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Agenda Item 7: Status of implementation of the Ecosystem Approach (EcAp) Roadmap

7.1. Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and nonindigenous species) in the framework of the EcAp Roadmap

Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

UNEP/MAP
SPA/RAC - Tunis, 2021

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1. Introduction

1. The 19th Meeting of the Contracting Parties to the Barcelona Convention (COP 19) agreed on the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria which set, in its Decision IG.22/7, a specific list of 27 common indicators (CIs) and Good Environmental Status (GES) targets and principles of an integrated Mediterranean Monitoring and Assessment Programme.

2. The UNEP/MAP published the first assessment in the publication '2017 Mediterranean Quality Status Report (2017 MED QSR)'. This included information on the status of the marine and coastal environment in relation to GES and addressed most of the Ecological Objectives (EO) and their agreed IMAP CIs.

3. The exercise resulted in recognizing (in IG.23/6, COP 20, Albania 2017) several challenges that are still to be addressed on the path to the 2023 MED QSR:

(i) harmonization and standardization of IMAP monitoring and assessment methods;
(ii) improvement of availability and ensuring of long time-series, quality-assured data to monitor the trends in the status of the marine environment;
(iii) improvement in the availability of the synchronized datasets for the state of the marine environment assessment, including the use of data stored in other databases where some of the Mediterranean countries regularly contribute; and
(iv) improvement of data accessibility with the view to improving knowledge on the Mediterranean marine environment and ensuring that the Info-MAP System is operational and continuously upgraded. This is important to accommodate data submissions for all the IMAP CIs.

4. To operationalize the implementation of the above-mentioned Decision (IG.23/6), UNEP/MAP prepared a roadmap for the next MED QSR report in 2023 which aims to deliver the following main outputs:

- Integrated assessment of GES through the analysis of inter-actions between sectors, activities, pressures, as well as the defining of mapping process for IMAP CIs;
- Scales of monitoring assessment and reporting for all IMAP CIs clustered per Ecological Objectives proposed (2021-2022), and as per assessment criteria/ thresholds/ baseline values proposed/ updated for IMAP CIs (2020-2021);
- Full implementation of national IMAPs throughout the Mediterranean supported through country capacity building and technical assistance delivered in the form of training workshops in areas of common capacity needs and knowledge gaps (2019-2021); and
- Application of monitoring protocols, data quality assurance and quality control through IMAP data and information policy and the operational IMAP Info System for reporting data;

5. During the initial phase of the IMAP implementation (2016-2019), the Contracting Parties have made serious efforts towards the design of their respective national monitoring programmes on biodiversity (EO1) and non-indigenous species (EO2) and addressing to the extent possible all IMAP clusters.

6. The present report describes the activities made by the Specially Protected Areas Regional Activity Centre (SPA/RAC) in assisting the Contracting Parties to the Barcelona Convention, during the second phase of IMAP, in aligning the current monitoring activities, developed under the Protocol on Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol) and the Strategic Action Programme for the Conservation of Biological Diversity in the Mediterranean Region (SAP BIO) with the new requirements of the IMAP including, in particular, the above-outlined outputs highlighted in the MED QSR Decision related to biodiversity (EO1) and non-indigenous species (EO2).

7. The appendixes in the present document were discussed, as appropriate, with the informal Online Working Group and the COMON for approval.

2. Overview of the national activities on IMAP implementation related to biodiversity and non-indigenous species

8. Work is ongoing by all the Contracting Parties to the Barcelona Convention to progress on national implementation of IMAP, with the support of SPA/RAC, and building on the existing relevant monitoring programmes previously established under the SPA/BD Protocol, and on lessons learnt from other regional and/or global processes.

9. These activities are developed within the SPA/RAC Programme of Work (2020-2021) and with the support of the following two projects:

- Project “Towards achieving the Good Environmental Status of the Mediterranean Sea and coast through an ecologically representative and efficiently managed and monitored network of Marine Protected Areas” (hereafter referred to as IMAP-MPA project), funded by European Union (EU) – the Directorate-General for Neighbourhood and Enlargement Negotiations (DG NEAR) and the Green MED III: ENI South regional environment and water programme 2018-2022 financial instrument; and

- Project “Support to Efficient Implementation of the Ecosystem Approach-based Integrated Monitoring and Assessment of the Mediterranean Sea and Coasts and to delivery of data-based 2023 Quality Status Report in synergy with the EU MSFD (hereafter referred to as EcAp-MED III)”, funded by the European Union (EU) – Directorate-General for Environment (DG ENV).

10. These projects aim to address challenges related to the second phase of the IMAP (2019-2021), with a particular focus on the integration aspect of national IMAP implementation. Indeed, priorities is given to (i) the enhancement of the level of capacity in each country to facilitate the implementation of the system and the report of reliable data for the IMAP CIs (ii) the support to the implementation of a harmonized monitoring and assessment of IMAP CIs of the three clusters; and (iii) the contribution to the preparation and the delivery of the 2023 MED QSR, in line with the agreed roadmap milestones at national, sub-regional and regional levels.

11. SPA/RAC followed-up on the existing country specific capacity assessments to further the lessons learnt during the implementation of the EU funded EcAp-MED II Project (2015-2018). This includes reference to all comments, recommendations, and requests made by the Contracting Parties related to their capacity needs. All these information was recorded systematically during the trainings organized in the previous SPA/RAC Programme of Work of 2017-2018 and in the UNEP/MAP Ecosystem Approach (EcAp) relevant meetings (i.e., CORMONs, EcAp Coordination Group).

12. The Southern Mediterranean countries are supported to implement monitoring programmes in selected sites (marine Protected Areas (MPAs) and high-pressure areas). They are supported to apply common and harmonized monitoring methodologies. Best practices and lessons learnt are shared across countries at sub-regional and regional levels and respective countries capacities enhanced.

13. Several bilateral coordination meetings with national Focal Points and stakeholders, as appropriate, have been organized by videoconference: Algeria (2 March 2021), Libya (28 October 2020), Morocco (25 February 2021), and Tunisia (7 October 2020). These meetings were dedicated to support the establishment of the National IMAP Committee, the synchronization of the activities of the various stakeholders in the implementation of IMAP and the identification of their specific needs.

14. In Egypt and Lebanon, the organization of the national meetings and the official designation of the institutional members of the national IMAP committees are still ongoing and are expected to be organized during the last quarter of 2021. Follow-up correspondences and bilateral meetings are frequently organized to support as much as possible the timely implementation of the IMAP process.

15. Finally, based on requests from countries, trainings to reinforce national capacities concerning the implementation of biodiversity/non-indigenous species monitoring protocols will be developed during the summer of 2021, in close collaboration with the concerned national authorities and international partners. These actions will specifically include dedicated trainings, country missions, ‘Train the trainers’, exchange of specific best-practices (possible South-South, but also North-South cooperation), and assistance in applying the monitoring protocols/policy developments in line with the national IMAPs and specific country requirements.

16. Further specific trainings on data reporting are expected to be organized in summer 2022, in a new and innovative way, aiming at strengthening national capacities to report data into the UNEP/MAP platforms towards the 2023 MED QSR. Each Contracting Party will use its own quality assured data recorded during the implementation of the national IMAP.

3. Overview of the regional activities on IMAP implementation related to biodiversity and non-indigenous species

17. The informal Online Working Groups to the CORMONs, as well as the EcAp Coordination Group Meetings, have been established by UNEP/MAP specifically to coordinate and provide guidance for the implementation of IMAP at all levels including on cross cutting issues. The outcomes and recommendations of these meetings are crucial for the success of IMAP implementation and the delivery of the 2023 MED QSR. These instances are with a fundamental support to reach proposed EcAp/IMAP objectives and priorities.

18. In line with the IMAP timeline, SPA/RAC co-organized the integrated Meetings of the Ecosystem Approach Correspondence Groups on IMAP Implementation (CORMONs) (Videoconference, 1-3 December 2020) and organized the Meeting of the Ecosystem Approach Correspondence Groups on Monitoring (CORMON), Biodiversity and Fisheries (Videoconference, 10-11 June 2021) to discuss monitoring and assessment elements on common indicators related to biodiversity (EO1) and non-indigenous species (EO2) (UNEP/MAP WG502/inf.12 and UNEP/MAP WG.502/inf.13).

19. Following the recommendations of the Integrated CORMON meetings (December 2020), the informal thematic Online Working Groups (OWGs) were established to provide important scientific feedback and technical support to the IMAP implementation at regional/sub-regional level, in particular on the aspects related to development of methodologies, assessment, scales, integration, protocols and guidelines in line with the approved 2020-2021 Programme of Work.

20. These OWGs were operational for the following EOs/CIs: EO1 CI 3,4 and 5 related to marine turtles (29 March 2021); marine mammals (7 April 2021); and sea birds (16 April 2021) and EO2 CI6 related to non-indigenous species (20 April 2021). OWG on habitats (EO1 CI 1 and 2) is already established and meetings are scheduled during the third quarter of 2021.

21. Cross cutting issues, integration modalities between the IMAP clusters at national level are ongoing. Regional experts/consultants have been onboard to work and elaborate the scales of monitoring and assessment, assessment criteria and threshold and baseline values for marine mammals and sea turtles (IMAP EO1, CIs 3-4-5) since September 2020. During the first quarter of 2021, additional experts were recruited for sea birds (IMAP EO1, CIs 3-4-5), habitats (IMAP EO1, CIs 1-2) and non-indigenous species (IMAP EO1, CI6).

22. Decision IG.23/6 on the 2017 MED QSR (COP 20, Tirana, Albania, 17-20 December 2017) recommended, as general directions towards a successful 2023 MED QSR, the harmonization and standardization of monitoring and assessment methods of the agreed common indicators.

23. The monitoring protocols on habitats, species and non-indigenous species were previously endorsed by the 14th meeting of the SPA/BD thematic Focal points (Portoroz, Slovenia, 18-21 June 2019) and the 7th Meeting of the Ecosystem Approach Coordination Group (Athens, Greece, 9 September 2019). Minor adjustment needs of monitoring parameters on benthic habitats, i.e. marine vegetation and coralligenous and other calcareous bioconstructions, were highlighted. Consequently, the Meeting requested the Secretariat to bring them to the attention of respective CORMONs in 2020 and 2021.

24. SPA/RAC updated the monitoring protocols on benthic Habitats, which provide detailed methodologies and protocols for monitoring benthic habitats, that can be helpful to national managers and decision makers (e.g., environmental authority representatives, researchers, Marine Protected Area (MPA)'s management unit(s)) for implementing a monitoring programme on CI 1 and CI 2, on yearly basis, in at least two monitoring areas, one in a low pressure area (e.g. Marine Protected Area/Specially Protected Area of Mediterranean Importance (SPAMI)), or in sites of high conservation relevance (e.g., Natura 2000 sites), and one in a high pressure area due to human activity (see Appendix A).

25. The first drafts of the deliverables on scales of monitoring and assessment, assessment criteria and threshold and baseline values on marine mammals, sea turtles and non-indigenous species have been prepared and were reviewed and discussed by the informal OWGs and the CORMON (see Appendixes B, C and E).

26. Guidance factsheet on non-indigenous species (IMAP EO2, CI6) were revised considering the "Study on trends and outlook of marine pollution from ships and activities and of maritime traffic and offshore activities in the Mediterranean". The revision process also has been based on the conclusions of the 2017 MED QSR, and other documents of ongoing processes (in particular on multi-scale approach for monitoring and assessment and the definition of "significant acute pollution" events under the Bonn Agreement) provided by the Regional Marine Pollution Emergency Response Centre for the

Mediterranean Sea (REMPEC). The revised Guidance Factsheet of CI6 were reviewed by the OWG and the CORMONs (see Appendix D).

27. The elaboration of baseline for non-indigenous species at national, sub-regional and regional levels is ongoing considering the results of similar work made in the framework of the Marine Strategy Framework Directive (MSFD). The National non-indigenous species' inventories were already received from the Contracting Parties and are being reviewed and validated in close collaboration with the national experts designated by the Contracting Parties (see Appendix F).

28. In May 2017, the European Commission endorsed the Decision on GES of marine waters, which contains a number of criteria and methodological standards for determining GES, in relation to the 11 descriptors of GES laid down in Annex I of the MSFD - Commission Decision (EU) 2017/848. This Decision also contains specifications and standardized methods for monitoring and assessing marine waters. SPA/RAC developed a comparative analysis of the methodology applied for the development of the 2017 MED QSR and the corresponding elements of the revised GES Decision 2017/848/EU to identify concrete steps towards enhancing synergies between IMAP and MSFD (UNEP/MED WG.502/inf.10).

29. The Regional Meeting on IMAP Implementation: Best Practices, Gaps and Common Challenges (IMAP Best Practices Meeting, Rome, Italy, 10-12 July 2018) requested the Secretariat to more in-depth discussion on the better interlinkages between activities/pressure/impacts and clarification of definition of impacts noting that such a definition should primarily focus on biodiversity.

