UNITED NATIONS

EP

UNEP/MED WG.457/Inf.3

UNEP

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

2 January 2019
Original: English

Meeting of Experts on the finalization of the Classification of benthic marine habitat types for the Mediterranean region and the Reference List of Marine and Coastal Habitat Types in the Mediterranean

Rome, Italy, 22-23 January 2019

Agenda item 5: Draft Updated classification of benthic marine habitat types for the Mediterranean region

Approach for the revision and the update of the existing classification of Mediterranean benthic marine habitats

UNEP/MAP
SPA/RAC - Tunis, 2019

Note:

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General premises

To capture the distribution of biodiversity at large spatial scale, the definition of an adequate operational unit is necessary when the objective is not to obtain a small-scale inventory of the biodiversity from a detailed list of all the species occurring in a specific area. The operational unit that allows the description and the classification of distinct "groups" of species, according to the environmental features shaping their distribution, has been defined as "habitat" by the Contracting Parties to Barcelona Convention (UNEP, 2006).

The classification of Mediterranean benthic marine habitats dates back to the second half of the 19th century, thanks to the pioneer work by Marion (1870) in the Gulf of Marseille, followed some decades later by the work of Vatova (1946) in the Adriatic. Major steps forward were done after the second world war thanks to the impressive and productive effort by the so-called School of Endoume, culminating in the well-known masterpiece "*Nouveau manuel de bionomie benthique de la mer Méditerranée*" (Pérès and Picard, 1964), most of which was subsequently translated in English by Pérès himself (1982) to generalise the proposed approach at a world wide scale. For Pérès and Picard, the basic unit of the bionomic classification, which can be used to describe the zonation of biological assemblages, was the "biocoenosis", defined in the late 19th century by Möbius. The biocoenosis is defined as "a group of living organisms corresponding for composition, number of species and individuals, to some average conditions of the environment; such living organisms are linked by mutual interdependence and, through reproduction, perpetuate the occupancy of a geographical area, called biotope, of variable dimensions, where the dominant conditions are homogeneous". To define biocoenosis, Pérès and Picard adopted the faithfulness criteria, which distinguishes a group of species of fixed composition by one or more characteristic species, these being defined as located exclusively, or almost so, in that unit (Bianchi and Morri, 2001). Pèrès (1982) replaced the term biocoenosis with assemblage.

Roughly in the same period, marine botanists developed a more detailed classification system for vegetated benthic marine habitats based on a phytosociological approach (Molinier, 1960), where assemblage units are distinguished on the basis of pilot species that are abundant, dominant in terms of weight, frequent, neither short-lived nor seasonal, and show homogeneous distribution in the area (Bianchi and Morri, 2001). The most comprehensive synthesis of the botanist approach can be found in Giaccone (1993, 1994a, 1994b). Despite a long tradition of interchange between the followers of the two systems, a true integration has hardly been attempted. A first exercise, finalized to environmental management, was accomplished by Augier (1982) for the Council of Europe and by Bellan-Santini (1994), but both received little attention by benthic ecologists. The classification handbook edited by SPA/RAC (Pergent et al., 2002; UNEP, 2006) has therefore been the first reference truly used to classify Mediterranean benthic marine habitats in modern times. However, the merging of different systems did not resolve completely two major problems:

1) the methodological approach;
2) the scale.

The methodological approach

Both the *Nouveau Manuel* and the phytosociological approach were basically built on the faithfulness criterion. Pérès and Picard use biocoenosis as assemblage units, defined as previously described, but they also draw much from a physiognomic approach, where the assemblage units, and especially the sub-units of facies and associations, are distinguished according to their appearance or physiognomy.

