shelf brake (Fourt et al., 2017)).

13. The inventory of Mediterranean canyons, seamounts and areas with chemosynthetic phenomena is still not complete (Harris & Macmillan-Lawler, 2015; Würtz & Rovere, 2015), the distribution knowledge of associated assemblages and ecosystems presents therefore even larger gaps. Only part of the Mediterranean deep-sea habitats has been explored mainly in the north-western sector. To be in capacity of building a coherent Mediterranean network of protected deep-sea marine habitats, efforts are still needed to acquire basic data on spatial and bathymetric distribution of deep-sea habitats in the Mediterranean Sea.

III.2 Composition

III.2.1 Marine caves

14. Marine caves are acknowledged as "biodiversity reservoirs" and "refuge habitats" of great conservation value, as they harbour a rich biodiversity (32-71% of the Mediterranean sponge, anthozoan, bryozoan, tardigrade and brachiopod fauna) that includes several rare, exclusive, endangered, protected, as well as deep-sea species (Harmelin et al., 1985; Gerovasileiou & Voultsiadou, 2012; Gerovasileiou et al., 2015; Ouerghi et al., 2019; SPA/RAC-UNEP/MAP, 2020). A total of 2,369 taxa has been reported from ca. 350 marine caves in 15 Mediterranean countries (Gerovasileiou & Voultsiadou, 2014; Gerovasileiou & Bianchi, in press). Studies in Mediterranean marine caves are continuously bringing to light new species, several of which have not been yet reported from other habitats, and thus can be considered as cave-exclusive *sensu lato* (Gerovasileiou & Voultsiadou, 2012). However, the majority of species found in marine caves are cryptobiotic or crevicular and deep-water species which secondarily colonize caves, originating from external dim-light and dark environments (*e.g.* coralligenous beds, circalittoral bottoms and deep-water habitats) (Gerovasileiou & Bianchi, in press). Therefore, marine dark caves have been considered as "natural laboratories" or "deep-sea mesocosms" in the littoral zone because they provide direct human access to bathyal-like conditions (Harmelin & Vacelet, 1997).

III.2.2 Deep sea

15. Remotely Operated underwater Vehicles (ROVs) have enabled a better exploration and understanding especially of rocky substrates. Extensive areas can be covered by photographs and video-footages allowing researchers to describe habitats and mega-benthic species composing the assemblages. ROVs, but also landers and dropping cameras can reveal precious information on the habitus, coloration and behaviour of species (Bo et al., 2020). Many explorations of deep-sea habitats, based on images and videos, allow qualitative/quantitative analysis of mega-benthic assemblages and description of the associated megafauna. Nevertheless, sampling is often necessary to assert species identifications and determine composition of small (not identifiable on images) species.

16. Recent publications have focused on the emblematic ecological role of CWC assemblages, describing their composition and function (Orejas & Jiménez, 2019). Other deep-sea anthozoan assemblages, described as gardens or forests because of their three dimensional development, show a rich biodiversity (*e.g.* Bo et al., 2015; Ingrassia et al., 2016). In parallel, the composition of sponge aggregations has been studied in the western Mediterranean (see Maldonado et al., 2015; Santín et al., 2018).

17. Furthermore, ecosystem functioning and relations between deep-sea benthic and vagile species are more and more investigated. Publications suggest that fish are very abundant in CWC assemblages and canyons (D'Onghia et al., 2015; Capezzuto et al., 2018a, b). Besides, the nursery function of coral

forests appears to be important as they are described as spawning areas for fish and sharks (see Cau et al., 2017).

18.To better understand the sensitivity of CWC communities to climate change impacts, relations between bacteria and CWC are also being investigated (Meistertzheim et al., 2016).

19.New species of the Mediterranean deep-sea are regularly described (*e.g.* Boury-Esnault et al., 2015, 2017; López-González et al., 2015; Fernandez-Leborans et al., 2017; Bo et al., 2020) but difficulty in collecting samples limits their identifications. Many species of the deep-sea assemblages are still to be discovered and their population dynamics and interrelations need more systematic and rigorous investigation.

IV. Main threats

IV.1 For marine caves

20.Considering marine caves as a whole (semi-dark and dark parts), they are fragile ecosystems with low resilience (Harmelin et al., 1985; Rastorgueff et al., 2015) that are vulnerable to seawater warming, unregulated visits by SCUBA divers and tourist boats (*e.g.* mechanical damages by unintentional contact, sediment resuspension and accumulation of exhaled air bubbles), red coral harvesting, spearfishing, urbanization and building of coastal structures, waste outflows, littering and non-indigenous species (Chevaldonné & Lejeusne, 2003; Parravicini et al., 2010; Di Franco et al., 2010; Guarnieri et al., 2012; Giakoumi et al., 2013; Rastorgueff et al., 2015; Gerovasileiou et al., 2016; Nepote et al., 2017; SPA/RAC-UNEP/MAP, 2020).

21.Climate change effects (*e.g.* heat waves and temperature anomalies) and local disturbances caused by coastal interventions and constructions (*e.g.* extension of harbours and beach nourishments) have proved to generate structural and functional homogenization of marine cave communities, such as the decrease of structural complexity and parallel increase of turf and sediment (Nepote et al., 2017; Montefalcone et al., 2018; Sempere-Valverde et al., 2019). Marine pollution and littering constitute additional threats especially in semi-submerged caves where litter often accumulate on internal beaches, drifted by wave action (Mačić et al., 2018) or dark cave zones where the lack of water movement may also favour the entrapment of litter (Gerovasileiou & Bianchi, in press).

22.An additional threat to Mediterranean marine cave communities involves the continuous spreading of non-indigenous species (NIS), especially in the south-eastern Mediterranean Sea (Gerovasileiou et al., 2016; Öztürk, 2019). NIS are mainly observed at the entrance and semi-dark zones of shallow and semi-submerged caves and less frequently in dark zones. However, their impact on cave communities is unknown and should be urgently monitored, especially in marine caves of the Levantine and Aegean ecoregions.

IV.2 For Mediterranean deep sea

IV.2.1 Trawling

23.The most important threats perhaps for deep-sea habitats are the direct and indirect impacts of trawling activities. In canyons, soft bottom corals undergo direct destruction by trawling activities (Petović et al., 2016; Lauria et al., 2017; Pierdomenico et al., 2018). *Isidella elongata,* the only Mediterranean Anthozoan considered as Critically Endangered (Otero et al., 2017), is directly threatened by trawling impacts (Pierdomenico et al., 2018). CWC assemblages represent a threat for bottom trawling and since the adoption of electronic maps and GPS navigation systems allowing trawlers to navigate precisely, these areas are generally avoided although the present direct trawling impact by destruction of the vulnerable structures of the main builders, is not excluded. Until the mid-

1990s, when the GPS systems were not available on trawling boats and scientific knowledge on the CWC areas was minimal, trawlers hit most CWC areas causing severe damage (Tunesi et al., 2001).

24. Trawling also impacts indirectly canyon habitats and CWC assemblages by increasing water turbidity and sediment resuspension and deposit (Puig et al., 2015; Paradis et al., 2017; Arjona-Camas et al., 2019; Lastras et al., 2016; 2019). Thus, recent studies have shown that as well as displacing sediments, trawling affects the morphology of the seabed, as is known by high-resolution relief maps of seabed, causing damage comparable to that caused by ploughing farmland (Puig et al., 2012). Also, discards of vulnerable by-caught species from deep-sea trawling are not negligible (Gorelli et al., 2016).

25. In the Mediterranean Sea, the General Fisheries Commission for the Mediterranean (GFCM), led by the precautionary principal, banned bottom trawling activities in depths over 1000 m since 2005. However, CWC dwell also shallower than 1000 m depth, highlighting the ineffectiveness of this restriction for a large part of these vulnerable ecosystems. Therefore, the deep-sea habitats between 200 and 1000 m depth, especially along canyons, stay threatened and vulnerable to bottom trawling. To address this issue, in certain areas, GFCM has adopted Fisheries Restricted Areas (FRAs), ecosystem based spatial management measures that restrict fishing activities with a total closure to bottom trawling. FRAs insure the protection of deep-sea sensitive habitats such as VMEs (it is the case of the *Lophelia* reef off Capo Santa Maria di Leuca in 2006; the Eratosthenes seamount in 2006; an area in the Nile delta with cold hydrocarbon seeps since 2006) and essential fish habitats (it is the case of the Eastern Gulf of Lion area in 2009; the three areas in the Strait of Sicily in 2016; and the Jabuka/Pomo Pit in the Adriatic in 2018).

IV.2.2 Other fishing activities

26. Practically every recent publication based on mega-benthic deep-sea observations mentions visible anthropogenic impacts with a high number of derelict fishing gear either on CWC assemblages, or on other coral assemblages (Angiolillo & Canese 2018; Capezzuto et al., 2018a; Chimienti et al., 2019; Giusti et al., 2019; Angiolillo & Fortibuoni, 2020). Presence and impact of lost fishing nets and longlines are especially noticeable on deep-sea habitats that are close to the coast because more accessible to artisanal and recreational fishing activities.

IV.2.3 Industrial discharges and marine litter

27. Impacts of terrestrial human activities such as industrial discharges (Bouchoucha et al., 2019; Fontanier et al., 2020), dumping (Taviani et al., 2019), marine litter (Pierdomenico et al., 2019; Angiolillo & Fortibuoni, 2020) and transfer of pollutants to the deep-sea (Sanchez-Vidal et al., 2015) represent important pressures on deep-sea habitats and species.

28. Because of their geomorphology and the oceanographic currents occurring around submarine canyons, these structures tend to funnel, collect and accumulate litter at the base or in depression. This is particularly true for canyons that are close to the coast. The Mediterranean holds the submarine canyons with the highest concentration of plastic in Europe (Aguilar et al., 2020; Canals et al., 2021). The other deep-sea geomorphological structures undergo the impact of marine litter as well (see Aguilar et al., 2020).

IV.2.4 Climate change

29. Although poorly known, climate change impacts cumulated to the previous threats, could drive important changes in Mediterranean deep-sea ecosystem structures (Sweetman et al., 2017). The impacts of acidification combined to the increase of the sea temperature on reef building deep species such as scleractinian CWCs is not yet well known but the development of these species seems altered (see Maier et al., 2012; Hennige et al., 2014; Rodolfo-Metalpa et al., 2015; Gómez et al., 2018).

30. Benthic non-indigenous species (NIS) have rather rarely been reported in deep-sea habitats (Galil et al., 2019) and for the moment they do not represent the most important threat. Nonetheless, the rise of sea temperature attributed to climate changes occurs also in deep-sea and could contribute significantly to expand the bathymetric distribution of actual shallow NIS (see *e.g.* Innocenti et al., 2017).

IV.2.5 Other threats that could develop in the future

31. Offshore oil and gas developments (exploration, offshore infrastructures, drilling operations and transport by pipelines and/or tankers) represent a direct and increasing threat for deep-sea ecosystems, especially for benthic habitats (Cordes et al., 2016). Discoveries of new hydrocarbon resources in the Mediterranean will probably lead to an increasing number of drilling licences as well as the development of pipelines crossing deep-sea benthic habitats and increasing tanker traffic in the Mediterranean.

32. Marine noise pollution (MNP) can be a side effects of such explorations and developments but can also originate from many other anthropogenic activities (*e.g.* maritime traffic, military activities). MNP have considerably increased since the second world war (Frisk, 2012) and can interfere with behaviour and vital processes of marine mammals (*e.g.* Erbe et al., 2018) but also have various impacts on deep-sea fauna including invertebrates (see Di Franco et al., 2020).

V. Objectives of the Action Plan

33. The objectives of the Action Plan are to:

- develop and improve knowledge about dark habitats and their assemblages (*e.g.* distribution, species richness, composition, functioning, and ecology).

- conserve the habitats' integrity, functionality (favourable state of conservation) by maintaining the main ecosystem services (*e.g.* carbon sink, halieutic recruitment and production, biogeochemical cycles) and their interest in terms of biodiversity (*e.g.* specific diversity, genetics);

- encourage the natural restoration of degraded habitats (*e.g.* reduction of anthropogenic impacts)

VI. Actions required to attain the objectives of the Action Plan

VI.1 <u>Improving inventories, location and characterisation</u>

34. During recent decades, interest and concern for dark habitats has increased, and knowledge has been improved by newly available exploration technologies (see SPA/RAC-UN Environment/MAP & OCEANA, 2017). However, this knowledge is often scattered, even at national level, and spatially uneven throughout the Mediterranean. Efforts are made by the scientific community, international and national bodies to acquire information on the distribution and composition of marine caves and deep-sea benthic habitats. Still, the difficulty of access and the high cost of deep-sea scientific campaigns explain the large knowledge gaps on the distribution, biodiversity, ecosystem functioning, dynamics and ecological status of the various types of dark habitats and their assemblages. Yet, this information is vital for the implementation of an optimal management strategy on these ecosystems.
The following actions could help improve the lack of knowledge for all dark habitats:

- Aggregate the available knowledge, taking into account not only national and regional data (*e.g.* RAC/SPA, GFCM, IUCN, OCEANA, WCMC) but also scientific works. The information should be integrated within a geographical information system (GIS) and could be shared via online consultation.