30. SPA/RAC reviewed the suitable tools to show the environmental status of the biodiversity EOs across the Mediterranean Sea and Coasts, and pressures/impacts/state interactions and discussed it during the CORMONs (UNEP/MED WG502/inf.11).

The appendixes in the present document were discussed, as appropriate, with the informal Online Working Group and were submitted to the COMON meeting (10-11 June 2021) for consideration, discussion and agreement on their submission to this Meeting, and as appropriate to the EcAp Coordination Group and the MAP Focal Points meetings.

Revised version of these appendixes taking into consideration the comments highlighted during the CORMON meeting will be available before the present Meeting.

Appendixes

Appendix A Rev.1:	Update of Monitoring Protocols on Benthic Habitats
Appendix B:	Monitoring and Assessment Scales, Assessment Criteria, Thresholds and Baseline Values for the IMAP Common Indicators 3, 4 and 5 related to Marine Mammals
Appendix C Rev.1:	Monitoring and Assessment Scales, Assessment Criteria, Thresholds and Baseline Values for the IMAP Common Indicators 3, 4 and 5 related to Marine Turtles
Appendix D:	Revised Guidance Fact Sheets for the IMAP Common Indicator 6 related to Non-Indigenous Species
Appendix E:	Monitoring and Assessment Scales, Assessment Criteria and Thresholds Values for the IMAP Common Indicator 6 related to Non-Indigenous Species
Appendix F:	Progress in the Development of the Baseline Values for the IMAP Common Indicator 6 related to Non-Indigenous Species

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UNITED NATIONS ENVIRONMENT PROGRAMME MEDITERRANEAN ACTION PLAN

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Fifteenth Meeting of SPA/BD Focal Points

Videoconference, 23-25 June 2021

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Appendix A Rev.1 Update of Monitoring Protocols on Benthic Habitats

UNEP/MAP
SPA/RAC-Tunis, 2021

1. Guidelines for monitoring marine vegetation in the Mediterranean

Introduction

1. Seagrass meadows are widely recognized as key habitats in tropical and temperate shallow coastal waters of the world (UNEP-MAP-Blue Plan, 2009). They form some of the most productive ecosystems on earth (McRoy and McMillan, 1977), shaping coastal seascapes and providing essential ecological and economic services (Green and Short, 2003; Vassallo et al., 2013). They support high biodiverse associated communities, primary production and nutrient cycling, sediment stabilization and protection of the littoral, and globally significant ~~sequestration of carbon~~carbon sequestration (Waycott et al., 2009 and references therein). A ~~major~~significant economic value of over 17 000 $ per ha and ~~per~~ annum has been quantified for seagrass meadows worldwide (Costanza et al., 1997).

2. Seagrass, like all ~~Magnoliophyta~~Magnoliophytes, are marine flowering plants of terrestrial origin ~~which~~ that returned to the marine environment approx. 120 to 100 million ~~of~~ years. The global species diversity of seagrass is low ~~when~~ compared to any other marine Phylum or Division, with less than sixty species throughout the world. However, they form extensive meadows that extend for thousands of ~~kilometres~~ kilometers of coastline between the surface~~s~~ down to about 50 m depth (according to water transparency) in ~~very clear~~apparent marine ~~waters~~ and ~~or~~ transitional waters (e.g., estuaries and lagoons). In the Mediterranean region five seagrass species occur: *Cymodocea nodosa*, *Halophila stipulacea* (an invasive Lessepsian species), *Posidonia oceanica*, *Zostera marina*, and *Zostera noltei*. The endemic *Posidonia oceanica* is doubtless the dominant and the most important seagrass species (Green and Short, 2003), and the only one able to build a ‘‘matte’’, a monumental construction resulting from horizontal and vertical growth of rhizomes with entangled roots and entrapped sediment (Boudouresque et al., 2006).

3. Physical damages and stressful conditions resulting from intense human pressures, environmental alterations, climate warming, and reduction of water and sediment quality are causing structural degradation of seagrass meadows worldwide (Orth et al., 2006). Biological impact caused by the spread of non-indigenous species (NIS) on seagrass beds must also be considered (Montefalcone et al., 2007). An alarming ~~and accelerating~~ decline of seagrass meadows ~~has been~~was reported in the Mediterranean Sea and mainly in the north-western side of the basin, where many meadows have ~~already~~ been lost during the last decades (Boudouresque et al., 2009; Waycott et al., 2009; Pergent et al., 2012; Marbà et al., 2014; Burgos et al., 2017). However, a deceleration in the rate of loss and some signs of local recovery have also been observed, ~~which are~~ indicative of a recent trend reversal in seagrass extent and density, thanks to ~~effective~~adequate management actions (de los Santos et al., 2019).

4. Concerns about these declines have prompted efforts to protect ~~legally these habitats~~these habitats legally in several countries. Control and reduction of the full suite of anthropogenic impacts via legislation and enforcement at local and regional scales have been carried out in many countries. *Posidonia oceanica* meadows are defined as priority natural habitats on Annex I of the EC Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (EEC, 1992), which lists those natural habitat types whose conservation requires the designation of special areas of conservation (SACs), identified as s~~S~~ites of c~~C~~ommunity i~~I~~nterest (SCIs). Also, the establishment of marine protected areas (MPAs) locally enforces the level of protection on these priority habitats.

5. Due to their wide distribution~~, their sedentary habit~~ and their susceptibility to changing environmental conditions, seagrass are habitually used as biological indicators of water quality in accordance with the Water Framework Directive (WFD, 2000/60/EC) and of environmental quality in accordance with the Marine Strategy Framework Directive (MSFD, 2008/56/EC) (Montefalcone, 2009). Due to its recognized ecological importance, *Posidonia oceanica* is considered as the main biological quality element in monitoring programs developed to evaluate the status of marine coastal

environment. Standardized monitoring protocols for evaluating and classifying the conservation status of seagrass meadows already exist, which are summarised in the “Guidelines for standardisation of mapping and monitoring methods of marine Magnoliophyta in the Mediterranean” (UNEP/MAP-RAC/SPA, 2015). These monitoring guidelines have been the base for the updating and harmonization process undertaken in this document.

6. Detailed spatial information on habitat distribution is ~~a~~ prerequisite knowledge for ~~a~~ the sustainable use of marine coastal areas. The f~~F~~irst step in the prior assessment of the status of any benthic habitat is thus the definition of its geographical distribution and bathymetrical ranges. Seagrass distribution maps are a fundamental prerequisite to any conservation action on these habitats. The available information on the exact geographical distribution of seagrass meadows is still fragmentary on a regional level (UNEP/MAP-RAC/SPA, 2015). F~~and a f~~ew ~~extent~~extents of the coastline ha~~s~~ve been mapped, as only 5 States out of the 21 have a mapped inventory covering at least half of their coasts (UNEP/MAP-Blue Plan, 2009). Within the framework of the Action Plan for the Conservation of Marine Vegetation in the Mediterranean, adopted in 1999 by the Contracting Parties to the Barcelona Convention (UNEP/MAP-RAC/SPA, 1999) and during the implementation evaluation of this Action Plan in 2005 (UNEP/MAP-RAC/SPA, 2005), emerged that very few countries were able to set up adequate and standardized monitoring and mapping programs. As a ~~consequence, and~~consequence and following an explicit request by managers on the need ~~of~~ for practical guides aimed at harmonizing existing methods for seagrass monitoring and ~~for~~ subsequent comparison of results obtained by different countries, the Contracting Parties asked the Regional Activity Centre for Specially Protected Areas (RAC/SPA) to improve the existing inventory tools and to propose ~~a~~ standardization of the mapping and monitoring techniques for these habitats. Thus, the “Guidelines for standardisation of mapping and monitoring methods of marine Magnoliophyta in the Mediterranean” (UNEP/MAP-RAC/SPA, 2015) have been produced, as the result of ~~a number of~~several scientific round tables addressed explicitly ~~specifically addressed~~ on this topic.

7. For mapping seagrass habitats, the previous Guidelines (UNEP/MAP-RAC/SPA, 2015) highlighted the following main findings:

- Several national and international mapping programs have already been carried out;
- ~~A~~ S~~s~~tandardization and a clear consensus in the mapping methodology have been reached;
- All the methods proposed are usable in all the Mediterranean regions, but some of them are more suitable for a given species (e.g., large-sized species) or particular assemblages (e.g., dense meadows);
- Implementation of procedures could be difficult in some regions due to the absence of training, competence and/or specific financing.

8. For monitoring the condition of seagrass habitats, the previous Guidelines (UNEP/MAP-RAC/SPA, 2015) highlighted the following main findings:

- Several national and international monitoring programs have been successfully implemented in the Mediterranean (e.g., SeagrassNet, Posidonia national monitoring networks);
- Notwithstanding that most of the Mediterranean monitoring systems are mainly dedicated to *Posidonia oceanica*, there are some programs (e.g., SeagrassNet) that can be used for almost all seagrass species;
- Although the existing monitoring methods are similar, the descriptors used to provide information on the state of the system are quite diverse and cover a vast array of ecological complexity levels (i.e., from the plant to the seascape);
- Some descriptors are used by all the Mediterranean scientific communities (e.g., seagrass shoot density, lower limit depth), but the measuring techniques are often very different, and still require a larger effort to reach precise standardization;
- The different monitoring methods available in the Mediterranean countries seem all feasible when appropriate training is undertaken.

9. Based on recommendations from the previous CPs group meeting, SPA/RAC has been requested to develop an updated version of the "Guidelines for monitoring marine vegetation in Mediterranean" (UNEP/MAP-RAC/SPA, 2015), in the context of the IMAP common indicators and ~~in order to~~to ease the task of the MPA managers when implementing their monitoring programs. A reviewing process on the scientific literature, ~~taking into account~~considering the latest techniques and the recent ~~works carried out~~findings by the scientific community at the international level, has been carried out.

Monitoring methods

a) COMMON INDICATOR 1: Habitat distributional range and extent

Approach

10. The CI1 is aimed at providing information about the geographical area in which seagrass meadows occur in the Mediterranean and the total extent of surfaces covered by meadows. The approach proposed for mapping seagrass meadows in the Mediterranean follow the overall procedure established for mapping marine habitats in ~~the~~ north-west Europe within the framework of the European projects MESH (Mapping European Seabed Habitats; MESH, 2007) and EUSeaMap (Vasquez et al., 2021a, b)~~project, ended in 2008~~. The mapping procedure includes different actions (Fig. 1), that can be synthesised into three main steps:

1) Initial planning
2) Ground surveys
3) Processing and data interpretation

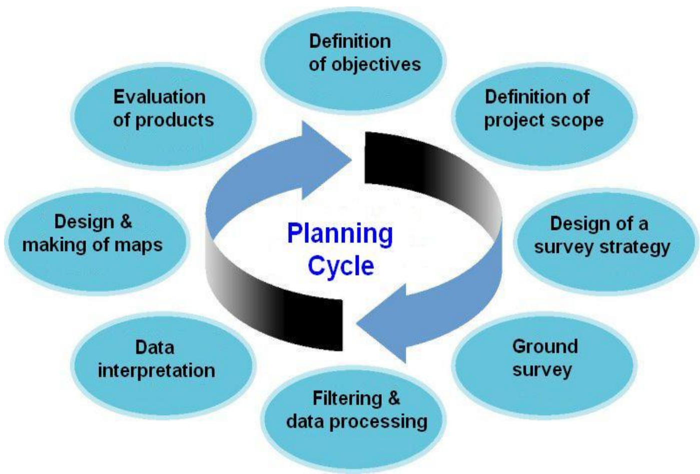

Figure 1: Planning cycle for a habitats' mapping programme (according to the MESH project~~, 2008~~).

11. Initial planning includes ~~the definition~~defining ~~of~~ the objectives ~~in order to~~to select the minimum surface to be mapped and the necessary resolution. During this initial phase, tools to be used in the following phases must be defined and the effort (human, material, and financial costs) necessary to produce the mapping evaluated. A successful mapping approach requires the definition of a clear and feasible survey strategy.

12. Ground survey is the practical phase for data collection. It is often the costliest phase as it generally requires field activities. A prior inventory of the existing data for the area being mapped is recommended, to reduce the amount of work or to have ~~a~~ better targeting of the work to be done.

13. Processing and data interpretation are doubtlessly the most complex phase, as it requires knowledge and experience, so that the data gathered can be usable and reliable. The products obtained must be evaluated to ensure their coherence and the validity of the results obtained.

Resolution

14. Selecting an appropriate scale is a critical stage in the planning phase (Mc Kenzie et al., 2001). Even though there is no technical impossibility in using a high precision over large surface areas (or inversely), there is generally an inverse relationship between the precision accuracy used and the surface area to be mapped (Mc Kenzie et al., 2001; Fig. 2).