The physiognomic character is defined by the dominance of a single species, or of a complex of similar species, or of a set of species that, even if different, show common characters in their organization (Bianchi and Morri, 2001). The physiognomic approach represents the most instinctive method to differentiate assemblages, as it can be easily adopted during field work (e.g., by dredging) to describe the aspect of the habitat dealt with, and is also suitable for a quick characterization carried out by visual techniques (scuba diving, remotely controlled videos), these latter being among the most adopted methods for mapping, monitoring, and managing marine ecosystems. The phytosociological approach, on the contrary, relied upon a much more rigorous methodology of analysing samples. While rigorous and detailed analytic methods are always welcome for the in-deep study of the different habitats, as for instance the characterization of soft bottom communities which requires direct sampling activities, we do believe that a generalized physiognomic approach should be preferred to distinguish the different habitats for their management and conservation. The work of Ros et al. (1985) was already in this direction. For example, they distinguished algal habitats according to the presence or not of a canopy of Fucales (*Cystoseira* spp. and *Sargassum* spp.). The physiognomic approach has also been adopted by the Italian Society of Marine Biology to define the list of priority habitats occurring in Italy (Relini, 2000; Relini and Giaccone, 2009). This "not destructive" approach should, in our opinion, be pursued especially with the aim to conserve biodiversity, without insisting in more detailed refinements that would, necessarily, require "destructive" and direct samplings.

The problem of scale

The spatial scale is essential in the definition of habitats. Both Pérès and Picard and the phytosociological approaches are hierarchic, in that they recognize various levels of habitat definition. For Pérès and Picard these were mostly *étages*, *sous-étages*, *biocénoses* and *facies*. *Étages* (zones in English) represents the basic element for the bathymetrical zonation of benthos used to define habitats.

For the phytosociologists the levels were classes (named with the suffix *-etea*), orders (suffix *-etalia*), alliances (suffix *-ion*), association (suffix *-etum*), and sub-associations (suffix *-etosum*). Different authors used the phytosociological units to describe hard bottom communities of the Mediterranean (e.g., Molinier, 1960; Boudouresque, 1971; Giaccone, 1973) and Giaccone (1993, 1994a, 1994b) provided an updated and complete list.

For the Mediterranean Sea, the EUNIS and the Barcelona Convention habitat classification systems are also hierarchic. But for all of them the hierarchy is bionomical, not spatial. The problem is that vertically distributed habitats are hardy representable on 2D maps, which are the main tool for marine spatial planning and management (Bianchi et al., 2012). Earliest attempt individuated the scale at which habitats could be mapped (Augier, 1982). The seminal

paper by Meinesz et al. (1983) individuated (mostly on a physiognomic basis) the habitats that could be mapped for management purposes. However, the original Barcelona Convention and EUNIS classifications still include habitats, often of conservation interest, too small to be mapped at the scale normally used for marine costal management (e.g., 1:5000).

A possible solution is the one proposed by Mariani et al. (2014). In this document all selected habitats can be successfully mapped for management purposes. Further detailed sub-divisions within habitats (i.e., facies or associations) may be mentioned but should not be separated to avoid the risk of overlooking them because of the small size. For example, what is presently called the "biocoenosis of the lower midlittoral rock", which is already too narrow to be adequately represented on maps, is generally of little conservation interest but may contain the *Lithophyllum byssoides* association, which is considered of high importance. We therefore suggest envisaging a single and comprehensive main habitat of the lower mediolittoral rock, underlining that it may contain remarkable/important elements (in terms of facies, associations or single indicative species) and that it should be therefore carefully inspected regionally to verify whether they must be selected for the reference lists of conservation interest.

Review of the existing classifications

The European Union Nature Information System (EUNIS) classification (available at http://eunis.eea.europa.eu) has been developed since the mid-1990s by the European Topic Center for Biodiversity (ETC/BD) for the European Agency for the Environment with the collaboration of a number of experts to classify European habitats (both terrestrial and marine) (Davies and Moss, 1998). It has not changed significantly since 2004 (Davies et al., 2004), and it received its last revision in 2016 (Evans et al., 2016), which is still underway. This classification is likely to be the most complete and widespread pan-European system. It is a hierarchical classification and has a homogeneous description of all the main units. Although the EUNIS classification has been largely followed on the Atlantic coasts, it has had little acceptance in the Mediterranean (Templado et al., 2012).