- Identify geographical areas of interest presenting important knowledge gaps and enhance national capacities and international cooperation for investigation campaigns.
- Set up a database of people-resources in identified fields (*i.e.* caves, deep-sea populations), of institutes and bodies working in this field and of the available means of investigation.
- Quantify the proven or potential pressures (*e.g.* commercial and recreational fishing, leisure activities and diving, undersea prospecting). New knowledge must be acquired in areas of regional interest to promote a multidisciplinary approach and enhance international cooperation over these sites. Such joint action will permit the exchange of experience and the setting up of shared management strategies (building guidelines).
- Maintain regular theme-based workshops that bring together experts on dark habitats (biodiversity, methodology, monitoring, threats, conservation etc.).

VI.2 Building-up management measures

35. Management procedures involve enacting laws aimed at regulating human activities likely to affect dark habitats and permit their long-term conservation.

VI.2.1 Legislation

36. At national level, endangered and threatened species and populations of dark habitats should be identified in order to update corresponding national species lists. They can then be considered as protected species as defined in Article 11 of the Protocol on Specially Protected Areas and Biological Diversity (SPA/BD Protocol, 1995). Special consideration should be given to species of Vulnerable Marine Ecosystems (VMEs)[2].

37. The regulations on impact studies must be strengthened to make compulsory the assessment of impacts on species and assemblages of dark habitats. The regulations should pay particular attention in the event of coastal development, the prospecting and exploiting of natural resources and the discharge and dumping of materials at sea.

38. Insofar as regulatory procedures already exist at international level to restrict or ban certain human activities, further actions are required in order to have them applied and develop new propositions. This is particularly so for the setting up of Fisheries Restricted Areas (FRA) as adopted in the context of the mandate of the General Commission on Mediterranean Fisheries, including the ban on trawling, in the Mediterranean, at depths of over 1,000 meters down (FAO-GFCM, 2006; GFCM, 2019). The Mediterranean states are invited to use and enhance, all means already available to ensure better conservation of dark habitats.

VI.2.2 Setting MPAs

39. Numerous Mediterranean MPAs encompass marine caves and in several cases, coastal areas with marine caves have been suggested for protection. Nevertheless, their number in MPAs remains unknown and - despite the establishment of new MPAs, EU environmental legislation and the Dark Habitats Action Plan - in most cases there is a lack of specific regulations or management plans for their protection, monitoring and restoration. Further specific regulations are needed for dark habitats within MPAs, especially marine caves.

40. Mediterranean deep-sea habitats are still poorly represented in MPAs partly due to the fact that these habitats are often distant from the coast and difficult to access, therefore their effective

[2] See report of GFCM Working Group on Vulnerable Marine Ecosystems (WGVME), Malaga, Spain, 3-5 April 2017

protection represents a real challenge. Adding to the difficulty of access, is the fact that deep-sea habitats are often areas beyond national jurisdiction (ABNJ).

41.Designation of Marine Protected Areas intended to permit more efficient conservation of these assemblages must be based on the identification of sites on the basis of the criteria such as uniqueness or rarity, particular importance for species biological stages, importance for threatened, endangered or declining habitats or species, vulnerability and reduced recuperative capacity after disturbance, biological productivity, biodiversity and naturalness as adopted in 2009 by the Contracting Parties (UNEP-MAP-RAC/SPA, 2009). At the Mediterranean level, the selection of sites to be protected must also be based on the ecosystem approach and take in consideration the patchy distribution of these habitats, as the only way to ensure a coherent and efficient network of MPAs for a sustainable management of the various types of dark habitats.

VI.2.3 Other management measures

42.Measures should be identified to reduce the pressures that hang over assemblages of dark habitats and to implement them. In the light of the precautionary principle, particular attention should be paid to the impacts that could arise as a result of the seawater temperature rise, acidification and/or fertilization of the oceans and the setting up of new emergent fisheries (border areas). MPAs which host dark habitats (e.g. dark marine caves) should update their management plans to include measures adapted to their conservation.

43.Procedures aimed at assessing the efficiency of these measures as a whole should be defined in consultation with the organisations concerned by the management of these assemblages (*e.g.* international conventions, GFCM, IUCN, NGOs) to promote sustainable, adaptable and concerted management.

44.In sites that have not yet been studied, a state of reference (‘zero state’) is a necessary precondition for setting up a monitoring system for these assemblages. For the sites for which data already exists, monitoring procedures should be started.

VI.3 Strengthening national plans

45.To give greater efficiency to the measures for setting up the present Action Plan, the Mediterranean countries are invited to build-up national plans for the protection of dark habitats. Each national plan should propose appropriate legislative measures, particularly as regards impact studies for coastal development and check the activities that can affect these assemblages.
The national plan should be elaborated on the basis of the available scientific data and should include programmes for:

(i) gathering and continuous updating of data,
(ii) training and updating of specialists,
(iii) education and awareness for the public, actors and decision makers, and
(iv) conservation of dark habitats and their assemblages that are significant for the marine environment in the Mediterranean Sea.

46.These national plans must be brought to the attention of all the concerned actors and as far as possible ensure coordination with other permanent national plans (*e. g.* emergency plan against accidental pollution).

VI.4 Establishing monitoring plans

47.Recent technological advances have enhanced the possibilities of studying and monitoring deep-sea habitats by acoustic, visual or sampling methods. These methods must be combined to obtain the most

cost-efficient monitoring of deep-sea habitats to reach the most accurate state of conservation. Plans for monitoring dark habitats and associated assemblages should be communicated at a Mediterranean scale to encourage transboundary exchanges, regional coherence, sharing effort and means of investigations (see Deep-sea exploration in France, Monaco and Italy in the framework of the international agreement Ramoge - Daniel et al., 2019).

48. The *Guidelines for inventorying and monitoring of Dark Habitats in the Mediterranean Sea* (SPA/RAC-UN Environment/MAP & OCEANA, 2017) details the methodologies and the IMAP common indicators selected for monitoring dark habitats. Monitoring of dark habitats should be based on these guidelines. Nevertheless, the absence of long time series depicting the past ecological status of dark habitats (*e.g.* marine caves) is a major impediment to the monitoring and evaluation of impacts and changes in their ecological status.

VI.5 Enhancing transboundary exchanges

49. In the light of the geographical distribution of many types of dark habitats in areas beyond national jurisdiction (ABNJ), and the difficulties of reaching them (bathymetric range, lack of knowledge, scientific means required and cost of study), it is important to:

(i) encourage the establishment of international cooperation to create synergies between the various actors (decision makers, scientists, socio-professionals) and set up shared management.
(ii) organise training courses and encourage the exchange of cross-border experience so as to enhance national capacities in the field.

VI.6 Developing public awareness and information

50. Information and awareness programmes to make dark habitats, their vulnerability and the interest for conservation better known should be crafted and continued for decision-makers, but also users such as SCUBA divers, fishermen and mine operators. Communication on these habitats should also be encouraged for the wider public. The participation of NGOs in these programmes should be encouraged.

VII. Regional coordination and implementation

51. Regional coordination of the implementation of the present Action Plan will be handled by the Secretariat of the Mediterranean Action Plan (MAP) via the Regional Activity Centre for Specially Protected Areas. The coordinating structure's main functions are:

(i) gathering, summarizing and circulating knowledge at Mediterranean level and permitting this to be integrated within the available instruments (*e. g.* Standard Data-Entry Form - SDF);
(ii) setting up and updating databases on people/resources, laboratories involved, and investigation means available;
(iii) helping states identify and assess the pressures on the various types of dark habitats and their assemblages at national and regional level;
(iv) promoting studies on dark habitats and making inventories of species in order to better figure out the way they function and better assess the ecosystem services they provide;
(v) promote cross-border cooperation;
(vi) back the setting up of monitoring networks for dark habitats;
(vii) organise meetings of experts and training courses on dark habitats and their biodiversity;
(viii) prepare reports on how implementation of the Action Plan is progressing, for submission to the Meeting of National Focal Points for SPAs and meetings of the Contracting Parties;
(ix) establish a work programme for implementing the Action Plan over a five-year period, which will be submitted to the Contracting Parties for adoption.

52. At the end of this period, if necessary, after assessment and updating, it can be repeated. Implementing the present Action Plan is the responsibility of the national authorities of the Contracting Parties. At each of their meetings, the National Focal Points for SPAs shall assess how far

the Action Plan is being implemented on the basis of national reports on the subject and a report made by RAC/SPA on implementation at regional level.

53. In the light of this assessment, the Meeting of National Focal Points for SPAs will suggest recommendations to be submitted to the Contracting Parties. If necessary, the Meeting of Focal Points will also suggest adjustments to the schedule that appears in the Appendix to the Action Plan.

VIII. Participation in the implementation

54. Supplementary work done by other international and/or non-governmental organisations, aiming at the same objectives, should be encouraged, encouraging their coordination and avoiding duplication of effort. At their ordinary meetings, the Contracting Parties could, at the suggestion of the Meeting of National Focal Points for SPAs, in order to encourage and reward implementation of the Action Plan, grant the title of 'Action Plan Partner' to any structure that may so request.

55. This label will be granted on the evidence of proven involvement in the implementing of the present Action Plan attested by concrete actions (*e. g.* conservation, management, research, awareness etc.).

56. The label can be extended at the same time as the multi- annual work programme on the grounds of an assessment of actions carried out during that period.

IX. Implementation schedule

Actions	Time	Who
Making a summary of knowledge of dark habitats and their distribution around the Mediterranean in the form of a geo-referenced information system	As soon as possible and continuously	RAC/SPA & Contracting Parties
Setting up a database of people/resources and means of investigation available	As soon as possible and continuously	RAC/SPA
Identify and assess proven pressures on each of the various types of dark habitats	Year 1 and 2	RAC/ SPA, Partners and Contracting Parties
Gathering data and information on research activities	Continuously	RAC/SPA & Contracting Parties
Revise the reference list of types of marine habitats for the selection of sites for inclusion in the national inventories of natural sites of conservation interest, in order to take into account dark habitats	Year 1 and 2	Contracting Parties
Revise the list of endangered or threatened species in order to take account of species and assemblages of dark habitats	Year 1 and 2	RAC/SPA & Contracting Parties
Promote the identifying of areas of interest for the conservation of dark habitats in the Mediterranean and carry out concerted actions in national and/or cross-border sites	Year 1 and 2	RAC/SPA & Contracting Parties
Implement and/or extend MPAs to include already identified sites of interest that host dark habitats at a national level and in areas beyond national jurisdiction (ABNJ)	As soon as possible and continuously	RAC/SPA & Contracting Parties
Introduce national legislation to reduce negative impacts on dark habitats and associated assemblages (including impact studies procedures)	On adoption	Contracting Parties
Regularly hold theme-based workshops (in coordination with those of the 'Coralligenous' AP)	Every three years	RAC/SPA
Update guidelines suited to the inventorying and monitoring of dark habitats and associated assemblages	Every five years	RAC/SPA and Partners
Implement monitoring systems	As soon as possible	RAC/SPA & Contracting Parties
Develop detailed guidelines for effective management measures of dark habitats	Year 1 and 2	RAC/ SPA, Partners and Contracting Parties
Enhance cooperation actions with concerned organisations and in particular with GFCM	Continuously	RAC/SPA
Step up awareness and information about dark habitats and associated assemblages with the various actors	Continuously	RAC/ SPA, Partners and Contracting Parties
Enhance national capacities and improve skills in taxonomy and monitoring methods	As needed	RAC/SPA

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ANNEX I: Status of implementation of the Action Plan concerning the conservation of Dark Habitats (2015 – 2020)

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Acronym list

ABNJ: Area Beyond National Jurisdiction
ACCOBAMS: Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area
CBD: Convention on Biological Diversity
CIESM: Mediterranean Science Commission (Commission Internationale pour l'Exploration) Scientifique de la Méditerranée
CWC: Cold-Water Corals
DSF: Deep-See Fisheries
EcAp: Ecosystem Approach under the Barcelona Convention
EEC: European Economic Community
EFH: Essential Fish Habitats
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
HD: Habitats Directive
IMAP: Intergrated 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 or **PAM**: Mediterranean Action Plan
MEDASSET: Mediterranean Association to Save the Sea Turtles
MedPAN: Mediterranean Protected Areas Network
MPA: Marine Protected Area
MSFD: Marine Strategy Framework Directive
MSP: Maritime Spatial Planning
NIS: Non-Indigenous Species
PNUE or **UNEP**: United Nations Environment Programme
RAC/SPA or **SPA/RAC**: Specially Protected Areas /Regional Activity Centre
RFMO: Regional Fisheries Management Organization
ROV: Remotely Operated Vehicle
SAI: Significant Adverse Impacts
SCUBA: Self Contained Underwater Breathing Apparatus
SPA/BD protocol: Protocol on Specially Protected Areas and Biological Diversity (Barcelona Convention)
SPA/RAC or **RAC/SPA**: Specially Protected Areas /Regional Activity Centre
SPAMI: Specially Protected Areas of Mediterranean Importance
TUDAV: Turkish Marine Research Foundation
UN: United Nationas
UNEP or **PNUE**: United Nations Environment Programme
UNEP-MAP: United Nations Environment Programme – Mediterranean Action Plan
VME: Vulnerable Marine Ecosystems
WFD: Water Framework Directive
WGMPA: Working Group on Marine Protected Areas
WGVME: Working Group on Vulnerable Marine Ecosystems
WoRCS: World Register of marine Cave Species
WWF: World Wide Fund for Nature
WWF MedPO: World Wide Fund for Nature Mediterranean Programme Office

1. Introduction

In the framework of the *Dark Habitats Action Plan*, dark habitats comprise ecosystems and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemosynthetic phenomena (UNEP-MAP-RAC/SPA, 2015). Such habitats are distributed throughout the Mediterranean from the sea surface (i.e. underwater dark caves) to the deep-sea (i.e. seamounts, canyons, cold seeps) in aphotic conditions. Dark habitats cover multiple and complex ecosystems, numerous and diverse species that generally develop in stable physico-chemical conditions.