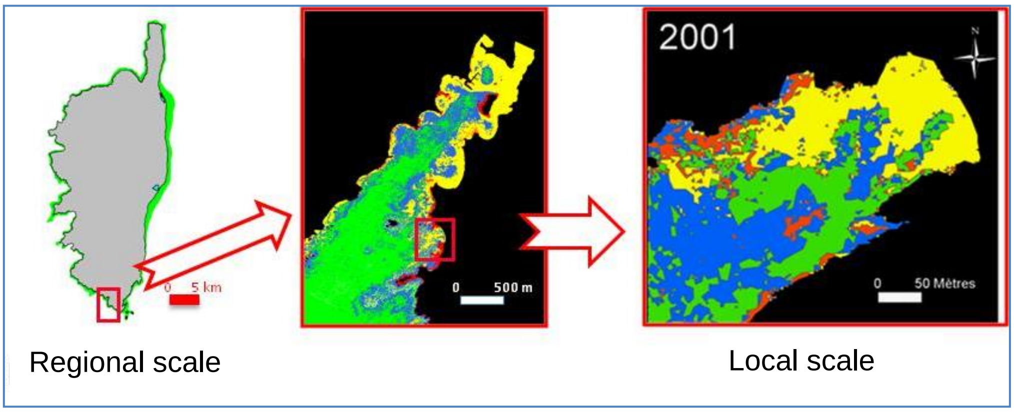

Figure 2: Resolution of a map from regional study to local study (from UNEP/MAP-RAC/SPA, 2015).

15. When large surface areas have to be mapped and global investigations carried out, an average precision and a lower detail level can be accepted, which means that the habitat distribution and the definition of its extension limits are often only indicative. Measures of the total habitat extent may be subjected to high variability., as Tthe final value is influenced by the methods used to obtain maps and by the resolution during both data acquisition and final cartographic restitution. This type of approach is used for national or sub-regional studies and the minimum mapped surface area is 25 m² (Pergent et al., 1995a). Recently, some global maps showing the distribution of *Posidonia oceanica* meadows in the Mediterranean have been produced (Giakoumi et al., 2013; Telesca et al., 2015) (Fig. 3). These maps, however, are still incomplete being the available information highly heterogeneous due to the high variability in the mapping and monitoring efforts across the Mediterranean basin. This is especially true for the southern and the eastern coasts of the Mediterranean, where data are scarce, often patchy and can be difficultly found in literature. In data-poor regions, availability of high-quality mapping information on benthic habitat distribution is practically inexistent, due to limited resources. However, these low-resolution global maps can be very useful for an overall knowledge of the bottom areas covered by the plant, and to evaluate where surveys must be enforced in the future to collect missing data. Also, those maps are important to highlight specific areas subjected to a declining trend, where monitoring and management actions must be implemented to reverse the observed trend and to ensure proper conservation.

16. On the contrary, when smaller areas have to be mapped, a much higher precision and resolution level is required and is easily achievable thanks to the high-resolution mapping techniques available to date. However, obtaining detailed maps is time consuming and costly, thus practically impossible when time or resources are limited (Giakoumi et al., 2013). The minimum surface area can be lower or equal to 1 m^2 in local scale studies (Pergent et al., 1995a). These detailed maps provide an accurate localisation of the habitat distribution and a precise definition of its extension limits and total habitat extent, all features necessary for future control and monitoring purposes over a defined period of time. These high-resolution scales are also used to select remarkable great sites where monitoring actions must be concentrated. As highlighted by the MESH EU projects (2008),

most of the environment management and marine spatial planning activities require a range of habitat maps between these two extremes.

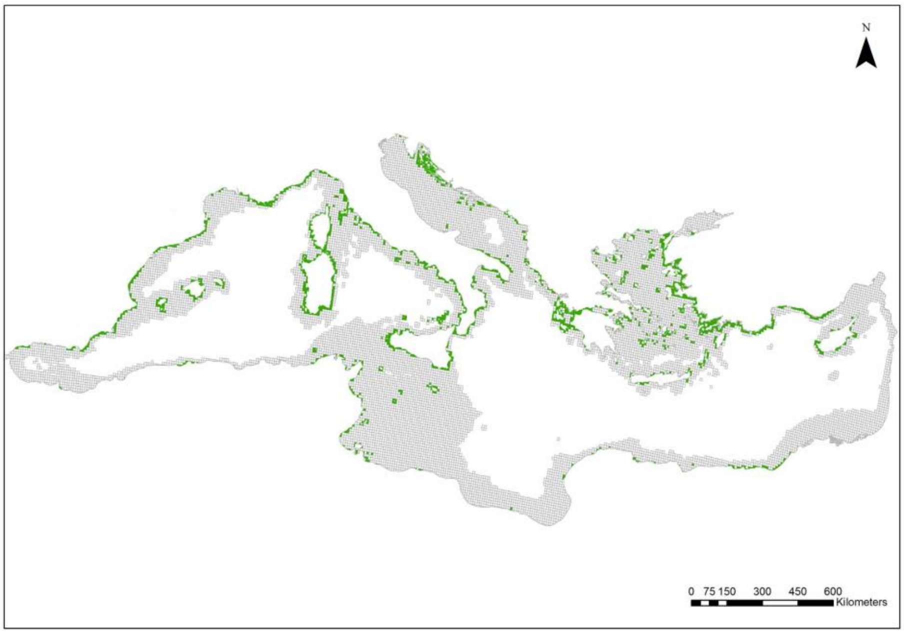

Figure 3: Distribution of *Posidonia oceanica* meadows in the Mediterranean Sea (green areas) (from Giakoumi et al., 2013).

Methods

17. Maps of seagrass distribution and extent can be obtained by using indirect instrumental mapping techniques and/or direct field visual surveys (Tab. 1). In the last 50 years the technology in benthic habitat mapping has increased a lot, and several instrumental mapping techniques have been successfully applied to seagrass meadows (see synthesis in Pergent et al., 1995a; McKenzie et al., 2001; Dekker et al., 2006; Hossain et al., 2015; Rende et al., 2020; Rowan and Kalacska, 2021). To map shallow meadows (from 0 to about 10-15 m depth, depending on water transparency and weather conditions), it is possible to use optical sensors (e.g., satellite telemetry, multi or hyper spectral imaging, aerial photography, unmanneduncrewed aerial vehicles). For meadows in deeper waters (down to 10-15 m depth), the acoustic techniques (e.g., side scan sonar, multi-beam echosounder) are recommended. Sampling methods involving blind grabs, dredges and box corers or direct field visual surveys by scuba diving observations (using transects or permanent square frames), Remotely Operated Vehicles (ROVs), and underwater video recordings allow to ground-truthing the remote sensing data, and provide very high-resolution maps of meadows over small spatial scales (Montefalcone et al., 2006). All these techniques are, however, time consuming, expensive, and provide only sporadic information. The simultaneous use of two or more methods makes it possible to optimize the results being the information obtained complementary. Four parameters can be mapped from remote sensing data: presence/absence, percentage cover, species, and biomass. The selection of the most relevant parameter in the scientific literature depended on the area mapped, the availability of ground truth data, and the specific target of each study (Topouzelis et al., 2018).

18. The use of remote sensing allows characterising extensive coastal areas for assessment of to assess the spatial patterns of seagrass meadows. It, and simultaneously can be used to reveal temporal patterns due to the high frequency of the observation. Remote sensing covers a variety of technologies from satellite telemetry, aerial photography, and unmanned aerial vehicles (UAVs), and vessel acousticacoustic vessel systems. The power of remote sensing techniques has been highlighted by Mumby et al. (2004), who highlighted showed that 20 s of airborne acquisition time would equal

6 six days of field surveys. However, all indirect mapping techniques are intrinsically affected by uncertainties due to manual or authomatic automatic supervised classification of spectral or acoustic signatures of seagrass meadows on the images and sonograms, respectively. Errors in images or sonograms interpretation may arise when two habitat types are not easily distinguished by the observer (e.g., shallow seagrass meadows or dense patch of canopy-forming macroalgae). Interpretation Understanding of remote sensing data requires extensive field calibration and the ground-truthing process remains essential (Pergent et al., 2017). As the interpretation of images/sonograms is also time-requiring, several image processing techniques were proposed in order toto rapidly automate the interpretation of images and sonograms and make this interpretation more reliable (Montefalcone et al., 2013 and references therein; Rowan and Kalacska, 2021). These methods allow a good discrimination between soft sediments and seagrass meadows, between continuous and patchy seagrass, between a dense seagrass meadow and one exhibiting only limited bottom cover. The hHuman eye, however, always remains the final judge.

19. Satellite telemetry is a valuable tool providing high-resolution regional- to global-scale observations and repeat time-series sampling a cost-effective way to easily acquiring large-scale and high-resolution on seagrass distribution information in shallow waters. However, satellite imagery has some disadvantages, such as theirits reliance on weather conditions, high cost per scene, the revisit period, and the scale of many ecological processes (Ventura et al., 2018). Landsat images have been used successfully for regional mapping of seagrass distribution in many Mediterranean countries. The wide vast area coverage of satellite imaging might reveal large-scale patterns; however, mapping seagrass meadows from space on a large scale cannot provide the same levels of accuracy and detail of a direct field visual survey. Thanks to emerging technologies, such as long-range transmitters, increasingly miniaturized components for positioning, and enhanced imaging sensors, the collection of images by unmanned aerial vehicles (UAVs), also known as "drones", coupled with the structure-from-motion (SfM) photogrammetry, offers a rapid and inexpensive tool to produce high-resolution orthomosaic (Ventura et al., 2018). Coupling a high-resolution digital camera with side scan sonar for acquiring underwater videos in a continuous way has recently proved to be a non-destructive and cost-effective method for ground-truthing satellite images in seagrass habitats mapping (Pergent et al., 2017).

19.20. Airborne LIDAR bathymetry (ALB) or airborne light (lazer) detection and ranging (LIDAR) is a remote sensing technique for the bathymetry with an airborne scanning pulsed laser beam (Guenther, 1985). The technique is well suited to nearshore mapping because it provides the three-dimensional data needed to create an accurate digital terrain model (DTM) with 15-cm vertical accuracy (Irish et al., 2000). The LIDAR technology can measure depths up to three times Secchi depths, corresponding to about 60 m in very clear water (Guenther et al., 2000).

20.21. Once the surveying is completed, data collected needs to be organised so that it canto be used in the future by everyone and can be appropriately archived and easily consulted. The rResulting dataset can be integrated with similar data from other sources, providing a clear definition of all metadata (MESH project, 2007).

21.22. Despite the increasing number of studies on seagrass mapping with remote sensing instruments, datasets are not often available in on digital the geographic information system (GIS) platforms. As a final remark, only recently some modelling modeling approaches have been developed to obtain estimationestimate of the potential distribution of seagrass meadows in the Mediterranean. The probability of presence of the a seagrass species in a given area has been modelled using: i) a binomial generalised linear model as a function of the bathymetry and water transparency, dissolved organic matter, sea surface temperature and salinity, mainly obtained from satellite data (Zucchetta et al., 2016); ii) morphodynamics features, i.e.i.e., wave, climate and seafloor morphology, to predict the seaward and landward boundaries of *Posidonia oceanica* meadows (Vacchi et al., 2012, 2014).

Table 1: Synthesis of the main survey tools used for defining the Common Indicator 1_Habitat distributional range and extent for seagrass meadows. When available, the depth range, the surface area mapped, the spatial resolution, the efficiency (expressed as area mapped in km^2 per hour), and the main advantages or andthe limits of each tool are indicated, with some bibliographical references.