The "Habitats Directive" (92/43/EEC), based on the CORINE classification, represents the most important initiative for the protection of biodiversity in Europe. In this Directive a list of priority habitats have been proposed in its Annex I[1], which require specific interventions of conservation. From the 198 habitats included in Annex I of the Directive, only 9 of them are entirely marine.

The classification of benthic marine habitats for the Mediterranean region adopted by the Contracting Parties to the Barcelona Convention[2] (UNEP, 2006) proposed an alternative classification derived from the classic "*Nouveau Manuel*" by Pérès and Picard (1964), and it can be considered the "official list" of the Mediterranean marine habitats types. It is a hierarchical classification based on zonation system proposed by Pérès and Picard (1964), which combines physical and biological information to define different habitats according to the specific bionomic zones and type of substratum in which they occur. This classification adopts the biocoenosis as the main unit, with associations and facies in the lower hierarchical levels (i.e., sub-habitats). The Barcelona Convention classification includes 11 habitats/sub-

[1]available at https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A31992L0043
[2]available at http://www.rac-spa.org/sites/default/files/doc_fsd/lchm_en.pdf

habitats for the Supralittoral zone, 25 for the Mediolittoral, 74 for the Infralittoral, 42 for the Circalittoral, 9 for the Bathyal and 1 for the Abyssal, for a total of 162 habitats/sub-habitats (including all biocoenosis, associations and facies).

More recently, Fraschetti et al. (2008) proposed a new, smaller and simplified classification scheme to be applied to Italian Marine Protected Areas, but which could be extended to the rest of the Mediterranean. In this scheme, the 162 habitats of the Barcelona Convention classification have been reduced to a new list of 94 habitats.

For Croatia, Bakran-Petricioli (2011) edited a manual that contains a list of 218 habitats requiring special protection; the classification follows the hierarchical scheme, from biocoenosis to associations and facies, and a full description of each habitat is also provided[3].

For Spain, Templado et al. (2012) proposed anew updated list of the marine habitats of the Mediterranean and Atlantic coasts, including the Canary Islands[4]. This classification is based on the term community as a descriptive unit and updated the original work by Capa and Luque (2006). The reference list describes a total of 886 marine habitats and is structured following a hierarchical scheme with different levels. This system reaches a very high degree of detail. The different habitats of this list have been defined, in the first instance, by some of their physical characteristics: first the bathymetric level or depth, according to the traditional scheme of zonation of the marine environment, followed by the type of substrate, hard or sedimentary, and then by other characteristics, such as exposure to hydrodynamism, irradiance or sedimentological characteristics (grain size and composition, in the case of sedimentary bottoms). Secondly, and especially the lower levels, are also defined by the most characteristic or dominant species. To refer to the species that characterize each habitat, they preferred to avoid terms such as “association”, “facies”, or “community” and reported only the name of the species.

Finally, Michez et al. (2014) proposed a new classification of the marine benthic habitats for the French coasts, maintaining the same system of categorization of the scheme by Péres and Picard (1964) and updating the work by Michez et al. (2011). This new classification includes 154 typological units, including biocenosis, associations and facies[5].

Proposal of an updated classification

Based on the above premises, a revised and updated version of the Mediterranean marine habitat classification was urgently needed to allow for the selection and definition of those reference habitat types to be monitored at the national level for their conservation. We thus propose a comprehensive and detailed updated classification of marine habitat types to allow a general description with a not exhaustive list of some specific “associations and facies” that can be found in each of the main habitat types.