Within the framework of the Protocol concerning specially protected areas and biological diversity in the Mediterranean (SPA/BD Protocol) of the Mediterranean Action Plan, the Contracting Parties have agreed on the "Dark Habitats Action Plan" for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemosynthetic phenomena in the Mediterranean Sea (UNEP-MAP-RAC/SPA, 2015). The aim of this document is to assess the status of the implementation of this Action Plan in 2020. Therefore, the present document (i) provides a general overview of the progress in knowledge on "dark habitats" in the Mediterranean since the adoption of the Action Plan in 2015, (ii) reviews the main regional actions carried out since 2015, and (iii) evaluates the implementation of the Action Plan by the contracting parties through a desk review and feedback by the Parties of a prefilled questionnaire.

Marine caves

Marine caves are defined as cavities entirely or partly occupied by the sea, accessible to humans, which have significant horizontal and volumetric development (Bianchi et al., 1996). They can be submerged or semi-submerged while their morphology varies from blind-ended caves (ending as a cul-de-sac) to tunnels with multiple entrances, vertical pits, or more complex morphologies (Gerovasileiou et al., 2016a). Marine cave formations constitute a characteristic feature of rocky coastlines in the Mediterranean Sea. According to the latest census more than 3,000 marine caves have been recorded in the Mediterranean (Giakoumi et al., 2013; Gerovasileiou & Bianchi, in press), mostly along the northern rocky coasts, where they are sometimes densely concentrated in islands and rocky peninsulas (e. g. eastern Adriatic, Aegean, Tyrrhenian, Provençal and Ionian coasts).

Marine caves are acknowledged as "biodiversity reservoirs" and "refuge habitats" of great conservation value, as they harbour a rich biodiversity (32-64% of the Mediterranean sponge, anthozoan, bryozoan, tardigrade and brachiopod fauna) that includes several rare, cave-exclusive, endangered, protected, as well as deep-sea species (Harmelin et al., 1985; Gerovasileiou & Voultsiadou, 2012; Gerovasileiou et al., 2015; Ouerghi et al., 2019). According to a recent review, a total of 2,366 taxa has been reported from ca. 350 marine caves in 15 Mediterranean countries (Gerovasileiou & Bianchi, in press). Studies in Mediterranean marine caves are continuously bringing to light new species, several of which have not been yet reported from other habitats, and thus can be considered as cave-exclusive *sensu lato* (Gerovasileiou & Voultsiadou, 2012). Most of these are recorded from a small number or even from a single marine cave. However, the majority of species found in marine caves are cryptobiotic or crevicular and deep-water species which secondarily colonize caves, originating from external dim-light and dark environments (e. g. coralligenous beds, circalittoral bottoms and deep-water habitats). Therefore, marine dark caves have been considered as "natural laboratories" or "deep-sea mesocosms" in the littoral zone because they provide direct human access to bathyal-like conditions (Harmelin & Vacelet, 1997). Several species that are listed as endangered or threatened species in the SPA/BD Protocol Annex II, have been reported from marine

caves, including the sponges *Asbestopluma hypogea* (now *Lycopodina hypogea*) and *Petrobiona massiliana* and the molluscs *Erosaria spurca*, *Lithophaga lithophaga* and *Luria lurida*.

A striking characteristic of marine cave communities is that they present a marked zonation due to steep environmental gradients, even within a scale of a few metres, such as the rapid decrease of light, hydrological confinement and trophic depletion from the entrance to the internal cave sectors (Riedl, 1966; Harmelin et al., 1985; Bianchi & Morri, 1994; Gerovasileiou & Bianchi, in press). Two main biocoenoses (i.e. semi-dark and dark caves) and up to six faunal and ecological zones have been described from Mediterranean marine caves (Pérès & Picard, 1964; Riedl, 1966; Bianchi & Morri, 1994). In addition, marine caves and their communities are characterized by small-scale heterogeneity which is usually generated by cave-specific topography and associated environmental gradients (Bussotti et al., 2006; Gerovasileiou & Voultsiadou, 2016).

Marine caves are fragile and poorly resilient ecosystems (Harmelin et al., 1985; Rastorgueff et al., 2015) that are vulnerable to seawater warming, unregulated visits by SCUBA divers and tourist boats (e.g. mechanical damages by unintentional contact, sediment resuspension and accumulation of exhaled air bubbles), red coral harvesting, spearfishing, urbanization and building of coastal structures, waste outflows, littering and non-indigenous species (Chevaldonné & Lejeusne, 2003; Parravicini et al., 2010; Di Franco et al., 2010; Guarnieri et al., 2012; Giakoumi et al., 2013; Rastorgueff et al., 2015; Gerovasileiou et al., 2016b; Nepote et al., 2017).

Despite the fact that Mediterranean marine caves have been studied more intensively than in any other marine region of the world, there are still important gaps in our knowledge regarding their distribution, biodiversity, ecosystem structure and functioning, dynamics, ecological status, impact and management potential (Gerovasileiou & Bianchi, in press). Guidelines for the inventorying and monitoring of marine caves have been recently provided by SPA/RAC-UNEP/MAP & OCEANA (2017). Nevertheless, the absence of long time series depicting the past ecological status of the marine cave ecosystem (except for a small number of caves in the Western Mediterranean) is a major impediment to the monitoring and evaluation of impacts and changes in their ecological status (Gerovasileiou et al., 2016b; SPA/RAC-UNEP/MAP & OCEANA, 2017).

For all the above reasons, marine caves are listed for protection by the European Union's Habitats Directive (92/43/EEC – habitat code 8330 "Submerged or partially submerged sea caves") and, at the Mediterranean level, under the "Action Plan for the conservation of the coralligenous and other calcareous bio-concretions", which also integrates semi-dark cave communities (UNEP-MAP-RAC/SPA, 2008), and the "Dark Habitats Action Plan" of the Barcelona Convention (UNEP-MAP-RAC/SPA, 2015). In addition, several species listed in Annexes II and III of the Bern Convention and the SPA/BD Protocol of the Barcelona Convention are commonly found in caves. The marine cave habitat is represented in 33 Marine Protected Areas (MPAs) in the Mediterranean Sea (Abdulla et al., 2008).

Deep-sea habitats

Deep-sea habitats comprise water and seafloor under roughly 200 m depth, in aphotic conditions. Over ¾ of the Mediterranean Sea surface covers such habitats (IUCN, 2019). Among the deep-sea geomorphologic features, seamounts, canyons, aphotic hard beds and chemosynthetic phenomena host unique, sensitive and fragile ecosystems, assemblages and species (UNEP-MAP-RAC/SPA, 2015). Seamounts, aphotic hard beds and canyons offer heterogeneous habitats that enhance biodiversity and

are considered as hotspots of biodiversity (Würtz, 2012; Danovaro et al., 2010; Würtz & Rovere, 2015). Such geomorphologic structures can be found throughout the Mediterranean (Harris & Whiteway, 2011; Würtz, 2012; Würtz & Rovere, 2015). They may harbour slow growing, longevous species, constitutive of sponge aggregations, deep-sea coral forests and Cold-Water Corals (CWCs), considered as Vulnerable Marine Ecosystems (VMEs) (see report of GFCM Working Group on Vulnerable Marine Ecosystems (WGVME), Malaga, Spain, 3-5 April 2017). The majority of the cnidarians that are listed as endangered or threatened species in the SPA/BD Protocol Annex II, are present and constitutive of deep-sea habitats. Areas with chemosynthetic phenomena (*e.g.* cold seeps, mud volcanoes, hydrothermal fields, pockmarks, brine pools), represent rare and fragile morphological structures (Angeletti et al., 2015) and shelter unique ecosystems and species (e.g. Esposito et al., 2015; Beccari et al., 2020).

During recent decades, interest and concern for deep-sea habitats has increased and knowledge has been enhanced by newly available exploration technologies. Therefore, efforts have been made by the scientific community, international and national bodies to acquire information on the distribution and composition of deep-sea benthic habitats especially in canyons, aphotic hard beds, on seamounts and around areas presenting chemosynthetic phenomena. Still, the difficulty of access and the high cost of deep-sea scientific campaigns explain the large knowledge gaps in basic understanding and distribution of these habitats, their associated species and the functioning of the related ecosystems. Nevertheless, because these habitats are heavily threatened by human activities and climatic changes, efforts have been already initiated to assess the conservation state (IUCN, 2019; Danovaro et al., 2020) and establish monitoring guidelines of the known deep-sea habitats (SPA/RAC – UN Environment/MAP & OCEANA, 2017).

As other marine habitats, deep-sea habitats are threatened by climatic changes, acidification, litter and derelict fishing gear (Ramirez-Llodra et al., 2013; Guisti et al., 2019; Pierdomenico et al., 2019). In addition, deep-sea assemblages are jeopardized by recently increasing anthropogenic activities, such as deep bottom trawling (e.g. Maynou & Cartes, 2011; Pusceddu et al., 2014; Puig et al., 2015) (between 200 and 1000 m[3]), offshore oil and gas drilling and exploration and mining which cumulate to the previous (Ramirez-Llodra et al., 2011). Recent explorations of deep habitats have led to the description of new species (e.g. Boury-Esnault et al., 2015; 2017; Chimienti et al., 2020) and it is likely that many unknown species are still to be discovered. Although very little is known about the effectiveness of conservation measures after disturbance, recovery of deep-sea ecosystems such as Cold-Water Coral (CWCs) assemblages, is very slow, which means that restoration approaches are of uncertain effectiveness, costly and difficult to implement (e.g. Huvenne et al., 2016; Gollner et al., 2017; Clark et al., 2019). Given the threats, paucity of knowledge, and apparent low resilience, it is urgently necessary to apply precautionary conservation measures limiting future damage on these Mediterranean deep-sea habitats (see Huvenne at al., 2016).

Seamounts, aphotic hard beds and canyons are listed for protection by the European Union's Habitats Directive 92/43/EEC under the code 1170 "Reefs", while areas presenting chemosynthetic phenomena are under the code 1180 "Submarine structures made by leaking gases". In the framework of the Convention on Biological Diversity (CBD), the countries committed to reduce pressure on vulnerable ecosystems impacted by climate change or ocean acidification by 2015 (Aichi Target 10 of CBD) and to protect 10% of coastal and marine areas by 2020 (Aichi Target 11 of CBD). Target 11 underlines

[3] GFCM/29/2005/1 Recommendation on the management of certain fisheries exploiting demersal and deep-water species and the establishment of a fisheries restricted area below 1000 m. Link

the particular emphasis that is needed to protect critical ecosystems such as deep-sea cold coral reefs and seamounts. In the Mediterranean, MPAs, for the large majority, concern littoral areas that do not comprise deep-sea habitats. In the Western basin, efforts have been made to include deep-sea habitats in MPAs. Nevertheless, at the Mediterranean scale deep-sea habitats are clearly underrepresented in the network of MPAs. MPAs cover only 3-4% of the depths over 1000 meters depths and 7-8% of depths between 200 and 1000 meters, the majority being covered by the Pelagos Sanctuary of Marine Mammals which does not actually target benthic species (MedPAN & SPA/RAC, 2019).

2. Progress in increasing knowledge on dark habitats in the Mediterranean Sea

The following assessment of the progress in knowledge on "Dark habitats" in the Mediterranean is mainly based on over 270 documents (published peer-review literature, books, reports, conference papers and posters) searched through databases and dating from 2015 to 2020 (October). This selection of documents enabled the elaboration of prefilled questionnaires for each of the 21 Mediterranean countries.

83 documents concern Mediterranean marine caves (in the large sense, not only dark caves) of which near 60 are peer-reviewed publications. 197 documents concerned Mediterranean deep-sea habitats and features (canyons, seamounts, aphotic hard beds, chemosynthetic phenomena) and associated species of which over 140 are peer-reviewed publications.

2.1. Spatial and bathymetric distribution

Marine caves

Spatial information on the distribution of marine caves in the Mediterranean Sea was published at the Mediterranean scale before the temporal scope of this review, by Giakoumi et al. (2013), who compiled information from various sources, such as detailed mappings from Italy (Cicogna et al., 2003) and other countries (see Figure 7). Recently, the distribution of the marine cave habitat in the Mediterranean Sea was updated (SPA/RAC-UNEP/MAP, 2020; Gerovasileiou & Bianchi, in press), integrating recent data from regional mapping initiatives.