Survey tool	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Satellite images	From 0 to 10-15 m	From few km² to large areas (over 100 400 km²)	From 0.5 m	Over 100 km²/hour	• A global and large-scale coverage of virtually all coastal areas • Availability of free digital images, usable without authorization, from the web (e.g., Google Earth) • High geometric resolution	• Limited to shallow waters characterization • Good weather conditions required (no clouds and no wind) • Possible errors in image interpretation among distinct habitats • Possible errors in image interpretation due to bathymetric variations • Not adequate for medium to small coastal dynamics	Kenny et al. (2003)
Multispectral and/or hyperspectral images	From 0 to 25 m, with an optimum up to 15 m	From 50 km² to 5000 km²	From 1 m		• High resolution that allowsing distinguishing seagrass species • Possibility to collect data even during bad weather conditions	• Complex acquisition and processing procedures requiring the presence of specialists • Necessary to validate the observations with field data • Difficulty in habitat identification in the case of very patchy populations	Mumby and Edwards (2002); Mumby et al. (2004); Dekker et al. (2006); Gagnon et al. (2008)

Survey tool	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Aerial images	From 0 to 10-15 m	Adapted to small areas (10 km²), but it can be used for areas over 100 km²	From 0.3 m	Over 10 km²/hour	• Very high resolution • Manual, direct and easy interpretation of the images • Availability of libraries with chronological series of images (often free) • Good identification of boundaries between populations • Fine-scale ecological studies	• Same limits as for satellite images • Difficulty in geometrical corrections and strong deformations if verticality is not respected or if image covers a small area (low altitude view) • Difficulty in obtaining authorizations for imaging in some countries • Expensive data aquisition	Frederiksen et al. (2004); Kenny et al. (2003); Diaz et al. (2004)
Drone images (UAVs)	From 0 to 10-15 m	Small areas (10 km²)	From 0.1 m	Less than 1km²/hour	• Very high resolution • Manual, direct, and easy interpretation of the images • Availability of automated approaches for data classification • Good identification of boundaries between populations • Low-cost	• Limited to shallow waters characterization • Require permissions to fly over specific areas • Optical refractive distortion effects created by the water surface	Ventura et al. (2017, 2018); Rende et al. (2020)
Side scan sonar	Below 8 m	From large to medium areas (50-100 km²)	From 0.1 m	0.8 to 3.5 km²/hour	• Very high resolution • Realistic representation of the seafloor • Good identification of boundaries between populations • Good identification between meadows of different density	• Small patches (smaller than 1 m²) or low-density meadows cannot be distinguished • Loss of definition at image edge, requiring adjustments between adjacent profiles • Possible errors in image interpretation due to large signal amplitude variations (levels of grey)	Paillard et al. (1993); Kenny et al. (2003); Clabaut et al. (2006)

					• Quick execution		
Survey tool	**Depth range**	**Surface area**	**Resolution**	**Efficiency**	**Advantages**	**Limits**	**References**
Single-beam acoustic sonar	Below 10 m		From 0.5 m	1.5km²/hour	• Good geo-referencing • Quick execution	• Low discrimination between habitats • Lower reliability compared to satellite techniques	Kenny et al. (2003); Riegl and Purkis (2005)
Multi-beam acoustic sonar	Below 2-8 m	From large (50-100 km²) to small areas (a few hundred square meters)	From 50 cm	0.2 km²/hour	• Possibility to obtain 3D image of a meadow • Data on biomass per surface area unit can be obtained • Huge amount of data collected	• Efficient computer systems for processing and archiving data are needed • Possible errors in image interpretation	Kenny et al. (2003); Komatsu et al. (2003)
Transect or permanent square frames (quadrates)	Depths easily accessible by scuba diving (0-40 m, according to local rules on scientific diving)	Small areas, usually between 25 m^2 to 100 m² for permanent square	From 0.1 m	0.01 km²/hour	• Very high resolution and detail in the information collected • Possibility to identify small structures (patches) and to localize population boundaries • Ground-truthing of the remote sensing data	• Many working hours • Small areas mapped • Necessity of numerous observers to cover larger areas	Pergent et al. (1995a); Montefalcone et al. (2006)

					• Possibility to do simultaneous monitoring		
Video camera (ROV or towed camera)	Whole bathymetric range of seagrass distribution	Small areas, usually under 1 km²	From 0.1 m	0.2 km²/hour	• Very high resolution • Easy to use • Possibility to record seafloor images for later interpretation	• Long time to gain and process data • Positioning errors due to gap between the vessel position and the camera when towed	Kenny et al. (2003); Diaz et al. (2004)

Survey tool	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Laser-telemetry	Depths easily accessible by scuba diving (0-40 m, according to local rules on scientific diving)	Small areas, under 1 km²	Some centimetres	0.01 km²/hour	• Very accurate localization of population boundaries or remarkable structures • Possibility to do simultaneous monitoring	• Range limited to 100 m in relation to the base, and thus no possibility to work over large areas • Necessity of markers on the seafloor for positioning the base when monitoring over time is requested • Possible acoustic signal perturbation due to large variations in temperature or salinity • Specific training on the equipment is requested	Descamp et al. (2005)

GIB (GPS intelligent buoy)	Depths easily accessible by scuba diving (0-40 m, according to local rules on scientific diving)	Small areas, under 1 km²	Some centimetres		• Same characteristics as for laser-telemetry, but with a greater range (1.5 km)	• Quite difficult technique • Need of many related equipments, and of a team of divers	Descamp et al. (2005)

1) Optical data

22.23. Satellite images are gained from satellites in orbit around the earth. Data is obtained continuously and today it is possible to buy data (sometimes subscribe for free) data that can reach a very high resolution (Tab. 2). It is also possible to ask for a specific programming of the satellite (programmed to pass over an identified sector with specific particular requirements), but this will require much higher costs.

23.24. The rough data must undergo a prior geometrical correction to compensate for errors due to the methods the images are obtained (e.g., errors of parallax, inclination of the satellite) before it can be used. Images already geo-referenced should can also be obtained even if their cost is much higher than the rough data. The use of satellite images for mapping seagrass meadows requires knowledge of satellite image analysis software (e.g., ENVI, ErdasGeomatica), mastery in the use of the water column correction algorithm (Lyzenga, 1978), and mastery with pixel-based remote sensing supervised image classifiers, for example, the OBIA systems (Object-Based Image Analysis). classification algorithm.

Table 2: Types of satellites and resolution of the sensors used for mapping seagrass meadows. n.a. = data not available.

Satellite	Resolution	References
LandSat 8	30 m	Dattola et al. (2018)
Sentinel 2A - 2B	10 m	Traganos and Reinartz (2018)
PLANETSPOT 5	3 m2.5 m	Traganos et al. (2017) Pasqualini et al. (2005)
SPOT 5	2.5 m	Pasqualini et al. (2005)
IKONOS (HR)	1.0 m	Fornes et al. (2006)
QuickBird	0.7 m	Lyons et al. (2007)
Geoeyes	0.5 m	Amran (2017)

24.25. In view of Given the changes of in the light spectrum depending on the depth, satellite telemetry can be used for mapping shallow meadows (see Tab. 1). In clear waters the maximum depths reached can be:

- With the blue channel up to approx. 20-25 m depth
- With the green channel up to 15-20 m
- With the red channel up to 5-7 m
- Channel close to the infra-red approx. from tens of centimetres up to 20 m.

25.26. Although the spatial resolution of satellite imagery has significantly improved in the last decade, the data collected is still not sufficient for medium to small coastal dynamics. In particular, resolutionThe rResolution of the LandSat--8 satellite is not adequate to have reach high resolution mappings of seagrass meadows. However, the image LandSat--8 OLI represents a valid useful tool to estimate the presence/absence of broad seagrass meadows; moreover, LandSat has a historical series of images useful to perform a multitemporal study. For these reasons, it has been suggested to consider the Sentinel-2A and 2B satellites of the Copernicus programme. The Sentinel-2A and 2B satellites have a 13-band multispectral sensor (between visible and near infrared), the spatial resolution varies between 10, 20 and 60 m and the satellite revisiting time in the same area is 5 days (whilest is 18 days for LandSat). Specifically, for mapping *Posidonia oceanica* meadows, various application tests demonstrated the good applicability of the Sentinel--2 image, at 10 m resolution, for an effective evaluation of the meadows' extent (Dattola et al., 2018; Traganos and Reinartz, 2018). The use of Sentinel--2A and 2B images, at the Mediterranean scale, can allow measuring the extent of the *P. oceanica* meadows habitat and verify any possible variations over time. The Sentinel-2A and 2B images are also useful for the analysis of pressure and impact drivers.

26.27.

27. Multispectral or hyperspectral imaging is based on images collected simultaneously and composed of numerous close and contiguous spectral bands (generally 100 or more). There is a wide variety of airborne sensors (e.g., CASI1[1], Deaedalus Airborne Thematic Mapper; Godet et al., 2009), which provide data in real time, and also during unfavourable lighting conditions (Tab. 1). It is possible to create libraries with specific spectral responses to measure values compared to distinct component species and appraise the vegetation cover (Ciraolo et al., 2006; Dekker et al., 2006). It is possible to create libraries with specific spectral responses, so that measured values can be compared to distinct component species and appraise the vegetation cover (Ciraolo et al., 2006; Dekker et al., 2006).

28. Aerial images obtained through various means (e.g., airplanes, drones, ULM) may have different technical characteristics (e.g., shooting altitude, verticality, optical quality). Even though it is more expensive, shooting films from a plane, that is equipped with an altitude and verticality control system and using large size negatives (24 × 24), allows for high quality results (i.e., increase in the geometrical resolution). For example, on a photo at the scale 1/25000 the surface area covered is 5.7 km × 5.7 km (Denis et al., 2003). In view ofGiven the progress made in the last few decades in terms of shooting (e.g., the quality of the film, filters, lens) and in the following processing (e.g., digitalization, geo-referencing), aerial photographs represents today one of the most preferred surveying methods for mapping shallow seagrass meadows (Mc Kenzie et al., 2001). Imagery acquired by unmanned aerial vehicles (UAVs), usually referred to as "drones", coupled with structure-from-motion photogrammetry, has recently been extensively tested and validated for the mapping of the upper limits of seagrass meadows, as they offer a rapid and cost-effective tool to produce very high-resolution orthomosaics and maps of coatal habitats (Ventura et al., 2018).

29. Recent applications of very fine resolution Unmanned Aerial Vehicles (UAVs), usually referred to as "drones", have showned effectiveness for mapping and for detecting changes in small patches and seascape features of seagrass meadows, at the scale and resolution that would not be possible with satellite or aerial photography (James et al., 2020). The application of UAVs for mapping and monitoring of seagrass habitats is limited by the optical characteristic of the water (e.g., turbidity) and environmental conditions (e.g., solar elevation angle, cloud cover, wind speed) during image acquisition (Rende et al., 2020 and references therein), and is therefore limited to shallow waters characterization. Imagery acquired by unmanned aerial vehicles (UAVs), usually referred to as "drones", coupled with structure-from-motion (SfM) photogrammetry, has recently been extensively tested and validated for the mapping of the upper limits of seagrass meadows, as they offer a rapid and cost-effective tool to produce very high-resolution orthomosaics and maps of coatalcoastal habitats (Ventura et al., 2018).

28. Only recently the importance to integrate different methodological techniques (i.e., multispectral satellite, drone, multibeam echosounder, underwater towed video camera, autonomous surface vehicle) in a multi-scale approach for mapping seagrass meadows has been highlighted, as it allows for the acquisition of data with very high resolution and accuracy (Rende et al., 2020). An immediate advantage is related to the collection of large-scale remote sense data (with optic and acoustic methods), combined with images from underwater photogrammetry cameras for ground-truth, which ensures very high accuracy in both shallow and deep waters. At present, an integrated approach is the best option for seagrass mapping, as it offers a greater modularity in function of the spatial scales and allows optimizing costs, always maintaining the primary objective of high-resolution seafloor and habitat mapping, from the coastline to deeper water.

[1]CASI: Compact Airborne Spectrographic Imager

2) Acoustic data

~~29.~~30. Sonar provides images of the seafloor through the emission and reception of ultrasounds. Among the main acoustic mapping techniques, Kenny et al. (2003) ~~distinguishs~~distinguishes: (1) wide acoustic beam systems like the ~~S~~Sside ~~s~~Scan ~~s~~Sonar (SSS), (2) single~~-~~-beam ~~sounders~~echosounder (3), multiple narrow beam bathymetric system~~s~~, and (4) multi-beam ~~sounders~~echosounder.

~~30.~~31. Side ~~scan~~ Scan ~~sonar~~ Sonar (SSS) tow-fish (transducer), with its fixed recorder, emits acoustic signals. The obtained images, or sonograms, visualize the distribution and the boundaries of the different entities over a surface area of 100 to 200 m along the pathway (Clabaut et al., 2006; Tab. 1). The resolution of the final map partly depends on the means of positioning used by the vessel (e.g., radio localisation or satellite positioning). The existence of a sonogram atlas (Clabaut et al., 2006) could ~~be helpful in interpreting~~help interpreting the data and ~~to differentiatein~~ differentiating among habitats or substrate typologies. Although this method has strong limitations in shallow waters (Tab. 1), a side scan sonar array able to efficiently map seagrass beds residing in 1 m or less of water has been recently developed (Greene et al., 2018).

~~31.~~32. Single-beam ~~sounder~~echosounder is based on the simultaneous emission of two frequencies separated by several octaves (38 kHz and 200 kHz) to obtain the seafloor characterisation and the bathymetric profile. The sounder's acoustic response is different depending on whether the sound wave is reflected by an area covered or not covered by vegetation.

~~32.~~33. Multi~~-~~-beam ~~sounder~~echosounder may precisely and rapidly provide: (i) topographical images of the seafloor (bathymetry), (ii) sonar images representing the local reflectivity of the seafloor as a consequence of its nature (backscatter). The instrument simultaneously measures the depth in several directions, determined by the system's receiver beams. These beams ~~form a beam~~are perpendicular to the axis of the ship. The seafloor can thus be explored over a wide band (5 to 7 times the depth) with a high degree of resolution. A high-resolution 3D structure of the seafloor is also obtained (the digital elevation model, DEM), where meadows can be visualized and the biomass can be evaluated (Komatsu et al., 2003). Other derived products can be slope, aspect, curvature, and terrain ruggedness maps. Multi-beam echosounders surveys are also limited in very shallow waters, and especially at depths lower than 5 m where vessel navigation might be difficult and dangerous and the swath coverage is very limited (generally, it is 3-4 times the depth of the seabed; Rende et al., 2020).