[3]available at http://www.haop.hr/sites/default/files/uploads/publications/2018-01/Bakran-Petricioli%20-%20Prirucnik%20za%20morska%20stanista.pdf
[4]available at http://www.mapama.gob.es/es/costas/publicaciones/GUIA_INTERP_HABITATS_WEB_tcm 7-270736.pdf
[5]available at https://inpn.mnhn.fr/actualites/lire/3601/

A first obstacle to establish a classification to be adopted in the Mediterranean is the lack of a common terminology (Costello, 2009). An ambiguity in the definition of "habitat" already exists, which overlaps with that of other terms such as "biotope", "biocoenosis" or "community", often used as synonymous (Dauvin et al., 2008a, b).

According to the Habitats Directive (92/43/EEC), a habitat is defined as the "terrestrial or aquatic area differentiated by its geographical, abiotic and biotic characteristics, in which the species live in any state of its life cycle". The term habitat tends to ignore biota and to consider only the environment where organisms live. In contrast, the concept of biocoenosis refers to the set of organisms that inhabit a certain habitat, term that overlaps with the definition of populations, associations, community or organisms that coexist in a given habitat. To be consistent, we propose to adopt the term "habitat" as operational unit in our revised classification, which is defined as a group or set of organisms found in a specific area according to the environmental features shaping their distribution (UNEP, 2006). The habitat, rather than a bionomic unit, can be also interpreted as a statistical-descriptive unit, useful for descriptive or cartographic purposes (Meinesz et al., 1983).
According to Pèrès and Picard, the proposed main habitat types have been named following a mesological denomination or, anyway, do not contain species names: this has the advantage to be not influenced by taxonomic or nomenclatural revisions of the species. However, the approach we used to define the main habitat types, which follow the physiognomic approach, differentiates habitats on the basis of the different assemblages that dominate each habitat rather than the geomorphologic features that may characterize the environment. In contrast to the national classification adopted in Spain (Templado et al., 2012), some peculiar morphological situations, such as seamounts and canyons, have thus not been included in the list of the main habitats.

A habitat may also be characterised by the quantitative redundancy of one or a few species because of a local predominance of certain factors or intense recruitment episodes without, however, essential changes in total composition. This specific aspect is usually referred to by the term *association* (dominant plant species) or *facies* (dominant animal species).
The revised and updated version of the Mediterranean marine habitat type classification integrates the recently revised classification of the EUNIS system (Evans et al., 2016; Table 1 and Table 2). The EUNIS classification has 7 depth zones of the marine environment (i.e., littoral, infralittoral, circalittoral, offshore circalittoral, upper bathyal, lower bathyal, abyssal), which represent the Level 2 as shown in Table 2. In each depth zone, habitats are defined according to the substrate type (i.e., rock, biogenic habitat, mixed, sand, mud). Each combination of depth zone and substrate type supports a characteristic suite of plant and/or animal communities.

Table 1. Level 2 units of the marine component of the revised EUNIS habitats classification, including proposed level 2 codes (Evans et al., 2016).

			Hard/firm		Soft			
			Rock*	Biogenic habitat**	Coarse	Mixed	Sand	Mud
Depth Zones	Phytal gradient/ hydrodynamic gradient	Littoral	MA1	MA2	MA3	MA4	MA5	MA6
		Infralittoral	MB1	MB2	MB3	MB4	MB5	MB6
		Circalittoral	MC1	MC2	MC3	MC4	MC5	MC6
	Aphytal/ hydodynamic gradient	Offshore circalittoral	MD1	MD2	MD3	MD4	MD5	MD6
		Upper bathyal	ME1	ME2	ME3	ME4	ME5	ME6
		Lower bathyal	MF1	MF2	MF3	MF4	MF5	MF6
		Abyssal	MG1	MG2	MG3	MG4	MG5	MG6

Table 2. Updated EUNIS habitat classification (Evans et al., 2016).

Level 1: Marine habitats (code M)

Level 2: Depth zone

LITTORAL (code A)
INFRALITTORAL (code B)
CIRACLITTORAL (code C)
OFFSHORE CIRCALITTORAL (code D)
UPPER BATHYAL (code E)
LOWER BATHYAL (code F)
ABYSSAL (code G)

Substrate type

ROCK (including soft rock, marls, clays, artificial hard substrata) (code 1)
BIOGENIC HABITAT (code 2)
COARSE (code 3)
MIXED (code 4)
SAND (code 5)
MUD (code 6)

Level 3: Regions: Atlantic, Baltic, Black Sea, Artic and Mediterranean (the latter corresponding to the code 5).