Specifically, recent expeditions and baseline studies in the framework of the projects MedKeyHabitats and MedMPAnet have provided information on the distribution of marine caves (including tunnels and caverns) in Rachgoun Island, Algeria (PNUE/PAM-CAR/ASP, 2016a) Batroun Kfar Abida, Medfoun and Byblos in Lebanon (SPA/RAC-UN Environment/MAP, 2017), Platamuni area in Montenegro (UNEP-MAP-RAC/SPA, 2016a, b; Mačić et al., 2019) and Cap des Trois Fourches and Jbel Moussa in Morocco (Espinosa et al., 2015; PNUE/PAM-CAR/ASP, 2016b).

In Malta and Gozo, the project LIFE BaĦAR for N2K identified 37 semi-submerged and 52 fully submerged caves, of various sizes and depth, as well as 17 deep-sea caves between 205 m and 795 m, extending the bathymetric distribution of the marine cave habitat to the deep Mediterranean Sea (Evans et al., 2016; Borg et al., 2017). An interactive digital geo-referenced map of the project findings, including occurrence data for marine caves, is available online.

The distribution of marine caves on the Greek coasts of the island-dominated Aegean Sea (622 marine caves) was updated in the framework of the research project MARISCA (Sini et al., 2017), based on information obtained during regional biodiversity assessments (Gerovasileiou et al., 2015a), interviews and questionnaires with divers, as well as diving surveys.

A preliminary survey on the distribution of marine caves along the Tunisian coast was presented in the 2nd Mediterranean Symposium on Dark habitats by Dridi et al. (2019). Numerous marine caves from the coasts of Turkey were listed and described in a publication by the TUDAV (Öztürk, 2019). In addition, within the East Med Cave Project that is conducted by TUDAV more than 200 marine caves have been identified along Aegean and Mediterranean coasts of Turkey.

Detailed mapping of marine caves takes place or has been scheduled within national and EU-funded projects aiming at the mapping of habitats listed in the EU Habitats Directive, in Croatia, Cyprus and parts of Greece, specifically within marine areas of the Natura 2000 network.

The majority of existing occurrence data regarding marine caves corresponds to shallow and semi-submerged caves, mostly in the northern Mediterranean basin. Mapping efforts are required in order to fill distribution gaps in the eastern and southern Mediterranean Sea, but also in deeper waters.

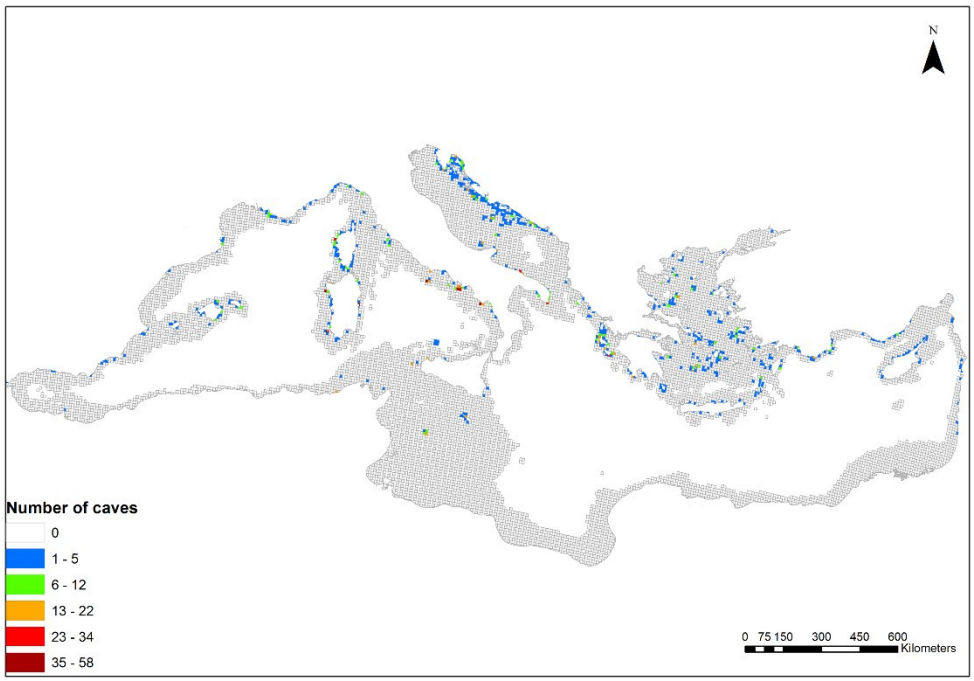

Figure 7: Distribution of marine caves in the Mediterranean Sea. Different colours indicate the number of caves recorded in cells of 10x10 km (from Giakoumi et al., 2013)

Deep-sea

Spatial information on deep-sea geomorphologic structures such as canyons (Figure 8) had already been compiled at the Mediterranean scale (Würtz, 2012) and have been updated (Harris & Macmillan-Lawler, 2015, SPA/RAC-UN Environment/MAP & OCEANA, 2017). More recently Würtz & Rovere (2015) have compiled detailed information on the distribution of seamounts and seamount like structures in the Mediterranean and a general distribution at the Mediterranean can be found in SPA/RAC-UN Environment/MAP & OCEANA, 2017 (see Figure 9). This document also identifies areas comprising chemosynthetic assemblages (see Figure 10). Concerning the Cold-Water Corals (CWCs), one of the most emblematic and fragile Mediterranean deep-sea assemblages, a recent compilation of chapters on the subject has been published (Orejas & Jiménez, 2019).

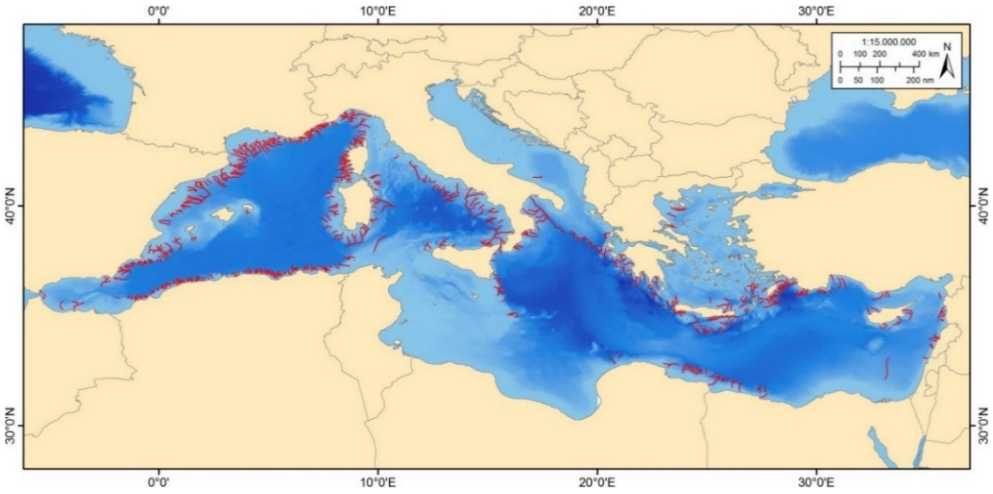

Figure 8: Distribution of Mediterranean submarine canyons (from SPA/RAC-UN Environment/MAP & OCEANA, 2017; compiled by the authors based on data available from different sources)

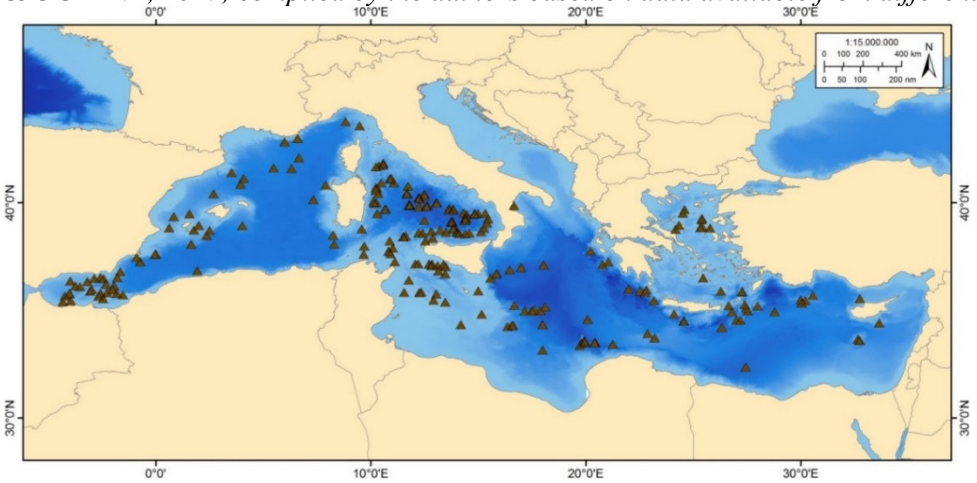

Figure 9: Distribution of Mediterranean seamounts (from SPA/RAC-UN Environment/MAP & OCEANA, 2017; compiled by the authors based on data available from different sources)

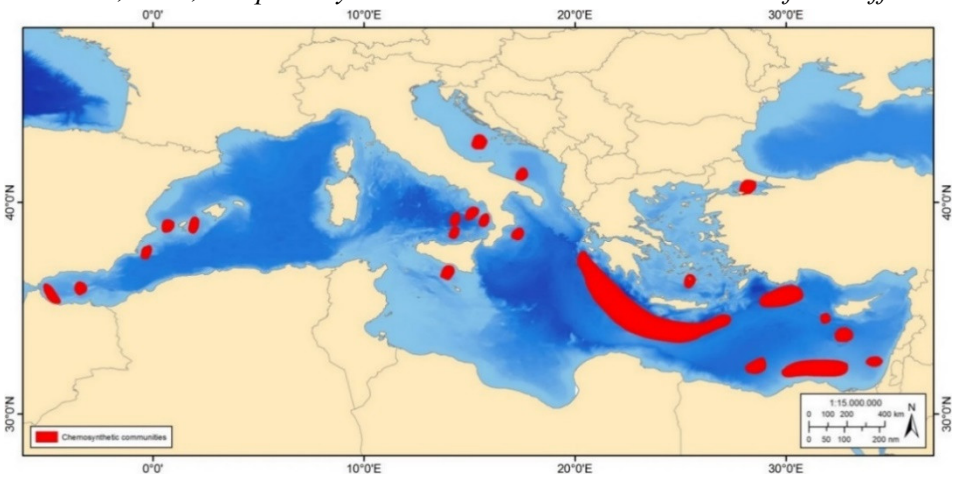

Figure 10: Identified areas with chemosynthetic assemblages (from SPA/RAC-UN Environment/MAP & OCEANA, 2017; compiled by the authors based on data available from different sources)

At the Mediterranean scale, spatial distribution of few emblematic deep-sea assemblages or species have been mapped such as Cold-Water Coral (CWC) provinces (Chimienti et al., 2019), the black coral *Leiopathes glaberrima* a representative species of Vulnerable Marine Ecosystems (VMEs) (Massi et al., 2018) and *Dendrophyllia cornigera* (Castellan et al., 2019). These are present in the Alboran, Ligurian and Tyrrhenian Sea, the Algero-Provençal Basin, the Sicily channel, the Northern Ionian Sea, the Southern Adriatic, the Aegean Sea and the North Levantine (near Rhodes Island).

At regional or national levels, efforts have been done to communicate mapped data acquired during exploration campaigns for data acquisition intended for existing or future MPAs. Localization of the Remotely Operated Vehicle (ROV) dives and general information on 43 sites of the Medseacan and Corseacan explorations of French Mediterranean deep-sea that had taken place between 2008 and 2010, were made available on internet in 2016[4] (Link). In the same way, georeferenced data from the RAMOGE deep-sea explorations 2015 and 2018 between Italy, Monaco and France (Daniel et al., 2019) are available through a cartographic site [5]. Data from the LIFE BaĦAR for N2K project that explored Maltese escarpments (Evans et al., 2016, Knittweis et al., 2019) are available through a cartographic site [6]. Data from the Deep-sea Lebanon Expedition that explored Lebanese canyons and escarpments are available in a report (Aguilar et al., 2018).

In the frame of the recent project "DEEPEASTMED: State of the knowledge on deep-water vulnerable species and habitats in the Eastern Mediterranean", the distribution of deep-water (>200 m) vulnerable marine species, communities and geomorphological features of special interest (e.g. canyons, seamounts, cold seeps, brine lakes, pockmarks, active volcanic structures, hydrothermal vents and mud volcanoes) was mapped in the eastern Mediterranean Sea, based on archive video (from ROV, towed video systems and manned submarine), photographic material (on-board and laboratory deep-water experimental fishing catches) and a detailed review of published and grey literature (Gerovasileiou et al., 2019a, b; Mytilineou et al., 2019; Smith et al., 2019). The final report of the project will be available by the end of 2020.