3) Samplings and visual surveys

~~33.~~34. Field samples and direct underwater observations provide discrete punctual data (sampling of distinct points regularly spread out in a study area). They are vital for ground-truthing the instrumental surveys, and for the validation of continuous information (i.e., having a complete coverage of surface areas) obtained through interpolation methods from data collected on limited portions of the study area or along the pathway. Field surveys must be sufficiently numerous and distributed appropriately to obtain the necessary precision, ~~and~~ also in view of the heterogeneity of the habitats. In the case of meadows of *Cymodocea nodosa*, *Posidonia oceanica*, *Zostera marina* or *Zostera noltei*, destructive sampling (using dredger buckets, core samplers, trawls, dredgers) are forbidden ~~in view~~given ~~of~~ the protected character of these species (UNEP/MAP, 2009) and direct underwater samples (e.g., shoot samples) should be limited as much as possible.

~~34.~~ Observations from the surface can ~~also~~ be made by observers on a vessel using, for instance, a bathyscope, or underwater by using ~~imagery~~ visual techniques such as photography and video recording. Video-photography plays a valuable role in seagrass research, as a non-destructive technique and especially in fine and meso-scale studies. Photographic equipment and ~~cameras~~video cameras can also be mounted on a ~~vertical~~ platform structure (sleigh) or within the remotely operated vehicle (ROV). The camera on ~~a~~ the ~~vertical structure~~platform is submerged at the back of the vessel and is towed by the vessel that advances very slowly (under 1 knot), allowing for the collection of long video transects; on the contrary ~~whilst~~ the ROVs have their ~~own~~ propulsion system and are remotely controlled from the surface and allow recording comparatively shorter video transects. Recent development in underwater photogrammetry and 2D photo mosaicing (i.e., merging several images of the same scene into a single and larger composite image photo mosaic by aligning and stitching photographs together) provided an ultrafine scaling methodology for micro-chartography and for monitoring activities in the short term to assess current regression/progression of individual meadows, such as using permanent squares or for monitoring the meadow boundaries (Rende et al., 2015). To acquire overlapping pictures, ensuring about 75% of shared coverage between two consecutive photos, the vessel needs to maintain a speed of about 1 knot/h.

35. The use of towed video cameras (or ROVs) during surveys makes it possible to see the images on the screen in real time, to identify specific features of the habitat and to evaluate any changes in the habitat or any other characteristic element of the seafloor. ~~, and~~ T~~t~~his preliminary video survey may ~~be also~~also be useful to locate sampling stations. Recorded images are then reviewed to obtain a cartographical restitution on a GIS platform for each of the areas surveyed. To facilitate and ~~to~~ improve the results obtained with the camera, joint acquisition modules integrating the depth~~,~~ and images of the seafloor ~~and~~ with geographical positioning have been developed (UNEP/MAP-RAC/SPA, 2015).

36. *In situ* direct underwater observations by scuba diving represent the most reliable, although time-consuming, surveying technique. Surveys can be done along lines (transects), or over small surface areas (permanent square frames, i.e., quadrates) positioned on the seafloor and located to follow the ~~limits of the habitat~~habitat limits. The transect consists of a marked line wrapped on a rib and laid on the bottom from fixed points and in a precise direction, typically perpendicular or parallel ~~with respect~~ to the coastline (Bianchi et al., 2004). Any changes in the habitat and in the substrate typology, within a belt at both sides of the line (considering a surface area of about 1-2 m per side), are recorded on underwater slates (Fig. 4). The information registered allows precise and detailed mapping of the sector studied (Tab. 1).

37. Marking the limits of a meadow also allows obtaining a distribution map. Laser-telemetry is a ~~useful~~ valuable technique for highly precise mapping surveying over small surface areas (Descamp et al., 2005). The GIB system (GPS Intelligent Buoys) consists of 4 surface buoys equipped with differential GPS receivers and submerged hydrophones. Each of the hydrophones receives the acoustic impulses emitted periodically by a synchronized pinger installed on-board the underwater platform and recordeds their ~~times of arrival~~arrival times. Knowing the moment of emission of these signals and the sound propagation speed in the water, the distances between the pinger and the 4 buoys is directly calculated. The buoys communicate via radio with a central station (typically on-board a support vessel) where the position of the underwater target is computed and displayed. The depth is also indicated by the pressure sensor (Alcocer et al., 2006). To optimize meadows mapping operations, the pinger can ~~be also~~also be fixed on a submarine scooter driven by a diver. The maximum distance of the pinger in relationship to the ~~centre~~ center of the polygon formed by the 4 buoys can be approx. 1500 m (UNEP/MAP-RAC/SPA, 2015).

38. Free-diving monitoring with a differential GPS can also be envisaged to locate the upper limits of the meadows. The diver precisely follows ~~precisely~~ the contours of the limits and the ~~D~~GPS continuously records the diver's geographical ~~data~~position. The mapping data is integrated on a GIS platform using the route followed. The acquisition speed is 2-3 km/hour, the sensor precision can be sub metric (UNEP/MAP-RAC/SPA, 2015).*In situ* direct underwater observations by scuba diving along a depth transect perpendicular ~~on~~ to the coastline (© Monica Montefalcone).

Data interpretation

39. The recent ~~MESH~~ EU projects ~~(2008)~~ on habitat mapping (MESH, 2007; Vasquez et al., 2021a, b) identified four ~~important~~ essential stages ~~for the production of~~to produce a habitat map:

- Processing, analysis and classification of the biological data, through a process of interpretation of acoustic and optical images, when available;

- Selecting the most appropriate physical layers (e.g., substrate, bathymetry, hydrodynamics);
- Integration of biological data and physical layers, and use of statistical model~~l~~ing to predict seagrass distribution and interpolate information;
- The map produced must then be evaluated for its accuracy, i.e., its capacity to represent reality, and ~~therefore~~ its reliability.

40. During the processing, analysis and classification stage, pixels in the image (obtained from both optical and acoustic methods) are given a thematic label as belonging to groups that have either been defined by the user or generated by algorithm models to automate the classification process (Rowan and Kalacska, 2021). Object-Based Image Analysis (OBIA) differs from traditional pixel-based classification methods (maximum likelihood classifiers) because these latter techniques group similar, neighbo~~u~~ring pixels into distinct image objects within designated parameters. A typical OBIA workflow involves firstly image segmentation (sequence of processes that are executed in a defined order including segmentation parameters that create meaningful objects made up of multiple neighbouring pixels sharing similar spectral values) and secondly classification of the segmented data through a multiresolution segmentation algorithm that generates objects with similar information by using only the most important features identified (Rende et al., 2020). OBIA methodology allows classifying also underwater cover classes in a rapid, accurate and cost-effective way, and represents to date an effective tool to obtain robust thematic maps of benthic communities. An automatic classification approach can also be applied ~~on~~to underwater photogrammetry (Marre et al., 2020). Images must be georeferenced and before performing the 3D processing, an image enhancement technique should be performed to minimize the effect of the water column on the underwater images. After the image enhancement step, a Structure-from-Motion (SfM) 3D reconstruction is performed using any commercial software available (Rende et al., 2020). Finally, a Multiview Stereo (MVS) algorithm can be used to produce a dense 3D point cloud from the refined intrinsic orientation and ground-referenced camera exterior orientation.

To label and classify benthic habitats on resulting maps, a standardised classification system must be used to ensure the uniformity and the readability of maps.

~~40.~~41. ~~During the processing analysis and classification stage, t~~The two recently updated lists of benthic marine habitat types should be consulted, which are: 1) the European Nature Information System (EUNIS) proposed for the European seas (available at https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification; Evans et al., 2016); and 2) the Barcelona Convention classification of marine benthic habitat types adopted for the Mediterranean region~~[1]~~ by the Contracting Parties ~~should be consulted~~ (available at https://www.rac-spa.org/sites/default/files/doc_fsd/habitats_list_en.pdf; SPA/RAC-UN Environment/MAP, 2019a, b; Montefalcone et al., 2021~~UNEP/MAP-SPA/RAC, 2019~~) ~~to recognize any specific habitat type (i.e., seagrass species)~~. As seagrass assemblages are often ~~small in size~~small, they can only be identified with high (metric) precision mapping. The updated lists identif~~y~~~~ies~~ the specific "seagrass meadow" habitats that are also listed in the annex of the Habitats Directive (Directive 92/43/EEC), and which must be taken into consideration within the framework of the NATURA 2000 programs. ~~A complete~~ The first original description of ~~these~~ habitat types for the Mediterranean has been revised in 2015 (UNEP/MAP-RAC/SPA, 2015b), but a newly updated interpretation manual of all the updated reference habitat types for the Mediterranean region is under elaboration, which also provides ~~s and~~ the criteria for their identification ~~are available in Bellan-Santini et al. (2002)~~. Habitats dominated by seagrass species ~~that must be represented on maps~~ listed in the updated Barcelona

~~[1]The updated list of benthic marine habitat types for the Mediterranean region is in a draft stage. It was endorsed by the 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 (Roma, Italy 22-23 January 2019). The draft updated list will be examined by the 14th Meeting of SPA/BD FocalPoints (Portoroz, Slovenia, 18-21 June 2019) andsubmitted to the MAP Focal Points meeting and to the 21st Ordinary Meeting of the Contracting Parties, for adoption.~~

Convention classification system are the following (SPA/RAC-UN Environment/MAP, 2019a, bUNEP/MAP-SPA/RAC, 2019):

LITTORAL

MA3.5 Littoral coarse sediment

MA3.52 Medidolittoral coarse sediment

MA3.521 Association with indigenous marine angiosperms

MA3.522 Association with *Halophila stipulacea*

MA4.5 Littoral mixed sediment

MA4.52 Medidolittoral mixed sediment

MA4.521 Association with indigenous marine angiosperms

MA4.522 Association with *Halophila stipulacea*

MA5.5 Littoral sand

MA5.52 Meidiolittoral sands

MA5.521 Association with indigenous marine angiosperms

MA5.522 Association with *Halophila stipulacea*

MA6.5 Littoral mud

MA6.52 Medidiolittoral mud

MA6.52a Habitats of transitional waters (e.g. estuaries and lagoons)

MA6.521a Association with halophytes (*Salicornia* spp.) or marine angiosperms (e.g. *Zostera noltei*)

INFRALITTORAL

MB1.5 Infralittoral rock

MB1.54 Habitats of transitional waters (e.g. estuaries and lagoons)

MB1.541 Association with marine angiosperms or other halophytesa

MB2.5 Infralittoral biogenic habitat

MB2.54 *Posidonia oceanica* meadows

MB2.541 *Posidonia oceanica* meadow on rock

MB2.542 *Posidonia oceanica* meadow on matte

MB2.543 *Posidonia oceanica* meadow on sand, coarse or mixed sediment

MB2.544 Dead matte of *Posidonia oceanica*

MB2.545 Natural monuments/Ecomorphoses of *Posidonia oceanica* (fringing reef, barrier reef, stripped meadow, atollls)

MB2.546 Association of *Posidonia oceanica* with *Cymodocea nodosa* or *Caulerpa* spp.

MB2.547 Association of *Cymodocea nodosa* or *Caulerpa* spp. with dead matte of *Posidonia oceanica*

MB5.5 Infralittoral sand

MB5.52 Well sorted fine sand

MB5.521 Association with indigenous marine angiosperms

MB5.522 Association with *Halophila stipulacea*

MB5.53 Fine sand in sheltered waters

MB5.531 Association with indigenous marine angiosperms

MB5.532 Association with *Halophila stipulacea*

MB5.54 Habitats of transitional waters (~~e.g.~~ estuaries and lagoons)

MB5.541 Association with marine angiosperms or other halophytes~~a~~

MB6.5 Infralittoral mud sediment

MB6.51 Habitats of transitional waters (~~e.g.~~ estuaries and lagoons)

MB6.511 Association with marine angiosperms or other ~~halophyta~~halophytes

42. The selection of physical layers to be shown on maps and to be used for following predictive statistical analyses may be an interesting approach within the general framework of mapping seagrass habitats, and it would reduce the processing time, but it is still of little use for the Mediterranean meadows as only few of the classical physical parameters (e.g., substrate type, depth, salinity) are able to clearly predict the distribution of species (Fig. 5).