The revised and updated version of the Mediterranean marine habitat types classification contains 35 main "habitats" divided among the 7 depth zones and the 6 substrate types (corresponding to the level 1, 2, and 3 of the EUNIS classification). For example, in the habitat MA1.5 Littoral rock, M is the code for the level 1, A1 is the code for the level 2, and 5 is the code for the level 3. Each habitat may also contain sub-levels (level 4, indicated by numbers) that are habitat types defined according to either the environmental features, such as exposure to hydrodynamism, irradiance, sedimentological/morphological characteristics, etc., or to the main biological assemblages dominating the habitat (e.g., algal-dominated, invertebrate-dominated, bioconstructors): e.g., MA1.51 Supralittoral rock. Specific environmental and/or morphological situations occurring within the level 4 have further been labelled with lower letters (a, b, c, etc.): e.g., MA1.51a Supralittoral euryhaline and eurythermal pools. A total of 123 main habitat types have been proposed up to the level 4. Finally, the level 5 represents associations and facies and is always labelled with numbers: e.g., MA1.515 Facies with Chthamalidae. The level 5 can be further modified and/or improved according to specific geographical situations or future increase in the state of knowledge.

Hydrodynamism is the movements of water due to waves and currents. With regard to this factor, the coasts can be more or less exposed, giving rise to different types of habitats, the so-called “smooth or calm modes” according to the nomenclature of the French school. In this list, these names have been changed in “sheltered” and “exposed”. Light intensity is another fundamental factor that influences the vertical zonation of biological assemblages, and we differentiated “well illuminated” from “moderately illuminated (i.e., shaded)” habitats. According to the degree of sedimentation, habitats affected by high levels of sedimentation can be further distinguished. Other specific habitats and environmental situations hosting particular assemblages, such as caves, overhangs, pools, lagoons, meadows, reefs, wracks or banks, etc., have also been included in the list.

Habitats representing enclaves (i.e., the local existence, for microclimatic reasons, of a biocoenosis within an area occupied by another biocoenosis, *sensu* Peres, 1961), in shallower zones have also been indicated.

Some specific geomorphologic/hydrologic features, which are thus not defined from a biotic point of view, were not considered in the main list of habitats because their presence is independent from the depth zone and the substrate type, such as hydrothermal vents, cold seeps (methane and sulfide), freshwater resurgences, seamounts, and canyons. They have been added at the end of the list and coded by capital letters, which could be eventually used to add detail in the code of the already existing habitats that can be found in those specific situations.

With respect to the original version of the Mediterranean marine habitat classification (UNEP, 2006), which defined a total of 162 habitats (including biocoenosis, associations and facies), in this updated and revised version of marine habitats the total number of the main habitats (i.e., up to the level 4) is 123, but the total number of habitat types also including the level 5 (i.e., including the provided not exhaustive examples of association and facies) is much more higher. In the updated list some new habitat types have been included thanks to the increase in the state of knowledge gained in recent years. This is especially true for the circalittoral,

bathyal, and abyssal zones, where the introduction of remotely operated vehicles allowed the visual inspection of these deep-water zones.