The first Turkish national workshop on deep-sea ecosytems was held in Gökçeada, Turkey in 2017 and workshop proceedings were published (Gönülal et al., 2017). In this document, Dalyan (2017) reported on commercial species caught from 28 trawl hauls between 200 and 800 m in the Bay of İskenderun, Levantine Sea. Gönülal (2017) caught 78 species between 50 and 1000 m in the North Aegean Sea. According to the workshop habitats and species deeper then 200 m are poorly known in the Turkish waters and special attention should be given this topic. More research intensity and funds should be allocated by relevant state organizations.

In the western Mediterranean, the authors Chevaldonné et al. (2015) mapped the occurrence of the deep-sea Porifera, *Asbestopluma hypogea* (now *Lycopodina hypogea*) occurring also in shallow but dark caves. At national levels, spatial distribution of the critically endangered bamboo coral *Isidella elongata* was published for Greece (Gerovasileiou et al., 2019b). The spatial and bathymetric

[4] https://gis-posidonie.maps.arcgis.com/apps/MapJournal/index.html?appid=dfb74da3673f4a9ea6abc50ca0556601
[5] See https://gis-posidonie.maps.arcgis.com/apps/MapSeries/index.html?appid=8bc12e7babc2446bab808c307620c783&folderid=90598c9f63a648e9afb1d9e46488b914
[6] See https://oceana.maps.arcgis.com/apps/MapSeries/index.html?appid=6b6c687101b841588dc91b84d3a25ef3

distribution of 130 deep-sea taxa along the French Mediterranean shelf brake were published (Fourt et al., 2017).

In the framework of the implementation of the EU Habitat Directive, focusing on the deeper component of the habitat 1170 "rocky reefs" and of the EU Marine Strategy Framework Directive, Italy has initiated nationwide deep coral monitoring activities for the systematic collection of data on their presence and health status, applying specific standards (La Mesa et al., 2019).

In the northern Mediterranean Sea, some recent papers describe spatial distribution of deep-sea fish such as macrourids (García-Ruiz et al., 2020) and gurnards (Colloca et al., 2020) and commercial decapods (Sbrana et al., 2019).

New records for some areas have also been published: ichthyofauna from the Egyptian coast (Farrag, 2016), extension of the geographic distribution of the hydroid *Lytocarpia myriophyllum* to Cyprus (Gerovasileiou et al., 2020) and extension of the coral *Denrophyllia ramea* to the eastern Mediterranean (Orejas et al., 2017, 2019a, b). First records for the Mediterranean Sea of the sea pen *Protoptilum carpenteri* or first observations for specific canyons or areas have also been published (Mastrototaro et al., 2015; Bo et al., 2020a; Salvati et al., in press).

At a local level, some chemosynthetic formations and assemblages have been described e.g. in the Adriatic Sea (Angeletti et al., 2015), in the Levantine Sea (Beccari et al., 2020) and in the Tyrrhenian Sea (Esposito et al., 2015). Spatial and bathymetric distribution of deep-sea assemblages or species have also been acquired and mapped e.g.: lithistid sponge aggregations around the Balearic islands (Maldonado et al., 2015), CWCs in the Cassidaigne canyon (Fabri et al., 2017), microbenthic assemblages in the Menorca Channel (Grinyó, 2016), sponge aggregations (Santín et al., 2018), deep Scleractinia and Gorgonaria in the canyon of Stoechade (Sartoretto & Zibrowius, 2018), macrobenthic assemblages of the Aeolian Islands (Aguilar et al., 2019b), assemblages of the Cap de Creus, La Fonera and Blanes canyons (Aymà et al., 2019), CWC assemblages around Malta (Knittweis et al., 2019), a new coral-bivalve biotope off Naples (Taviani et al., 2019) and the new "Corsica Channel Cold-Water Coral Province" (Angeletti et al., 2020). An extensive ROV survey on the summits of two upper bathyal seamounts in the Ligurian Sea allowed characterizing their megabenthic assemblages, analysing the biogeographic implications of the findings and the possible environmental factors favouring the occurrence of the recorded communities (Bo et al., 2020b).

Only part of the Mediterranean deep-sea habitats has been explored, mainly in the northwestern sector; efforts are still needed to acquire basic knowledge on spatial and bathymetric distribution of deep-sea habitats in the Mediterranean Sea to be in capacity to build a coherent Mediterranean network of protected deep-sea marine habitats.

2.2. Composition structure, population dynamics and new species

Marine caves

During the last five years, community structure of sessile benthos on hard substrates in marine caves has been quantitatively studied in the Greek Aegean coasts (Gerovasileiou & Voultsiadou, 2016; Gerovasileiou et al., 2017; Sanfilippo et al., 2017; Dimarchopoulou et al., 2018; Galani et al., 2019; Rosso et al., 2019), the Ligurian and Tyrrhenian coasts of Italy (Nepote et al., 2017; Scotti et al., 2017; Montefalcone et al. 2018), South France (Grenier et al., 2018) and the Alboran coasts of Spain

(Sempere-Valverde et al., 2019). Several other studies have provided biodiversity checklists, qualitative and semi-quantitative descriptions of benthic communities in caves of the Eastern Mediterranean (Gerovasileiou et al., 2015a; Öztürk, 2019), Malta (Knittweis et al., 2015), Croatia **(**Radolović et al., 2015), Italy (Onorato & Belmonte, 2017; Padiglia et al., 2018), Montenegro (Mačić et al., 2019) and Cyprus (Jimenez et al., 2019).

Four publications have focused on sessile invertebrates which form bioconstructions, also known as "biostalactites", with their hard skeletons or tubes (e. g. serpulids, bryozoans and corals) in marine caves of Sicily (Sanfilippo et al., 2015), Cyprus (Guido et al., 2017) and Greece (Guido et al., 2019a, b). In addition, the ecosystem-engineering role of sponges, anthozoans, bryozoans and other sessile invertebrates, which increase 3D complexity in caves and harbour rich associated macrofauna, was investigated in marine caves of Spain (Navarro-Barranco et al., 2015a) and Greece (Gerovasileiou et al., 2016c).

Soft substrate benthos has been rarely studied in Mediterranean marine caves (Gerovasileiou & Bianchi, in press). Five studies were published during the reporting period. Pino et al. (2020) studied molluscs and brachiopods (including thanatocoenoses) in cave sediments from the Alboran coasts of Spain. Ape et al. (2016) investigated meiofauna in two marine caves in Ustica Island MPA, Italy. Three studies examined benthic foraminifera in sediments from marine caves of Sardinia (Bergamin et al., 2018; Romano et al., 2018, 2020) and Spain (Bergamin et al., 2020).

Only one publication has investigated microbial mats in marine caves in the National Marine Park of Zakynthos Island, Ionian Sea, Greece (Polymenakou et al., 2018).

The composition and distribution patterns of mobile fauna (i.e. crustaceans and fish) and its role on the functioning of the marine cave ecosystem was investigated in the North-western Mediterranean Sea (Bussotti et al., 2015, 2017, 2018; Navarro-Barranco et al., 2015b). A theoretical model on the trophic organization and functioning of marine cave ecosystems was developed by Rastorgueff et al. (2015), providing the basis for evaluating the ecological quality of the marine cave ecosystem. In the Eastern Mediterranean Sea information on mobile fauna was mainly published within checklists and studies focusing on ichthyofauna (e.g. Gerovasileiou et al., 2015a, b; Öztürk, 2019).

Since 2015 nine new species have been described from Mediterranean marine caves. The demosponge *Protosuberites mereui* was described from Bue Marino Cave in Sardinia, Italy (Melis et al., 2016). Four new homoscleromorph sponges were described from Greek Aegean islands, namely *Plakina anisoactina*, *P. anomala* and *P. hellenica* from marine caves in Lesvos Island (Lage et al., 2019) and *P. strongylata* from a marine cave of Crete (Lage et al., 2018). The bryozoan *Setosella rossanae* was described from marine caves of Sicily (Granchi, Gymnasium and Mazzere) and France (Trémies Cave) by Rosso et al. (2020). A crustacean, the thermosbaenacean *Tethysbaena ledoyeri* was also described from in the Parc National des Calanque in the Port-Miou cave (Wagner & Chevaldonné, 2020). The gastropod *Ocenebra vazzanai* was recently described from a circalittoral cave located at a depth of 50-52 m in the Messina Strait, Italy (Crocetta et al., 2020). The species *Gwynia capsula*, previously undocumented in the western Mediterranean, was sporadically found in a cave of Spain (Bergamin et al., 2020). Very recently, unique formations of lithistid sponges that could be up to 769-909 years old were found in marine caves of Crete, Greece (Pisera & Gerovasileiou, 2021).

Dynamics and seasonality of marine cave communities have been rarely investigated (Gerovasileiou & Bianchi, in press). Russo et al. (2015) studied dynamics of hard substratum meiobenthos in a marine cave of Salento Peninsula (Italy) by using artificial panels over a period of two years. Romano et al.

(2020) investigated seasonal variability of benthic foraminiferal assemblages in marine caves of Sardinia, Italy. Nepote at al. (2017) monitored benthic communities in two shallow marine caves in the Ligurian Sea, Italy, between 2010 and 2015, in order to assess the impact of the construction of a touristic harbor in the area. Costa et al. (2018) compared the present sponge populations in two semi-submerged caves in the Ligurian Sea (Italy) with data obtained 55 years ago and found a replacement of 3D growth forms with encrusting ones. Thanks to the availability of a nearly 30-year-long data series (1986-2013), Montefalcone et al. (2018) evaluated ecosystem change in the marine cave of the Bergeggi MPA (Ligurian Sea, Italy), revealing a decline in the cover of sessile taxa (especially 3D forms) combined with an increase of turf and sediment. This decline of ecological quality was also reported from the same cave through the implementation of an ecosystem-based index by Rastorgueff et al. (2015).

Sempere-Valverde et al. (2019) investigated sessile benthos in Cerro-Gordo submerged cave on the Alboran coasts of Spain over a decade (2007-2016) and revealed significant temporal variability in community structure and morphology in both external and internal cave zones.

Deep sea

To explore deep-sea assemblages and species the most frequently used method these last decades is probably the Remotely Operated Vehicle (ROV). ROVs have enabled a better exploration and understanding especially of rocky substrates. Extensive areas can be covered by photographs and video-footages permitting a better description of habitats, macro-benthic species composing an assemblage, as well as reveal precious information on the habitus, behavior and coloration of species (Bo et al., 2020a).

Many of the previous works cited under section 2.1 are based on ROV footages and therefore include a description of the associated macro-benthic assemblages observed (e.g. Evans et al., 2016; Fabri et al., 2017; Grinyó, 2016; Fourt et al., 2017; Aguilar et al., 2018, 2019a, 2019b; Daniel et al., 2019; Beccari et al., 2020). Recent publications have focused on the emblematic Cold-Water Coral assemblages, describing their composition such as in the northwestern Mediterranean (Taviani et al., 2016, 2019; Fanelli et al., 2017; Aymà et al., 2019; Lastras et al., 2019), in the Adriatic Sea (Angeletti et al., 2020; Prampolini et al., 2020) and in the Sicily channel (Knittweis et al., 2019). Other deep-sea anthozoan assemblages, described as gardens or forests because of their three-dimensional deployment, show a rich biodiversity in the Tyrrhenian Sea (Ingrassia et al., 2016) and off Sardinia (Bo et al., 2015) for example. In parallel, the composition of sponge aggregations has been studied in the western Mediterranean using ROV images and samples (Maldonado et al., 2015; Santín et al., 2018).

Ecosystem functioning and relations between deep-sea macro-benthic and mobile species are more and more investigated using various tools such as longline surveys (Capezzuto et al., 2018a) to sample fish or landers that enable the observation of the fauna in a given site over many hours (D'Onghia et al., 2015; Linley et al., 2017). These publications, mainly concentrated in the southern Adriatic, suggest that fish are more abundant in CWC assemblages and canyons than in reference stations (D'Onghia et al., 2015; Capezzuto et al., 2018b) and that CWC sites act as spawning areas for fish species. Comparable observations were described in Sardinia, by Cau et al. (2017) that underlined the importance of antipatharian forests as a nursery ground for small spotted sharks. At another scale,

relations between bacteria and CWC are also being investigated (Meistertzheim et al., 2016) to better understand for example the sensitivity of CWC communities to climate change.

Bacterial, micro- and macro-benthic soft bottom ecology have been also lately investigated to better understand their role in the benthic deep-sea ecosystems of canyons, seamounts and submarine volcanos and hydrothermal vents, e.g.: Zeppilli et al. (2016) on the impact of seafloor heterogeneity; Pola et al. (2020) on macro-fauna of the Gioia Canyon; Ettoumi et al. (2016) on bacteria diversity of seamounts; Esposito et al. (2015) on the relation between amphipods and hydrothermal fields; Bourbouli et al. (2015) and Christakis et al. (2018) on the microbial community of the Kolumbo submarine volcano; Oulas and al. (2016) on microbial mats of the Hellenic Volcanic Arc; Rzeznik-Orignac et al. (2018) on the role of the nematodes and bacteria in the Lacaze-Duthiers canyon.