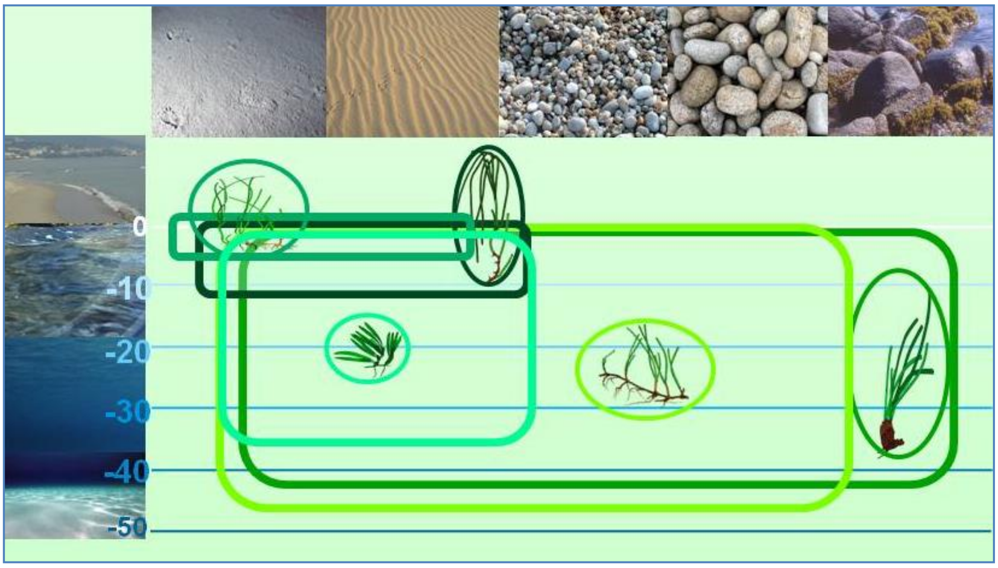

Figure 5: Distribution of seagrass species depending on the nature of the substrate and the depth in the Mediterranean (from UNEP/MAP-RAC/SPA, 2015a).

~~41.~~ The data integration and model~~l~~ing stage will differ depending on the survey tools and acquisition strategy used. Due to its acquisition rapidity, aerial techniques usually allow ~~to~~ for a complete coverage ~~completely~~ of the littoral and shallow infralittoral zones and this ~~greatly~~ dramatically reduces interpolation of data. On the contrary, surveys from vessels are often limited because of time and costs involved, and only rarely allow ~~to~~ obtaining a complete coverage of the area. Coverage under 100% automatically means that it is impossible to obtain get high resolution maps and therefore interpolation procedures have to must be used, so that from partial surveys a lower resolution map can be obtained (MESH project, 20078; Fig. 6). Spatial interpolation is a geostatistical procedure for estimating data values at unsampled sites between actual data collection locations. Elaborating the final meadow distribution map on a GIS platform allows using different spatial interpolation tools and algorithms (e.g., Inverse Distance Weighted, Kriging) provided by the software. Even though this is rarely mentioned, it is important to provide information on the number and the percentage of data acquired on the field and the percentage of interpolations. run.

42.43. An "overlapping" survey strategy combining a partial coverage of a large surface area and a more detailed coverage of smaller zones of particular interest could be an interesting compromise. Sometimes it might be enough to have a precise and detailed map only of the extension boundaries limits (upper and lower limits) of the meadow., and Tthe presence description between these two limits could be reduced to occasional field investigations leaving the interpolation to play its part (Pasqualini et al., 1998).

43.44. The processing and digital analysis of data (optical or acoustic) on GIS allows to creating charts where each tonality of grey is associated to with a specific texture representing a type of population/habitat, also on the basis ofbased on *in situ* observations and sampling for ground-truthing. A final map is thus created, where it is possible to identify the bare substrate, hard substrates and seagrass meadows. Specific processing (e.g., analysis of the roughness, filtering, and thresholding) makes additional information accessible, such as the seagrass cover or the presence of anthropogenic signs (Pasqualini et al., 1999).

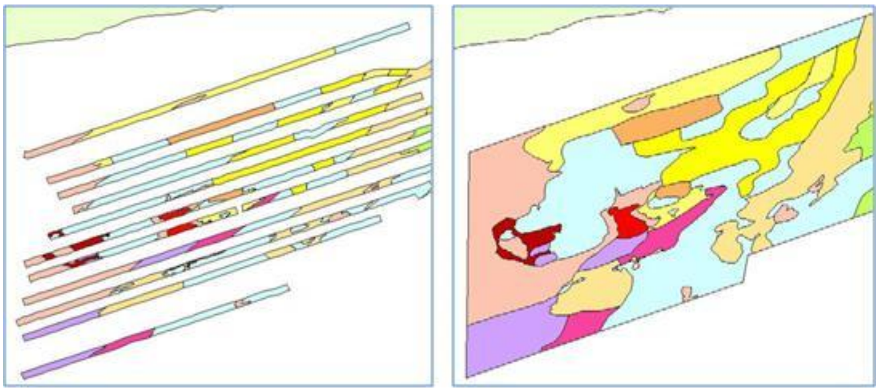

Figure 6: Example of partial coverage survey (left) and the output of the final map produced through interpolation (right). The area surveyed is about 20 km wide (from UNEP/MAP-RAC/SPA, 2015a).

44.45. To facilitate a comparison among maps, standardized symbols and colours should be used for the graphic representation of the main seagrass assemblages (Meinesz and Laurent, 1978; Fig. 7). According to the newly updated classification of marine benthic habitat types for the Mediterranean region adopted by the Contracting Parties of the Barcelona Convention (available at https://www.rac-spa.org/sites/default/files/doc_fsd/habitats_list_en.pdf; SPA/RAC-UN Environment/MAP, 2019a, b; Montefalcone et al., 2021), all the habitats dominated by seagrass can be represented on maps using specific symbols and/or colours that can be labelled in the legend using their relative codes (e.g., code MB2.54: *Posidonia oceanica* meadow; code MB5.531: Association with indigenous marine angiosperms on fine sand in sheltered waters). When the cartographical detail is good enough, it is possible also to indicate alsoalsorepresent the discontinuous meadows that are characterised by a cover below 50%, or the two main species that constitute a mixed meadow (the colour of the patches allows identification of the species concerned). To represent some typical forms of *Posidonia oceanica* meadows (e.g., striped, atolls) no specific symbols are available being these forms (bands and circular structures, respectively) easily identifiable on the map.

46. On the resulting maps the seagrass habitat distributional range and its total extent (expressed in square meters or hectares) can be defined. These maps can ~~be also~~also be compared with previous historical available data from the literature to evaluate any changes experienced by meadow over time ~~a period of time~~ (Mc Kenzie et al., 2001). Using the overlay vector methods on GIS, a diachronic analysis can be done, where temporal changes are measured in terms of percentage gained or lost~~s~~ ~~of~~ in the meadow extension, through the creation of concordance and discordance maps (Barsanti et al., 2007).

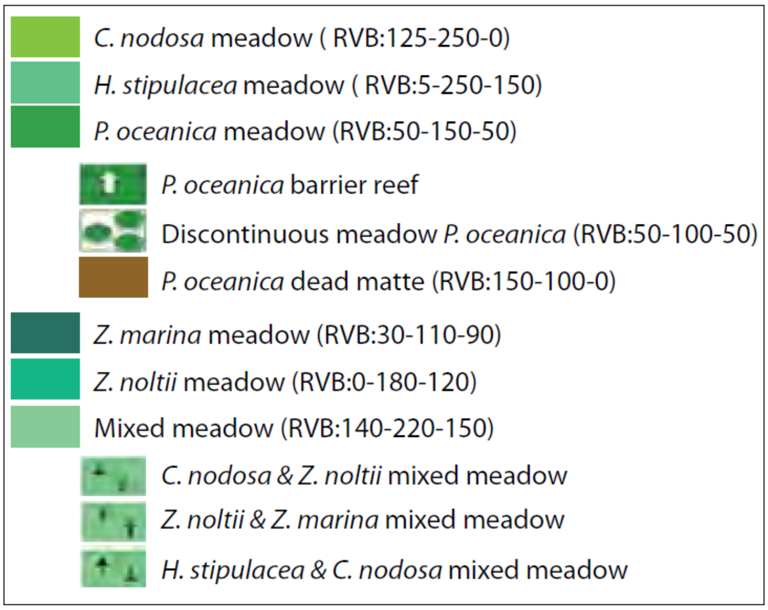

Figure 7: Examples of ~~s~~symbols and colours used for the graphic representation of the main seagrass assemblages. RVB: values in red, ~~green~~green, and blue for each type of meadow (from UNEP/MAP-RAC/SPA, 2015a).

~~45.~~47. The reliability of the map produced should also be evaluated. Several evaluation scales ~~of~~ for reliability have already been proposed and may be ~~useful~~ helpful for seagrass meadows. Pasqualini (1997) propose~~s~~d a reliability scale ~~in relation to~~about the image processing of the aerial photos, which can also be applied to satellite images, or another scale in relation to the processing of sonograms (UNEP/MAP-RAC/SPA, 2015a). Reliability lower than or equal to 50% means that the author should try to improve the reliability of the data (for example increasing the number of segments during image processing) or maybe that the restitution scale needs to be adapted.

~~46.~~48. Denis et al. (2003) proposed a reliability index ~~of~~ for the cartographic data based on the map scale (scale of 5), the positioning system (scale of 5) and the acquisition method (scale of 10) (UNEP/MAP-RAC/SPA, 2015a). The reliability index ranges from 0 to 20 and can vary from one point to another ~~of~~ on the map, depending on the bathymetry ~~or~~ and the survey technique used.

~~47.~~49. Leriche et al. (2001) proposed a reliability index rated from 0 to 50, which weighs three parameters: (i) the initial scale of the map (source map) and the working scale (target map), (ii) the method of data acquisition (e.g., dredges, grabs, aerial photography, side scan sonar, scuba diving), and (iii) the method of data georeferencing.

b) COMMON INDICATOR 2: Condition of the habitat's typical species and communities

Approach

~~48.~~50. Seagrasses are used as biological indicators of the water quality according to the European Water Framework Directive (WFD, 2000/60/EC), and as indicators of the environmental quality (i.e., condition of the habitat) according to the Marine Strategy Framework Directive ~~MSFD~~ (MSFD, 2008/56/EC) and the IMAP ~~EcAp~~ CI2-related to EO1 "biodiversity". The CI2 is aimed at providing information about the condition (i.e., ecological status) of seagrass meadows.

~~49.~~51. Monitoring the ecological status of seagrass meadows is today mandatory and is even an obligation for numerous Mediterranean countries ~~due to the fact that~~since:

- Four out of the five species present in the Mediterranean (*C~~.~~ymodocea nodosa*, *P~~.~~osidonia oceanica*, *Z~~.~~ostera marina*, and *Z. noltei*) are listed in the Annex II (list of endangered or threatened species) of the Protocol concerning Specially Protected Areas and Biological Diversity (SPA/BD protocol, Decision of the 16th Ordinary meeting of the Contracting Parties, Marrakech, 3-5 November 2009; UNEP/MAP, 2009);

- Three species (*C. nodosa, P. oceanica*, and *Z. marina*) are listed in the Annex I (strictly protected flora species) of the Bern Convention concerning the Mediterranean geographical region;

- Seagrass meadows are defined as priority natural habitats by the European Directive No. 92/43 (EEC, 1992).

~~50.~~52. This regulatory "recognition" also means that efficient management measures and conservation practices are required to ensure that these priority habitats, their constituent species, and their associated communities are and remain in a satisfactory ecological status. The good state of health of seagrass~~es~~ will then reflect the Good Environmental Status (GES) pursued by the Contracting Parties to the Barcelona Convention under the Ecosystem Approach (EcAp) and under the Marine Strategy Framework Directive (MSFD).

~~51.~~53. ~~A d~~Defined and standardized procedures for monitoring the status of seagrass meadows, comparable to th~~oat~~se provided for their mapping, should follow these three main steps:

1. Initial planning;
2. Setting-up the monitoring system;
3. Monitoring over time and analysis.

~~52.~~54. The initial planning is required to define the objective(s), determine the duration, identify the sites to be monitored, choose the descriptors to be evaluated with their acquisition modalities (i.e., the sampling strategy), and evaluate the human, technical and financial needs to ensure implementation and sustainability. This initial phase is therefore very important.

~~53.~~55. The setting-up phase is the concrete operational phase, when the monitoring program is set-up (e.g., positioning fixed markers) and realised. This phase may turn out to be the most expensive, including costs for going out to sea during field activities, equipment for sampling, and human resources, especially under difficult weather conditions. Field activities ~~must thus~~should be planned during a favourable season, also because some of the parameters chosen for monitoring purposes must be collected during the same period due to the seasonality in seagrass growth. This phase might be quite long, especially if numerous sites have to be monitored.

~~54.~~56. Monitoring over time and data analysis phase seems to be easy being the data acquisition a routin~~ary~~e operation, with no major difficulties if the previous two phases had been carried out correctly. Data analysis needs clear scientific competence. Duration of the monitoring, ~~in order to~~to be useful, must be ~~medium-time~~medium time at least. This phase often constitutes the key element of the monitoring system as it makes ~~it~~ possible to:

- Interpret the acquired data;
- Demonstrate its validity and interest;
- Check that the monitoring objectives have been attained.