It is often difficult to represent the details in habitat description on cartographies, even when data are processed on GIS databases, especially when wide areas and coastlines are to be mapped. For instance, habitat digital mapping and 2D representation becomes a particularly complex challenge to carry out on steep slopes shores and on vertically stratified habitats (Mariani et al., 2015). All the main 123 habitat types considered in the list are easily identifiable with the physiognomic approach (through direct underwater observations by scuba diving or remote images) and their mapping and monitoring is feasible, at least up to the level 3 of the EUNIS classification and to the level 4 of the here presented classification. These habitats would be what we could call "management or management units". However, we cannot describe and understand the habitats without referring to the assemblages or species that structure and compose them. The further sub-level of the association and facies (level 5), included in the original Barcelona list of the marine habitats (UNEP, 2006) and in most of the following national classifications (e.g., Bakran-Petricioli, 2011;Templado et al., 2012; Michez et al., 2014) has been reviewed and simplified with some examples of the possible facies/associations that can be found in each habitat type. The list at the level 5 is limited to those facies/associations most widely distributed in each specific habitat type, but it must be viewed as a not exhaustive list because it most often constitutes strictly local and punctual information. This list has thus only an indicative value and it should be updated and improved according to any geographical area and to specific local environmental situations. For instance, facies/associations characterised by alien species should be proposed and then used only in those specific invaded areas. The species that can be listed should also preferably be those that determine the physiognomic aspect and function of each habitat where they can be found, and they should be easily identifiable, at least at the genera level. In addition, many sub-levels of the habitat types in the previous existing classifications were originally based on various components of algae, which are seasonal (like those of the *Cystoseira* genus that characterizes many habitats of the Infralittoral zone), so their inclusion in the definition of the habitats of which they belong discriminates the information on the dynamics of benthic populations. We thus propose to avoid reaching the species taxonomic detail for macroalgae in the list of habitat types, but referring to main associations using a higher taxonomic level, such as the order (e.g., association with Fucales, Laminariales).

Conclusions

Producing an integrated and updated classification of the Mediterranean marine habitats types is urgently needed for the management and the conservation of our Sea and of its biodiversity. It also follows requirements for the implementation of the EcAp for the characterization of the marine environment, with the aim to reach the good environmental status by 2020 and the adopted Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and related Assessment Criteria (IMAP)[6]. The updated and revised classification of the Mediterranean marine habitat types here proposed has been developed following these main criteria:

[6] https://wedocs.unep.org/bitstream/handle/20.500.11822/17012/imap_2017_eng.pdf?sequence=5&isAllowed=y

1) The operational unit used to recognize and describe distinct “groups” of species, according to the environmental features shaping their distribution, has been defined as habitat.
2) The “not destructive” physiognomic approach should be preferred, whenever it is possible, to distinguish the different habitats for their management and conservation, without insisting in more detailed refinements that would, necessarily, require destructive and direct samplings.
3) The revised and updated version of the Mediterranean marine habitats classification here proposed integrates the level 1 (marine environment), 2 (combination of depth zone and substrate type), and 3 (biogeographical region) of the recently revised classification of the EUNIS system.
4) All the 123 main habitat types (up to level 4) are named following a mesological denomination and do not contain species names but are defined according to environmental features. The main habitats in the list may also contain the sub-level 5, i.e. associations and facies.
5) All the existing national classifications included sub-habitats (i.e., associations or facies) too small to be mapped at the scale normally used for marine costal management. The updated and comprehensive main list with the 123 major habitat types can be, on the contrary, fruitfully mapped up to the level 4.
6) Detailed sub-divisions within habitats (i.e., associations or facies, below the level 4) may be mentioned but could be often difficultly mapped. During mapping should be, however, underlined when, a specific main habitat, may contain remarkable/important elements that should be carefully inspected regionally to verify whether they must be selected for the reference lists of conservation interest.
7) The not exhaustive list of associations and facies provided at the level 5 is only indicative and should be continuously updated and improved according to the geographical area and the local situations, as well as increase in the state of knowledge.
8) New habitat types have been included in this revised and updated list, thanks to the increased knowledge gained in recent years. This is particularly true for the circalittoral, bathyal, and abyssal zones.

The document here proposed, the updated list of the main habitat types with the not exhaustive list of associations and facies, will thus represent the base for the selection of those reference marine habitats of the Mediterranean. These reference habitats will be used for the selection of sites to be included in the national inventories of natural Sites of Conservation Interest in the Mediterranean, which will be included in the future monitoring and conservation interventions.

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