Sampling is often necessary to assert identification of little known or small sized species, but hard substrate deep-sea sampling, generally performed with an ROV, is difficult and time consuming. Despite these impediments, hard substrate deep species have been sampled and new species have been described lately such as the hexactinellid sponges *Farrea bowerbanki, Tretodictyum reiswigi* (Boury-Esnault et al., 2017) and *Sympagella delauzei* (Boury-Esnault et al., 2015) and the soft coral *Chironephtya mediterranea* (López-González et al., 2015) while other new species of meiofauna are still discovered in canyons using standard sampling methods (e. g. Fernandez-Leborans et al., 2017).

Studies on deep-sea population dynamics are rare due to the difficulty and cost of monitoring in deep habitats. Working on the oldest studied CWC community of the Lacaze-Duthiers canyon, the authors Chapron et al. (2020) have recently published a study on the *in-situ* growth dynamics of two CWC species *Lophelia pertusa* and *Madrepora oculata,* in relation with environmental conditions.

2.3. Pressures and threats

Marine Caves

Climate change (e.g. heat waves and temperature anomalies) and local disturbances caused by coastal interventions and constructions (e.g. extension of harbours and beach nourishments) have proved to generate structural and functional homogenization of marine cave communities, such as the decrease of structural complexity (i.e. replacement of 3D with 2D growth forms) and increase of turf and sediment (Nepote et al., 2017; Costa et al., 2018; Montefalcone et al., 2018; Sempere-Valverde et al. 2019). Marine pollution and littering constitute additional threats especially in semi-submerged caves where litter often accumulate on internal beaches, drifted by wave action (Mačić et al., 2018, Öztürk et al., 2019) or dark cave zones where the lack of water movement may also favour the entrapment of litter (Gerovasileiou & Bianchi, in press).

An additional threat to Mediterranean marine cave communities involves the continuous spreading of non-indigenous species (NIS), especially in the south-eastern basin (Gerovasileiou et al., 2016b; Öztürk, 2019). Gerovasileiou et al. (2016b) listed a total of 56 NIS from about 50 Mediterranean marine caves, including molluscs (15), cnidarians (9), bryozoans (7), polychaetes (6), crustaceans (6), macroalgae (3), fish (3), and tunicates (2). Most NIS were found in Lebanon and the Levantine Sea. NIS are mainly observed at the entrance and semi-dark zones of shallow and/or semi-submerged caves and tunnels. However, their impact on cave communities remains unknown and should be urgently monitored, especially in marine caves of the Levantine and Aegean ecoregions.

Deep-sea

Practically all recent publications based on deep-sea observations mention anthropogenic impacts. Fishing pressure on CWCs have been underlined (D'Onghia et al., 2017, D'Onghia, 2019; Capezzuto et al., 2018a; Chimienti et al., 2019), as well as presence and impacts of fishing gear on coral assemblages (Angiolillo et al., 2015; Angiolillo & Canese 2018; Giusti et al., 2019) and important deep-sea fishery discards (Gorelli et al., 2016). Deep-sea habitats are also threatened by direct impacts of trawling activities on soft bottom corals (Petović et al., 2016; Lauria et al., 2017; Mastrototaro et al., 2017; Pierdomenico et al., 2018) or indirect impacts by increasing water turbidity, sediment resuspension and deposit, around and in canyons and CWC assemblages (Puig et al., 2015; Paradis et al., 2017; Arjona et al., 2018, Arjona-Camas et al., 2019; Lastras et al., 2016 and 2019). *Isidella elongata,* the only Mediterranean Anthozoan considered as Critically Endangered (Otero et al., 2017), is directly threatened by trawling impacts (Pierdomenico et al., 2018).

Also, impacts of terrestrial human activities such as industrial discharges (e.g. in the Cassidaigne canyon Fontanier et al., 2015, 2020; Bouchoucha et al., 2019), dumping (Taviani et al., 2019), marine litter (Vlachogianni et al., 2017; Fortibuoni et al., 2019; Pierdomenico et al., 2019) and transfer of pollutants to the deep-sea (Sanchez-Vidal et al., 2015) represent important pressures on deep-sea habitats and species.

Although poorly known, climate change impacts, cumulated to the previous threats, could drive important changes in Mediterranean deep-sea ecosystem structures (Sweetman et al., 2017). Benthic non-indigenous species (NIS) have rather rarely been reported in deep-sea habitats (Galil et al., 2019) and for the moment is not among the most important threats. Nonetheless, the rise of sea temperature attributed to climate changes occurs also in deep-sea and could contribute significantly to expanding the bathymetric distribution of actual shallow NIS (see e. g. Innocenti et al., 2017).

2.4. Protection measures

Marine Caves

According to the questionnaires filled during this survey, numerous Mediterranean MPAs encompass marine caves and in several cases, coastal areas with marine caves have been suggested for protection (e. g. Cap des Trois Fourches in Morocco). In Malta, information on reef and cave habitats, collected through the Life BaĦAR for N2K project, led to three inshore and five offshore areas being proposed and designated for the protection of these habitats. New MPAs have been established in coastal areas with marine caves in Cyprus (i. e. Cavo Greco, Peyia Sea Caves and Kakoskali MPAs) and Morocco (Jbel Mousa) while some national Natura 2000 networks were expanded to coastal and marine areas which encompass marine caves (e.g. Greece, Italy, Cyprus and Malta) withint the framework of EU marine Natura 2000 network sufficiency assessments for the Habitats Directive habitat "8330" (https://eunis.eea.europa.eu/habitats/10172). According to the interim study of East Med Cave Project three new caves were discovered in the Kaş/Kalkan special protected area in Turkey. Nevertheless, the number of marine caves in MPAs remains unknown and - despite the establishment of new MPAs, EU environmental legislation and the Dark Habitats Action Plan - in most cases there is a lack of specific regulations or management plans for their protection, monitoring and restoration.

Deep-sea

In the Meiterranean, deep-sea habitats can be protected by national, European and/or international legal frameworks. The General Fisheries Commission for the Mediterranean (GFCM) has defined areas in which some specific fishing activities are temporarly or permanently restricted to conserve specific stocks or habitats. To date, nine Fisheries Restricted Areas (FRA) have been established counting a large deep-water FRA that includes seabeds deeper than 1000 meters where towed dredges and trawls nets are banned to protect deep-sea habitats. The actual FRAs and the form to propose new ones can be found following this link.

In EU Member States, the protection of deep habitats mostly relies on the Marine Strategy Framework Directive (MSFD) and the Habitats Directive (HD). Under the MSFD, all EU waters, species and habitats should reach 'good environmental status' (GES). The MSFD requires Member States to take measures (some of them spatial protection measures) to protect and reduce pressures on species and habitats.

Mediterranean deep-sea habitats are still poorly represented in MPAs partly due to the fact that these habitats are often distant from the coast and difficult to access, therefore their protection represents a real challenge. Also, the governance issues concerning such areas often situated off shore, partly or entirely out of territorial seas, and requiring regional and international cooperation and intersectoral collaboration, represent a real challenge. Due to these difficulties, few national or marine parks have extended their area to include adjacent deep-sea habitats (e.g. recent expansion of the National Park of Cabrera in Spain in 2019) and in rare cases new ones include deep-sea habitats (e.g. the "Parc naturel marin du cap Corse et de l'Agriate" created in 2016 in France that followed the "Parc naturel marin du Golfe du Lion in 2011 and the "Parc National des Calanques in 2012 that also include deep-sea habitats). Some national Natura 2000 networks were extended to deep-water areas including marine vulnerable ecosystems, but effective management measures still need to be applied (e. g. site GR4220036 created in 2016 in Greece, sites FR9102016 and FR9102016 created in 2017 and FR9402020 and FR9402021 in 2018 in France). For these French sites, management plans are to be finalized in 2025. However, some Mediterranean EU countries have included deep-water stations in the monitoring networks under HD and MSFD framework or the MEDITS survey. Adding to the difficulty of access, is the fact that deep-sea habitats are often areas beyond national jurisdiction (ABNJ). The MSFD approach may be implemented in ABNJ and deep waters to assess GES but needs adaptation and standardized methods (Danovaro et al., 2020; Orejas et al., 2020). Concerns on conservation of deep-sea ecosystems grow world-wide and the United Nations are working to elaborate an international legally binding instrument for the conservation and sustainable use of marine biological diversity of ABNJ (see Intergovernmental Conference on Marine Biodiversity of Areas Beyond National Jurisdiction and Cremers et al., 2020).

Mediterranean deep-sea habitats and ecosystem functioning are poorly known and efforts still need to be devoted to the acquisition of basic knowledge on the deep Mediterranean ecosystems. Nevertheless, the knowledge acquired up to date underlines the fragility of these habitats and ecosystems, as well as the numerous and destructive threats that weigh on them. This should lead countries, regional and international organizations to urgently apply the precautionary approach by increasing inclusions of deep habitats in MPAs and by creating new Fisheries Restricted Areas (FRA) and Specially Protected Areas of Mediterranean Importance (SPAMIs) in sites where VMEs (e.g. *Isidella* forests) occur. However, they should be incorporated on the basis of marine conservation priorities, or precautionary principal with an integrated approach, in a coherent network of MPAs and in the framework of

Maritime Spatial Planning (MSP) when existing, not simply as extensions of existing protected areas (Katsanevakis et al., 2020). Therefore, international cooperation is necessary, as well as standardized monitoring and assessment tools to improve conservation of deep habitats (Ramos et al., 2015; Mazaris et al., 2018).

3. Regional activities carried out in accordance with the 2015-2020 timetable of the Action Plan on Dark Habitats and the Ecological Objective 1 (EO1) of the Ecosystem Approach (EcAp)

3.1. Activities conducted by SPA/RAC

SPA/RAC conducted or participated to the following actions:

- 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. Beneficiary countries of the project were: Algeria, Cyprus, Libya, Malta, Montenegro, Tunisia, Turkey and Morocco. In the framework of these projects marine caves have been mapped in several locations.

- 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.

In the framework of this project two documents were published and are available online:

- 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.
- SPA/RAC-UNEP/MAP & OCEANA (2017) Guidelines for inventorying and monitoring of dark habitats in the Mediterranean Sea. SPA/RAC publications, Tunis.

- 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 on supporting achieving 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.

One document has been published in the framework of the MedMPA Nerwork project and is available online:

- 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 Environmental Status (GES) in the Mediterranean Sea.

SPA/RAC has participated to CORMON meetings in order to create the Integrated Monitoring and Assessment Programme (IMAP) and has hired experts to contribute to the elaboration of the EcAp monitoring guidance document on the monitoring of biodiversity and non-indigenous species (NIS) under 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 of NIS, and particularly invasive NIS (EO2). Common indicators 1, 2 and 6 apply directly on dark habitats, among others, while indicators 3-5 concern selected species (i. e. marine mammals, seabirds and marine reptiles) some of which can be found in dark habitats (e.g. *Monachus monachus*).

The reports of the National Monitoring Programme of Lebanon, Morocco, Tunisia and Israel (available at here) include information on the presence of protected species in marine caves, the composition of marine cave communities and/or the mapping of caves which are used as a habitat by the Mediterranean monk seal.

➢ MedBycatch Project (2017-2020)

SPA/RAC was involved in the implementation of the MAVA-funded project "Understanding Mediterranean multi-taxa 'bycatch' of vulnerable species and testing mitigation - a collaborative approach" in partnership with BirdLife Europe and Central Asia (as coordinator), GFCM, ACCOBAMS, MEDASSET and IUCN-Med. The aim of the project was to support UNEP/MAP Barcelona Convention, and specifically the southern and eastern Mediterranean Contracting Parties (Morocco, Tunisia and Turkey), to implement national bycatch data collection (onboard observation and questionnaires) in order to identify and test measures to reduce impact of fisheries on vulnerable species (marine mammals, birds, turtles, elasmobranchs, sponges and corals). MedBycatch Project issued a standardized Mediterranean and Black Sea Bycatch protocol as well as a practical guide to help fishing communities and on-board observers identify, monitor, and improve their knowledge on vulnerable species potentially caught as bycatch:

- Otero, M., Serena F., Gerovasileiou, V., Barone, M., Bo, M., Arcos, J.M., Vulcano A., Xavier, J. (2019). Identification guide of vulnerable species incidentally caught in Mediterranean fisheries. IUCN, Malaga, Spain, 204 pages

In this comprehensive guide, the description of each species is supported by photographs, illustrations and narrative descriptions that highlight important anatomical structures of each species, as well as the common names in several languages. In addition, a pocket identification guide was produced for Morocco, Tunisia and Turkey highlighting the main species which may be incidentally caught during fishing activities in each country. The guides are available in Arabic, English, French and Turkish on SPA/RAC website.

Within the project framework, a database for bycatch was elaborated and hosted by GFCM.

- Updating of classification of benthic marine habitat types in the Mediterranean Sea

The updated classification includes several types of dark habitats among others.

- 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 dark habitats among others.