~~55.~~57. ~~The objectives of the~~ M~~m~~onitoring of seagrass meadows is~~can~~ linked ~~cover~~ with the conservation targets ~~of seagrass meadows~~ and ~~also~~ with their use as ~~an~~ ecological indicators of the quality of ~~the~~ marine environment. The main aims of seagrass monitoring are generally:

- Preserve and conserve the heritage of marine ~~the~~ priority habitats, with the aim of ensuring that ~~the~~ seagrass meadows are in a satisfactory ecological status (GES) and ~~also~~ to identify as early as possible any degradation of these priority habitats or any change~~s~~ in their distributional range and extent. Assessment of the ecological status of meadows allows ~~to~~ measuringe the effectiveness of local or regional environmental policies in terms of management of the coastal environment;
- Build and implement a regional integrated monitoring system of the quality of the environment, as requested by the ~~Integrated Monitoring and Assessment Programme and related Assessment Criteria (~~IMAP~~)~~ during the implementation of the EcAp in the framework of the Mediterranean Action Plan. The main goal of IMAP is to gather reliable quantitative and updated data on the status of marine and coastal Mediterranean environments;
- Evaluate effects of any coastal activity and construction likely to impact seagrass meadows during environmental impact assessment (EIA) procedures. This particular ~~type~~ kind of monitoring aims to establish the condition of the habitat at the time "zero" (i.e., before the beginning of activities), then ~~monitor~~ the state of health of the meadow is monitoreds during the development of the works~~s~~ phase or at the end of the phase, to check for any impact~~s~~ on the environment evaluated as changes in the meadow state of health. The EIA procedure is not intended as a typical monitoring activity, although it provides the state of the system at the "zero" time, which can be very useful in the time series obtained during a monitoring programme. Unfortunately, most of the EIA studies are qualitative and are often performed by environmental consultants without specialized personnel, using unspecific guidelines and without following any standardised procedure, which prevent their use in effective monitoring programs.

~~56.~~58. The objective(s) ~~chosen~~ of the monitoring system will influence the choices in the following steps (e.g., duration, sites to be monitored, descriptors, sampling methods; Tab. 3). In general, and irrespective of the objective advocated, it is judicious to focus initially on a small number of sites that are easily accessible and that can be regularly monitored after short intervals of time (Pergent and Pergent-Martini, 1995; Boudouresque et al., 2000). The sites chosen must be: i) representative of the portion of the coastal area investigated (e.g., nature of the substrate), ii) cover most of the possible range of environmental situations, and iii) include sensitive zones, stable zones, or reference zones. Then, with the experience gained by the surveyors and the means (funds) available, this network could be extended to a larger number of sites.

~~57.~~59. To ensure the sustainability of the monitoring system, the following final remarks must be taken into account:

- Identify the partners, competences and means available;
- Planning the partnership modalities (who is doing what? when? and how?);
- Ensure training for the stakeholders so that they can set up standardized procedures to guarantee the validity of the results, and so that comparisons can be made for a given site and among sites;

- Individuate a regional or national coordinator depending on the number of sites concerned for monitoring and their geographical distribution;
- Evaluate the minimum budget necessary for running the monitoring network (e.g., costs for permanent operators, temporary contracts, equipment, data acquisition, processing, and analysis).

Table 3: Monitoring criteria depending on the objectives.

Monitoring objective	**Sites to be monitored**	**Descriptors**	**Monitoring duration and interval**
Heritage conservation	Sites with low anthropogenic pressures or reference sites (i.e., MPAs, Sites of Community Interest) to get information on the natural evolution of the environment	• Extent of the meadow and depth~~s~~ of ~~their~~ its upper and lower limits • Descriptors of the state of health of meadow (e.g., cover, shoot density)	• Medium and long term (min. 10 years) • Data acquisition at least annually for non-persistent species and every 2-3 years for perennial species
Monitoring environmental quality	Identify the main anthropogenic pressures likely to affect the quality of the environment and initiate monitoring in at least 3 sites, 2 reference/control sites and 1 impact~~ed~~ site, all representative of the coastal area	• Physical ~~D~~descriptors of the quality of ~~the~~ environment (e.g., water turbidity, ~~depth of lower limit,~~ enhancement in nutrients, nitrogen content of leaves and rhizomes, chemical contamination, trace metals in plant) • Descriptors of the state of health of meadow (e.g., cover, shoot density, lower limit depth)	• Medium term (5 to 8 years) • Data acquisition is variable depending on the species concerned (every 1-3 years)
Environmental impact assessment (EIA)	The site subject to coastal development or interventions. The selection of 2 reference/control sites might be also useful for comparison	• Specific descriptors to be defined depending on the possible ~~consequences~~ effects of human activities on seagrass	• Short term (generally 1-2 years) • Initiate before the impact (“zero” time), it can be continued during, or just after the conclusion. A further control can be made one year after the conclusion

Methods

~~58.~~60. Descriptors basically provide information on the state of health of a meadow. A great number of descriptors has been proposed to assess the ecological status of seagrass meadow (e.g., Pergent-Martini et al., 2005; Foden and Brazier, 2007; Montefalcone, 2009; Orfanidis et al., 2010). Some of the most common descriptors (Tab. 4) use a standardized sampling method, especially for *P. oceanica* (Pergent-Martini et al., 2005), but there are still many disparities among data acquisition methods despite efforts to propose a common approach (Short and Coles, 2001; Buia et al., 2004; Lopez y Royo et al., 2010a). For each descriptor listed in Table 4, some bibliographic references are provided, where a detailed description~~s~~ of the sampling tools and methodologies can be found.

61. The many ~~available~~ descriptors available for monitoring seagrass habitat (see Table 4) work at ~~each of the~~ different ecological complexity levels ~~of seagrass~~ (Montefalcone, 2009), which are from the highest to the lowest: the seascape (i.e., the whole habitat), the ecosystem, the associated community (e.g., leaf epiphytes), the population (i.e., the meadow), the ~~individual~~ species (i.e., the plant), the ~~physiological or~~ cellular or physiological/biochemical level~~, and the associated community (especially leaf epiphytes)~~. At each ecological level, a pool of different descriptors and indices can be selected. The selection of the most appropriate descriptor/index should be made considering the ~~specifity~~specificity of the monitoring program and of its objectives, the means (also funds) available, and the duration of the activities. The best choice would be to combine two or more descriptors/indices to capture the various responses of the system to environmental conditions and to accurately define the health status of seagrass (Oprandi et al., 2019). Some ecological indices (see next section) ~~have been developed to~~ working at the highest ecological levels have been recently developed.~~s,~~ At ~~i.e.~~ the seascape level there are~~(~~, for instance, the Conservation Index~~,~~ (~~-~~Moreno et al., 2001), ~~;~~ the Substitution Index and the Phase Shift Index ~~,~~ (Montefalcone et al., 2007), and the ~~;~~ ~~P~~Patchiness Index ~~,~~ (Montefalcone et al., 2007); ~~or~~ at the ecosystem level ~~(~~there is the EBQI (~~;~~ Personnic et al., 2014), while ~~. Some recent~~ other ecological indices integrate different ecological levels, such as ~~(e.g.,~~ for instance the PREI (~~,~~Gobert et al., 2009), the BiPo (Lopez y Royo et al., 2009), and ~~;~~ the POMI ~~,~~ (Romero et al., 2007).

~~59.~~

~~60.~~62. Descriptors listed in Table 4 can be obtained using different methodologies and sampling approaches: i) on maps resulting from remote sensing surveys or visual inspections (e.g., meadow extent and depth~~s~~ of the limits); ii) *in situ* observations and measures by scuba diving (e.g., lower limit type, cover, rhizome baring, and shoot density); iii) direct sampling of plants (e.g., phenological descriptors). All methods requiring the direct sampling of plants for subsequent laboratory analyses are destructive, and thus the impact of the sampling procedure must be ~~taken into account~~considered during the initial planning phase (Buia et al., 2004). Not-destructive procedures should be always preferred, especially in the case of protected species (e.g., *Posidonia oceanica*) and when the monitoring is carried out ~~within~~ inside MPAs. However, when the monitoring objective is the assessment of environmental quality, descriptors capable to link the influence of pressures with the health status of the plants are necessary, which usually require the collection of shoots (e.g., descriptors working at the physiological/biochemical level). An effective monitoring should be done at intervals over ~~a period of time~~a fixed period, even if it ~~could~~ would mean a reduced number of sites and a reduced number of descriptors being monitored. Number of adopted descriptors should be ~~adequate enough~~adequate to avoid errors of interpretation, but sufficiently reduced to ensure permanent monitoring. Simultaneous application of various descriptors working at different ecological complexity levels is the best choice to understand most of the possible responses of the system to environmental alterations (Montefalcone, 2009; Oprandi et al., 2019). The nature of the descriptor~~s~~ is less important than its reproducibility, reliability and the precision of the method used for its acquisition.

63. *In situ* observations and samples must be done over defined and, possibly, standardized surface areas, and the number of replicates must be adequate for the descriptor involved and high enough to catch the heterogeneity of the habitat. The analyses at the ~~individual~~ species (the plant), cellular or physiological/biochemical level~~ or cellular~~, and most of the analyses ~~associated~~ at the community level (i.e., the associated organisms of leaves and rhizomes) require collection of shoots. For *P~~.~~osidonia oceanica*, the mean number of sampled ~~and measured~~ shoots ranges between a minimum of ~~10~~ 9 to a maximum of 18-21~~0~~ shoots collected at each sampling station (Pergent-Martini et al., 2005). At each station, an equal number of shoots should be collected in three distinct areas tens of meters apart (e.g., 3 to 6 shoots per area, for a total of 9 to 18 shoots per station).

Among all the descriptors listed in Table 4, the shoot density is the most adopted, standardized and not-destructive descriptor in the *P. oceanica* monitoring programs (Pergent-Martini et al., 2005) (Fig. 8), because it provides important information about vitality and dynamic of the meadow and proved effective in revealing environmental alterations (Montefalcone, 2009). Meadow seascape is often patchy (at large spatial scale), but the meadow distribution within patches (medium to small spatial scales) can also be highly heterogeneous (Bacci et al., 2015). The size of the quadrate and the criteria used for randomly placing it on the bottom are crucial to standardize the method to measure shoot density. For measuring *P. oceanica* shoot density, two a standardized sizes of the quadrate are usually adopted:surface area is settled at 40 cm × 40 cm and 20 cm × 20 cm. The use of a larger surface area (1600 cm^2) incorporate the small-scale meadow heterogeneity, increasing the variability between replicates and thus decreasing the sensibility of statistical test to detect differences between stations. The use of the 20 cm × 20 cm quadrate (400 cm^2) can reduce this small-scale variability increasing the probability to detect clear spatial patterns. The overall time required for data acquisition increases according to the quadrate size: counting shoots in a 40 cm × 40 cm quadrate is at least four times more time-consuming than in a 20 cm × 20 cm one (Bacci et al., 2015). Smaller quadrates are also easier to use and counting errors are less likely to happen. On the other hand, smaller quadrates require a larger number of replicates to catch the natural shoot density variability.

64. Many studies showed that the use of the 20 cm × 20 cm quadrate is more effective than the use of the 40 cm × 40 cm or larger quadrates, as it allows reaching a better accuracy level given the same sampling effort (Charbonnel et al., 2000; Bacci et al., 2015). To speed the count of shoot density in very dense *P. oceanica* meadows (as usually occur in correspondence of the upper limit), as well as in very sparse meadows (in correspondence of the lower limits), the use of the smaller quadrate 20 cm × 20 cm is recommended. Similarly, the 20 cm × 20 cm quadrate is generally used to measure shoot density of other smaller seagrass species (e.g., *Cymodocea nodosa*, *Zostera noltei*). with a A minimum of 3 3 independent replicated counts counts should be done per in each stationof the three distinct areas tens of meters apart, totalising 9 counts per station that are enough to catch the natural within patches variability. The 3 replicated quadrates in each area must be randomly located within homogeneous seagrass patches with maximum coverage. On the contrary, in the case of a patchy meadow, quadrates must be positioned randomly using a stratified sampling procedure on the vegetated patches, and the number of replicates can be increased with 6 replicated quadrates in each area, totalising 18 mesurements per sampling station.

65. Measuring the depth and defining the typology of both the upper and the lower limits of the meadow (Fig. 8), as well as monitoring over time their bathymetrical position with permanent marks (i.e., *balises*) are other commonly adopted procedures to assess the evolution of the meadow in term of stability, improvement or regression that is linked to water transparency, water movement, sedimentary balance, and human activities along the coastline.