- 2nd Mediterranean symposium on the conservation of dark habitats (Antalya, Turkey, 17 January 2019)

The 2nd Mediterranean symposium on the conservation of dark habitats was organized by SPA/RAC in collaboration with the Turkish Ministry of Environment and Urbanization as part of the "Mediterranean Symposia on Marine Key habitats and NIS" in Antalya, Turkey (17 January 2019). Proceedings have been published. The main recommendations of the symposium were:

  - There is an urgent need to speed up the increase of knowledge by investing in research and conservation activities, especially in understudied areas.
  - In order to achieve conservation targets it is important to assess vulnerability and prioritize protection of dark habitats. Special emphasis should be paid to the application of the precautionary approach for the management of human activities.
  - It is crucial to promote tools and protocols for the identification, monitoring and management of human activities and pressures which affect dark habitats, as well as taxonomic studies, since these habitats host rich and still unknown biodiversity.
  - The establishment of a dedicated network focusing on dark habitats is highly recommended, promoting capacity building initiatives (e.g. workshops and training), in order to facilitate the exchange of experience and data sharing on dark habitats across the Mediterranean Sea.

- National workshop on the marine cave habitats in Turkey

SPA/RAC supported the organization of a national workshop on the marine cave habitats in Turkey (Istanbul, 13 December 2019) in line with the Dark Habitats Action Plan and the MedKeyHabitats II project, financed by MAVA foundation.

➢ Contribution to the publication of a book on East Mediterranean marine caves:

Öztürk, B. (Ed.) 2019. Marine Caves of the Eastern Mediterranean Sea. Biodiversity, Threats and Conservation. Turkish Marine Research Foundation (TUDAV) Publication No: 53, Istanbul, Turkey. 258 pages.

➢ Elaboration of a desktop study on Mediterranean marine caves

Within the implementation of the Dark Habitats Action Plan, where collecting, improving scientific knowledge, circulating data at Mediterranean level is a high priority, SPA/RAC funded the elaboration of a desktop study on marine cave habitats, within the frame of MedKeyHabitats II project. The desktop study will be available soon on the SPA/RAC website.

– SPA/RAC-UNEP/MAP (2020) Mediterranean marine caves: remarkable habitats in need of protection. By Gerovasileiou, V. & Bianchi, C.N. Tunis: SPA/RAC, 78 pp (+ Annexes).

3.2. Other publications and actions at a regional scale

➢ IUCN with financial support from the Mava Foundation published

– Würtz, M. & Rovere, M. (2015) Atlas of the Mediterranean Seamounts and Seamount-like Structures. Gland, Switzerland and Malaga, Spain: IUCN. 276 pages.

– IUCN (2019). Thematic Report – Conservation overview of Mediterranean deep-sea biodiversity: A strategic assessment. Gland, Switzerland and Malaga, Spain: IUCN. 122 pages.

➢ IUCN Red List Assessment Review Workshop on Mediterranean Porifera

The workshop was organized at the Hellenic Centre for Marine Research in Crete, Greece (25-28 November 2019). Approximately 80 species of sponges were assessed by a group of experts, including deep-sea sponges of the class Hexactinellida and all the carnivorous species of the demosponge family Cladorhizidae. Link

➢ Creation of the World Register of marine Cave Species (WoRCS)

WoRCS is a thematic species database of the World Register for Marine Species (WoRMS) that was created in 2016 aiming at providing a comprehensive taxonomic and ecological database of species known from marine and anchialine cave environments worldwide. The creation of this database will provide information vital for evidence-based conservation. Link

➢ The non-governmental organization OCEANA leaded or participated to the following actions:

– Expeditions (2015-2018)

To Malta to survey deep-sea habitats and caves, southern Sicily to identify vulnerable deep-sea habitats and essential fish habitats, Lebanon to explore deep-sea submarine canyons and Aeolian Islands to survey deep-sea habitats.

- Events and reports
    - 2015-2018 Reports on the results of the LIFE+ Bahar project in Malta, attendance to final meetings and writing the Layman's Report: Research for the conservation of reefs and sea caves in Malta
    - 2016 Presentation on "deep-sea red coral distribution in Malta" and "*Neopycnodonte zibrowii* distribution" at the 2016 CIESM Congress
    - 2016-2017 Participation in the workshops and final report on the conservation status of Mediterranean Anthozoa and Actiinopterygii for the IUCN Red List
    - 2017 Participation in the "Guidelines for inventorying and monitoring of dark habitats in the Mediterranean Sea"
    - 2019 Participation to the Classification of benthic marine habitat types for the Mediterranean region and the Reference List of Marine and Coastal Habitat Types in the Mediterranean
    - 2019 Providing data to GFCM on *Isidella elongata* distribution based on Oceana research
    - 2019 Presentations in the 2019 CIESM conference about "*Pachylasma gigantea* in Maltese coral reef" and "Refining deep-sea habitat classification in Maltese waters"
    - 2020 Publication on findings of plastics and litter in deep-sea areas
- Conservation activities
    - 2015-2017 Working with the Italian Government to propose the protection of several coral species in the Mediterranean Sea (Antipatharia, *Callogorgia verticillata*, etc.)
    - 2017-2019 Working with the Spanish Government to propose the protection of several coral species in the Mediterranean Sea (*Isidella elongata*, *Dendrophyllia* spp., etc.)
    - 2015-2019 Working with the Spanish and Balearic Government for the enlargement of the Cabrera National Park to deep-sea areas.
    - 2015-2019 Working with SPA/RAC on developing analysis and protocols for deep-sea habitats
- Participation to 28 scientific publications related to deep-sea habitats and species in the Mediterranean Sea since 2015

➢ FAO/GFCM[7] actions concerning dark habitat populations in the Mediterranean since 2015

The actions led by FAO/GFCM mainly concern the prevention of significant adverse impacts (SAIs) of deep-sea fisheries (DSF) activities on vulnerable marine ecosystems (VMEs). Fisheries interact with deep-sea populations but do not interact with the dark habitats of caves.

- Meetings that include subjects on the protection of deep-sea habitats and populations
    - Third meeting of the Working Group on Marine Protected Areas (WGMPA), including a session on essential fish habitats (EFH), Rome, Italy, 18-21 February 2019. The meeting addressed the following main tasks: i) review new and pending proposals for the establishment of GFCM fisheries restricted areas (FRAs); ii) assess the effectiveness of existing FRAs against their objectives and propose suitable scientific monitoring plans; and iii) advance

[7] GFCM is a regional fisheries management organization (RFMO) established in 1949 under the provisions of Article XIV of the Constitution of the Food and Agriculture Organization of the United Nations (FAO).

on the implementation of Resolution GFCM/41/2017/5 on a network of essential fish habitats in the GFCM area of application. Finally, the meeting reiterated the importance of creating a scientific database collecting evidence on the existence of VME indicators and proposed a new template to populate the database with existing and new relevant scientific information. Link to report

- In collaboration with IUCN-Med and Oceana, the first meeting of the Working Group on Vulnerable Marine Ecosystems (WGVME), Malaga, Spain, 3-5 April 2017. Link to report
- FAO Workshop on the management of Deep-sea fisheries (DSF) and Vulnerable Marine Ecosystems (VMEs) in the Mediterranean organized in collaboration with the GFCM, Rome, Italy, 18-20 July 2016 Link
- Second meeting of the WGVME, Rome, Italy, 26-28 February 2018. Link to report

– GFCM Database on Sensitive Benthic Habitats and Species

The GFCM has recently released a Database on Sensitive Benthic Habitats and Species with the aim of mapping vulnerable marine ecosystem indicators in the Mediterranean using data derived from various types of surveys at sea. The database is hosted in a password-protected environment where data consultation dashboards and data diagnostics and analysis instruments are made available to users. An online presentation of the new database was organized on 17 July 2020.

– Publications that also concern deep-sea habitats and populations

- Poster Deep sea corals of the Mediterranean Sea (published by FAO) Link
- Poster 2017 Deep-sea sponges of the Mediterranean Sea (published by FAO) Link
- FAO. (2016). *The State of Mediterranean and Black Sea Fisheries* (p. 134). General Fisheries Commission for the Mediterranean. Link
- FAO. (2018). *The State of Mediterranean and Black Sea Fisheries* (p. 172). General Fisheries Commission for the Mediterranean. Link
- FAO. (2019). *Monitoring discards in Mediterranean and Black Sea fisheries: Methodology for data collection.* FAO Fisheries and Aquaculture Technical Paper No. 639. Rome. Link
- FAO. (2019). *Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries: Methodology for data collection* (p. 81) [FAO Fisheries and Aquaculture Technical Paper N°640]. FAO. Link

– GFCM decisions (resolutions and recommendations) since 2015 that also concern dark habitat populations.

- GFCM/40/2016/5 establishing a minimum conservation reference size for European hake in the Mediterranean Sea. Link
- GFCM/40/2016/7 concerning the authorisation of the use of ROVs within the framework of national scientific research programmes on red coral. Link
- GFCM/41/2017/3 on the establishment of a fisheries restricted area (FRA) in the Jabuka/Pomo Pit in the Adriatic Sea. Link
- GFCM/41/2017/4 on a permanent working group on VMEs. Link
- GFCM/41/2017/5 on the establishment of a regional adaptive management plan for the exploitation of red coral in the Mediterranean Sea. Link
- GFCM/41/2017/5 on a network of essential fish habitats in the GFCM area of application. Link

- GFCM/42/2018/2 on fisheries management measures for the conservation of sharks and rays in the GFCM area of application, amending Recommendation GFCM/36/2012/3. Link
- GFCM/42/2018/3 on a multiannual management plan for sustainable trawl fisheries targeting giant red shrimp and blue and red shrimp in the Levant Sea (geographical subareas 24, 25, 26 and 27). Link
- GFCM/42/2018/4 on a multiannual management plan for sustainable trawl fisheries targeting giant red shrimp and blue and red shrimp in the Ionian Sea (geographical subareas 19, 20 and 21). Link
- GFCM/42/2018/5 on a multiannual management plan for bottom trawl fisheries exploiting demersal stocks in the Strait of Sicily (geographical subareas 12 to 16), repealing Recommendations GFCM/39/2015/2 and GFCM/40/2016/4 Link
- GFCM/43/2019/4 on a management plan for the sustainable exploitation of red coral in the Mediterranean Sea. Link
- GFCM/43/2019/5 on a multiannual management plan for sustainable demersal fisheries in the Adriatic Sea (geographical subareas 17 and 18). Link
- GFCM/43/2019/6 on management measures for sustainable trawl fisheries targeting giant red shrimp and blue and red shrimp in the Strait of Sicily (geographical subareas 12, 13, 14, 15 and 16). Link
- GFCM/43/2019/6 on the establishment of a set of measures to protect VMEs formed by cnidarian (coral) communities in the Mediterranean Sea. Link

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

The present evaluation of the implementation of the Dark Habitat Action Plan at national level covers the period 2015 to 2020. The national reports on the implementation of the Barcelona Convention of the marine environment and the coastal region of the Mediterranean and its protocols of 2016-2017 and 2018-2019 were taken in account. Previous reports did not include a section on the Dark Habitat Action Plan. Out of the 21 Contracting Parties (not counting EU), 19 national reports were submitted to SPA/RAC in at least one of the two periods (Albania, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syria, Turkey). Of these 19, the Dark Habitat Action Plan section was completed at least partly by 7 countries (Algeria, Croatia, Egypt, Italy, Lebanon, Malta and Turkey), not completed by 10 countries and not applicable to 2 countries due to the absence of dark habitats (Slovenia and Bosnia-Herzegovina).

Due to the lack of information returned on dark habitats, a desk review preceded this evaluation to complete a questionnaire (corresponding to the dark habitat section of the national reports) for each of the 21 Mediterranean countries. Nineteen of these countries are concerned by dark habitats. These questionnaires were sent by SPA/RAC to the Parties for review, comments and additions. Six countries (Albania, Cyprus, Greece, Malta, Slovenia and Spain) sent feedback or accepted the prefilled questionnaire as it was.

The following analysis is based on the prefilled questionnaires (that had taken into account the information given in the national reports) and include the eventual feedback from the six countries. The prefilled questionnaire was considered as accepted by the Party when no feedback was sent.

The Parties were asked to inform about the status of implementation of the following actions and measures required to attain the objectives of the Dark Habitat Action Plan by 2020:

1) Making a summary of knowledge of dark populations and their distribution around the Mediterranean in the form of a geo-referenced information system
2) Identify and assess proven pressures on each of the various types of habitats
3) Revise the reference list of types of marine habitat for the selection of sites for inclusion in the national inventories of natural sites of conservation interest, in order to take account of dark assemblages
4) Revise the list of endangered or threatened species in order to take account of dark assemblages species
5) Promote the identifying of areas of interest for the conservation of dark assemblages in the Mediterranean and carry out concerted actions in national and/or cross-border sites
6) Finalise the implementing of MPAs in already identified sites at national level and outside waters that lie within national jurisdiction
7) Propose the creation of new MPAs
8) Extent existing MPAs to integrate nearby sites that host dark assemblages
9) Introduce national legislation to reduce negative impacts
10) Integrate taking dark assemblages into account within impact studies procedures
11) Step up awareness and information about dark assemblages with the various actors
12) Implement monitoring systems

The results of the prefilled questionnaires concerning the above questions for 21 Mediterranean countries are presented in Table 1 and Figure 1.

Table 1: Results of the prefilled questionnaires concerning the 12 questions regarding the implementation of the Dark Habitat Action Plan. Countries are presented in their spatial distribution around the Mediterranean Sea (counter clock-wise).

Country/Question	Making a summary of knowledge of dark populations and their distribution around the Mediterranean in the form of a geo-referenced information system	Identify and assess proven pressures on each of the various types of habitat	Revise the reference list of types of marine habitat for the selection of sites for inclusion in the national inventories of natural sites of conservation interest, in order to take account of dark	Revise the list of endangered or threatened species in order to take account of dark assemblages species	Promote the identifying of areas of interest for the conservation of dark assemblages in the Mediterranean and carry out concerted actions in national and/or cross-border sites	Finalise the implementing of MPAs in already identified sites at national level and outside waters that lie within national jurisdiction	Propose the creation of new MPAs	Extent existing MPAs to integrate nearby sites that host dark assemblages	Introduce national legislation to reduce negative impacts	Integrate taking dark assemblages into account within impact studies procedures	Step up awareness and information about dark assemblages with the various actors	Implement monitoring systems

			assemblages									
Spain	Yes	In process	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
France	Yes	Yes	Yes	In process	Yes	No	Yes	Yes	Yes	In process	Yes	In process
Monaco	Yes	Yes	No	No	Yes	No	No	No	No	No	Yes	No
Italy	In process	In process	In process	In process	Yes	In process	In process	In process	In process	Yes	In process	Yes
Malta	Yes	Yes	Yes	Yes	Yes	In process	Yes	Yes	Yes	Yes	Yes	Yes
Slovenia	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Croatia	In process	Yes	No	In process	No	In process	In process	Yes	Yes	Yes	No	In process
Bosnia-Herzegovina	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Montenegro	In process	In process	In process	No	No	In process	No	No	Yes	Yes	No	No
Albania	In process	No	No	No	No	No	In process	No	No	No	No	No

Greece	In process	In process	No	No	In process	In process	No	In process	No	No	In process	In process
Turkey	In process	No	No	No	Yes	In process	Yes	No	No	In process	In process	In process
Cyprus	In process	In process	No	Yes	In process	In process	In process	In process	No	Yes	In process	In process
Syria	No	No	No	No	No	No	No	No	No	No	No	No
Lebanon	Yes	In process	Yes	Yes	Yes	In process	In process	No	In process	In process	Yes	No
Israel	In process	In process	No	No	No	No	In process	No	No	No	No	No
Egypt	In process	Yes	In process	In process	In process	In process	In process	In process	In process	In process	In process	In process
Libya	No	No	No	No	No	No	No	No	No	No	No	No
Tunisia	In process	No	No	No	No	No	No	No	No	No	In process	In process
Algeria	In process	No	No	No	No	No	No	No	No	No	No	No
Morocco	In process	No	No	No	No	In process	In process	No	No	No	In process	In process

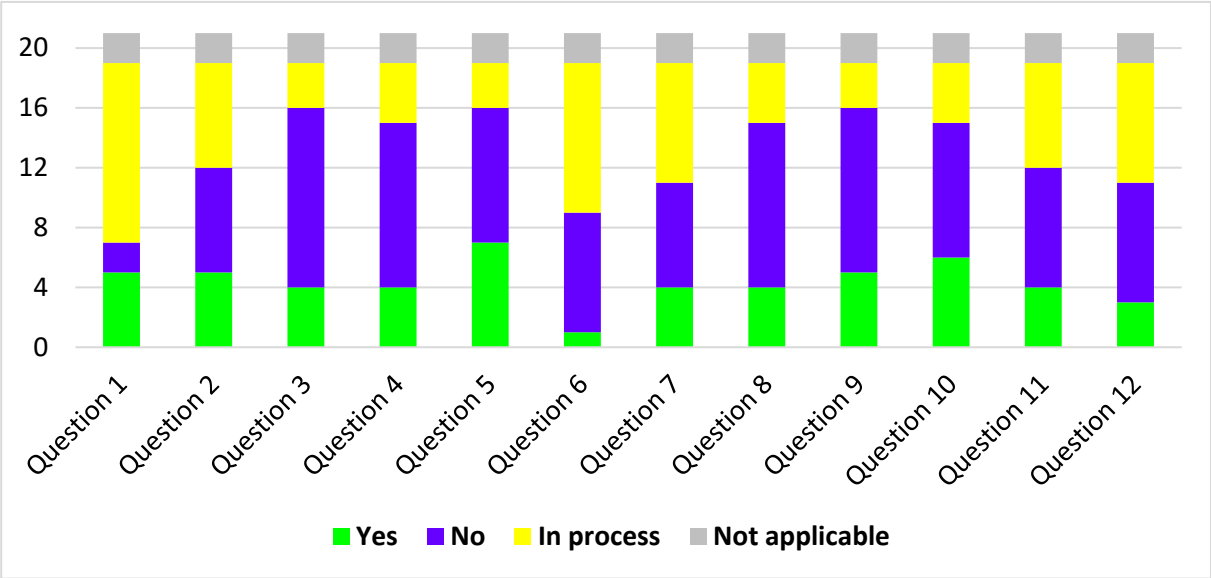

Figure 11: Bar chart of the results of the prefilled questionnaires concerning the 12 questions regarding the implementation of the Dark Habitat Action Plan for 21 Mediterranean countries.

Question 1: Has the Party made a summary of knowledge of dark populations and their distribution around the Mediterranean in the form of a geo-referenced information system?

It is considered that five Parties out of nineteen concerned by this action plan have a summary of knowledge of dark populations and their spatial georeferenced distribution in the Mediterranean. Twelve Parties are in process of this summary and two are not yet in process. The main difficulty reported by the Parties was the financial resources and, at a lesser degree, administrative management and technical guidance capacities.

Question 2: Has the Party identified and assessed proven pressures on each of the various types of habitat?

For five Parties it is considered that the pressures have been identified. For seven Parties it is a process in progress and for seven this assessment has not started. Financial resources were given as the main difficulty.

Question 3 and 4: Has the Party revised the reference list of types of marine habitats or the list of endangered or threatened species in order to take account of dark habitats and species?

Three Parties have revised both their reference list of habitats and endangered or threatened species taking into account dark habitats and species. One has revised its reference list of habitats and is in process for the species list and one its list of species but not habitats. Two Parties are in progress of revising both, one in revising the list of species but not yet of habitats and one is in progress of revising the list of habitats but not yet of species. Ten have not revised either one. The main difficulties encountered by the Parties are financial resources and administrative management.

Question 5: Has the Party promoted the identification of areas of interest for the conservation of dark assemblages in the Mediterranean and carried out concerted actions in national and/or cross-border sites?

Seven Parties are considered to have accomplished this action and three are in process, while nine have not started this action yet. The main difficulties encountered are lack of financial resources and administrative management difficulties.

Question 6, 7 and 8: Has the Party (i) finalized the implementation of MPAs, (ii) proposed the creation or (iii) extended existing MPAs at national level and outside waters that lie in within national jurisdiction that host dark assemblages?

Only five countries have accomplished one of these actions and nine additional countries are in process of accomplishing at least one. Five Parties have not started any of these actions. The main difficulties expressed are lack of financial resources and management difficulties and, to a lesser extent, lack of technical guidance capacities.

Question 9 and 10: Has the Party introduced national legislation to reduce impact on dark habitats including within impact studies?

Seven Parties have introduced national legislation to reduce impact on dark habitats and three are in process. Nine Parties have not yet started this action. The main difficulties encountered are policy and regulatory framework, administrative management and, to a lesser degree, financial resources and technical guidance capacities.

Question 11: Has the Party stepped up awareness and information about dark assemblages with the various actors?

Four Parties have stepped up awareness and information about dark assemblages with various actors and seven are in process. Eight parties have not yet started this process. The main difficulty underlined is lack of financial resources.

Question 12: Has the Party implemented monitoring systems for dark habitats?

Three Parties have implemented monitoring systems for dark habitats and eight are in process. Eight Parties have not yet started this action. The main difficulty encountered is lack of financial resources and, to a lesser extent, difficulties in administrative management and technical guidance capacities.

5. Conclusions

Since the implementation of the Action Plan for the conservation of habitats and species associated with seamounts, underwater caves and canyons, aphotic hard beds and chemosynthetic phenomena in the Mediterranean Sea (Dark Habitat Action Plan) in 2015, knowledge on their distribution, composition, ecosystem functioning and threats they undergo, has improved at the Mediterranean and national levels. However, this knowledge is often scattered, even at national level, and spatially uneven throughout the Mediterranean. Despite the progress that has been accomplished and is in progress by some Parties, there is still much to be done in terms of acquisition of knowledge but also in aggregation of data to reach the objectives of the Action Plan. Baseline information, quantitative data and time series for both caves and deep-sea habitats are limited or even lacking for several Mediterranean areas, hindering the evaluation of impacts and changes in their ecological status. The lack of funding seems to be a major break in acquiring knowledge on these habitats which are often remote and difficult of access. This appears especially in non-EU countries that cannot beneficiate directly of European projects funds. However, despite the fact that marine caves and deep-sea assemblages have been listed for protection under Mediterranean and EU frameworks, their mapping and monitoring have not been yet supported adequately when compared with other key marine habitats.

Efforts must be done to synthesize and aggregate knowledge on the spatial distribution and composition of dark habitats at the Mediterranean scale to identify spatial and knowledge gaps. It is only at this price that a coherent and ecosystem-based Mediterranean network of Marine Protected Areas can be efficient to protect dark habitats and ensure their representativeness and connectivity. SPA/RAC has supported with many efforts the Dark Habitat Action Plan by providing technical and information documents, revising reference and classification of habitats to include deep-sea and cave habitats, funding habitat-mapping expeditions in several countries and desktop review studies, raising awareness on species vulnerable to fisheries and organizing the 2nd Symposium on Dark Habitats.

The majority of the Parties has not yet clearly identified the threats these habitats undergo and has not revised their reference lists of protected species and habitats to include dark habitats. However, taking in consideration the difficulties encountered in scientific knowledge acquisition concerning dark habitats and the vulnerability of these fragile habitats, the precautionary principle should urgently be applied by Mediterranean countries to protect these habitats. Although in many countries specific threats have not yet been identified for dark habitats, studies show that a major threat for underwater caves is the lack of regulation for cave-diving activities and for deep-sea benthic species a major threat is representaed by fishing and specifically bottom trawling activities between 200 and 1000 meters. Management initiatives and actions for safeguarding these habitats should be enhanced and supported.

The latest list of endangered or threatened species in Annex II of the SPA-BD Protocol (Link to list) takes in account a certain number of cave and deep-sea species that should be integrated in the national lists of protected species. This could facilitate national and international safeguarding management actions.

Despite the fact that marine caves are better represented in MPAs than deep-sea habitats, only a few MPAs have taken specific measures of protection (e. g. diving regulation) and monitoring (e.g. impacts of water temperature rise and NIS), and thus, the actual number of protected caves remains unknown (Ouerghi et al., 2019; Gerovasileiou & Bianchi, in press). Considering the high levels of small- and large-scale heterogeneity in this habitat type (e.g. many cave-exclusive species are known only from a few or a single cave), different morphological types of caves (e.g. blind caves and tunnels,

entirely or semi-submerged) should be included in MPA Networks in different biogeographic regions, in order to safeguard maximum representation of diversity aspects (Gerovasileiou & Voultsiadou, 2012, Giakoumi et al., 2013; Gerovasileiou & Bianchi, in press). Protecting other habitat types (e. g. rocky reefs and deep-sea habitats, when present) in nearby external areas is also important since they often supply caves with trophic inputs and larvae (Harmelin et al., 1985; Jiménez et al., 2019). In future conservation planning, priority should be given to the protection of (i) caves harbouring exclusive, rare and protected species, (ii) caves with high species and functional diversity, and (iii) caves and cave types that could support unique communities (e. g. those with internal sulphur or freshwater springs and caves with a descending profile that can host deep water species) (Gerovasileiou & Bianchi, in press).

Concerns for the protection of deep-sea habitats is relatively recent, therefor a small portion of deep-sea habitats are actually included in Marine Protected Areas networks. These habitats should massively be protected in the near future through national legislation, under European and the SPA/BD Protocol framework. The Cold-Water Corals, the most emblematic deep-sea habitat, is a habitat that benefits of increasing awareness and a rather coherent and homogeneous protection status throughout the Mediterranean, in particular from fisheries identified as being one of the biggest threats for this habitat. However, further actions should be taken to achieve conservation of other deep-sea habitats, such as the inclusion of vulnerable deep habitats that shelter endangered and threatened species listed in the Annex II of the SPA/BD Protocol, in Mediterranean MPA networks. In parallel, the establishement of new Fisheries Restricted Areas (FRAs) should be encouraged. Although areas situated in high seas, that can include vulnerable deep-sea habitats, can also be eligible for inclusion in the SPAMI list (see link), to date only the Pelagos Sanctuary which does not actually target benthic species, clearly covers open seas.

6. References

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