66. An adequate number of sampling stations must be localised randomly within the meadow according to its extent, and usually in correspondence of the meadow upper limit, the meadow lower limit and at intermediate depth. As stated before, at each depth (i.e., station) 3 sampling areas must be selected, tens of meters apart. To assess the overall ecological condition of the meadow and to reduce the number of sampled shoots, samples of shoots can be performed collected only at the intermediate meadow depth of the meadow, which is usually located at about 15 m depth, where the meadow is expected to find the optimal conditions for its development (Buia et al., 2004). When the aim of the monitoring program includes biochemical measurements, a sampling station in the deepest portion of the meadow should also be included, since many sources of pressure are usually displaced to deep areas (e.g., wastewater treatment plants, fish farms). Due to the seasonality of most of the descriptors (especially for those linked with leaves growth), and sampling activities should be carried out during the late spring or early summer season (Gobert et al., 2009).

61.67. Among all the descriptors listed in Table 4, the shoot density can be viewed as the most adopted, standardized and not-destructive descriptor in the *P. oceanica* monitoring programs

(Pergent-Martini et al., 2005) (Fig. 8), because it provides important information about vitality and dynamic of the meadow and proves effective in revealing environmental alterations (Montefalcone, 2009). Following the requirements of the WFD and the MSFD in the European countries, the ecological quality of the environment must be defined according to classification scales. For *P. oceanica* shoot density the existing absolute scale proposed for its classification (Pergent-Martini et al., 2005) has been adapted with the creation of five classes of ecological quality (bad, poor, moderate, good, and high; Annex 1) and can be used at the Mediterranean wide spatial scale, although it has been elaborated using data from *P. oceanica* meadows of France and Corsica. This scale provides a tool to classify the ecological status of the meadow that can be used in the frame of the IMAP under the EcAp. Evaluating depth and typology of both the upper and the lower limits of the meadow and monitoring over time their positions with permanent marks (i.e., *balises*) are commonly adopted procedures to assess the evolution of the meadow in term of stability, improvement or regression that is linked to water transparency, hydrodynamic regimes, sedimentary balance and human activities along the coastline (Fig. 8). The absolute classification scale of for the lower limit depth (Annex 1) is another valid tool to assess the meadow ecological status. Although all the existing absolute scales proposed for *P. oceanica* represent important standardized tools to classify the ecological status of meadows in the frame of the IMAP- procedure under the EcAp. and allow for the comparisons among regions, they could require some adaptations according to the specific geographical area and the morphodynamics setting of the site. It is more than likely that the threshold values fixed between classes are not valid at the whole Mediterranean scale: regional and even more local sub-regional scales should be defined (Montefalcone et al., 2007), providing the same methodologies and intercalibration procedures. For instance, in many *P. oceanica* meadows in of the Ligurian Sea (NW Mediterranean), along the Spanish coast (NW Mediterranean), and or of the North Aegean Sea (NE Mediterranean) (Marbà et al., 2014; Oprandi et al., 2019; Gerakaris et al., (2021), the lower limit rarely reaches depths greater than 20-25 m, due to natural constrains (e.g., substrate typology, seafloor topography). Adopting the absolute scale proposed for the lower limit depth, all these meadows would be classified from moderate to bad ecological status, even in the case of low human pressure. Also the nitrogen (N) content in leaves is highly variable within meadows and shows a high natural variability among meadows in the Mediterranean. Each country/region is thus suggested to define proper local regional scales for the classification of each descriptor, which should also be compared with the absolute scales for the Mediterranean Sea to point out geographical patterns (Annex 1)

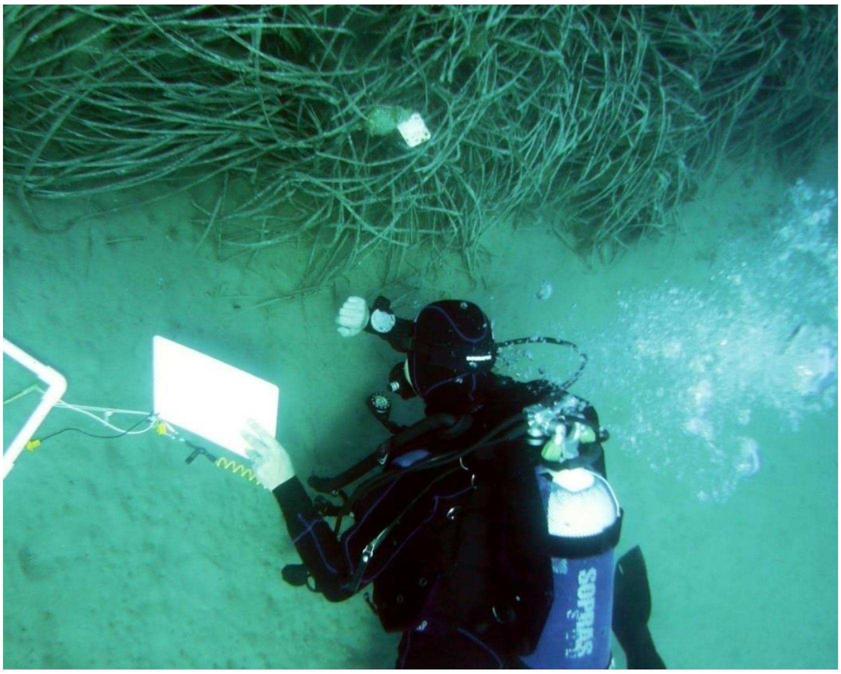

Figure 8: *In situ* measurement of *Posidonia oceanica* shoot density using the a standard square frame quadrate of 40 cm × 40 cm (upper imagepanel, © Monica Montefalcone) and monitoring over time of the meadow lower limit position with permanent marks (lower imagepanel), © Annalisa Azzola).

Table 4: Synthesis of main descriptors used in seagrass monitoring for defining the Common Indicator 2_Condition of the habitat. When available, the measuring/sampling method, the expected response in the case of increased human pressure and the main factors likely to affect the response of the descriptor, the destructive nature of the method (Destr.), the target species, the advantages and limits, and some bibliographic references are provided. The target species are: Cn = *Cymodocea nodosa*, Hs = *Halophila stipulacea*, Po = *Posidonia oceanica*, Zm = *Zostera marina*, Zn = *Zostera noltei*. The ecological complexity level at which each descriptor works is also indicated (i.e., seascape, population, individualspecies, physiologicalcell, community).

Descriptor	Method	Expected response/factors	Destr.	Target species	Advantages	Limits	References
Population Seascape (meadow)level							
Meadow extent (i.e. surface area)	Mapping (Cf. Part "a" of this document) and/or identification definition of the meadow boundaries position of limits	• Reduction of the total meadow extent • Coastal development, turbidity, mechanical impacts	No	All	• Informative of many aspects of the meadow • Usable everywhere in view of the many techniques available • Cover the whole depth range of meadow distribution	• For slow growing species (Po) needs of pre-positioning markers to evaluate change in meadow extent, and long response time (several years) • Sampling must be done during the season of maximum distribution for species with marked seasonal growth (generally in summer)	Foden and Brazier (2007)
Population (meadow) level							
Bathymetric position of the meadow upper limit (in m) and its morphology	A detailed mapping of the seagrass extension upper limit landward (Cf. Part "a" of this document) or placing fixed markers (e.g., permanent blocks, acoustic system)	• Shift of the upper limit at greatest depths • -Coastal development and direct destruction	No	All	• Easily measured (also by scuba diving) • Morphology of this limit may reflect environmental conditions	• For Cn, Hs and Zn, strong seasonal variability, requiring periodical monitoring or observations at during the same season for on all sites • Fixed markers *(balises)* might disappear if the	Pergent et al. (1995); Montefalcone (2009)

						site is strongly frequented •	
Descriptor	**Method**	**Expected response/factors**	**Destr**	**Target species**	**Advantages**	**Limits**	**References**
Bathymetric position of the meadow lower limit (in m)	A detailed mapping of the seagrass ~~extension~~ lower limit seaward (Cf. Part "a" of this document) or placing fixed markers (e.g., permanent blocks, acoustic system)	• Shift of the lower limit landward at shallower depths • Water ~~T~~turbidity	No	All	• Easily measured (also by scuba diving) • Absolute c~~C~~lassification scale available for Po	• For Cn, Hs and Zn, strong seasonal variability, requiring periodical monitoring or observations ~~at~~ during the same season ~~f~~on~~r~~ all sites • Beyond 30 m depth, underwater ~~acquisition~~ surveys ~~is~~ are difficult and costly (limited diving time, need for experienced divers, numerous dives requested) • Fixed markers (*balises*) might disappear (e.g., by trawling) • For slow growing species (Po) long time required to see any progress (several years)	Pergent et al. (2008); Annex 1

Meadow lower limit ~~type~~morphology	*In situ* visual observations	• Change in morphology • Water t~~T~~urbidity, mechanical ~~impacts~~ damages (e.g., trawling)	No	Po	• Well known descriptor • Several ~~types~~ morphologies described • ~~C~~Absolute classification scale for Po	• Good knowledge of Po meadows necessary to identify some of the morphologies~~types~~ • Beyond 30 m depth, underwater surveys are difficult and costly (limited diving time, need for experienced divers, numerous dives requested)~~Difficult and costly the assessment at great depths (>30 m)~~	Boudouresque and Meinesz (1982); Pergent et al. (1995); Montefalcone (2009); Annex 1
Descriptor	**Method**	**Expected response/factors**	**Destr**	**Target species**	**Advantages**	**Limits**	**References**
Presence of inter-matte channels and dead matte areas	High resolution and ~~ly~~ detailed mapping of the area (Cf. Part “a” of this document, permanent square frames) and/or *in situ* observations	• Increase in the extent • Mechanical ~~impacts~~ damages (e.g., anchoring, fishing gear)	No	Po	• Surface areas can be easily measured ~~can be measured~~ on maps	• Dead matte areas are natural components intrinsic ~~to~~ in some typologies of ~~types of~~ meadows (e.g., striped meadows) and do not reflect systematically human influence	Boudouresque et al. (2006)
Density (shoots · m^{-2})	No. of shoots counted underwater within a square frame (a quadrate of fixed dimension) by divers. The square size depends on the seagrass species and on the meadow density. For *P. oceanica* the most adopted sizes are 40 cm	• Reduction • Water ~~T~~turbidity, mechanical ~~impacts~~ damages (e.g., anchoring)	No	All	• Easily measured • Low-cost • Can be measured at all depths that can be safely reached by scuba diving • Absolute ~~C~~classification scale available for Po	• Strong variability with depth • Long acquisition time for densities over 800 shoots per square meter • Many replicates necessary to evaluate meadow heterogeneity	Duarte and Kirkman (2001); Pergent-Martini et al. (2005); Pergent et al. (2008); Bacci et al. (2015); Annex 1

Descriptor	Method	Expected response/factors	Destr	Target species	Advantages	Limits	References
	× 40 cm and 20 cm × 20 cm					• Considerable risk of error if: a) the surveyor is inexperienced; b) high density; c) small sized species. In this latter case *in situ* counting can be replaced by sampling over a given area and the counting can be done in the laboratory . (but becoming a destructive technique)	
Descriptor	**Method**	**Expected response/factors**	**Destr**	**Target species**	**Advantages**	**Limits**	**References**
Cover (in %)	Average percentage of the surface area occupied (in vertical projection) by meadow in relation to the surface area observed. Various methods to visual ~~measure~~ estimate the cover *in situ* by divers or in laboratory~~.~~ (from photos or video~~, visual estimation~~). Variable observation surface area (0.16 to 625 m²), visualised by a quadrate or a transparent plate	• Reduction • Water t~~T~~urbidity, mechanical damages	No	All	• Rapid • On photos, possibility of comparison over time and less errors due to subjectivity • All depths • Estimated also from aerial images or sonograms at large spatial scale	• Strong seasonal and bathymetric variability • Comparison of data obtained using different methods and different observation surface areas is not always reliable due to the fractal nature of cover • Sampling strategy and design must include proper spatial variability • High subjectivity of *in situ* estimations	Buia et al. (2004); Pergent-Martini et al. (2005); Boudouresque et al. (2006); Romero et al. (2007); Montefalcone (2009)

						•	
Percentage of plagiotropic rhizomes	Counting of plagiotropic rhizomes ~~in a given~~ on a defined surface area (e.g., ~~40~~ 20 cm × ~~40~~ 20 cm, which can be visualised by a quadrate)	• Increase • Mechanical ~~impacts~~ damages (e.g., anchoring, fishing gear)	No	Cn, Po	• Easy, rapid, and low-cost • Absolute c~~C~~lassification scale available for Po	• Mainly used at shallow depths (0-20 m)	Boudouresque et al. (2006); Annex 1
~~Individual~~ Species (plant) level							
Leaves surface area (cm² · shoot), and other phenological measures	Counting and measuring the length and width of the different types of leaves in each shoot (~~10~~ 9 to 18-20 shoots according to the sampling design)	• Reduction of leaves surface area (Po) for overgrazing and human impacts • Increase in the length of leaves (Po, Cn) for nutri~~m~~ents enhancement	Yes	All	• Easy~~, rapid~~ and low-cost • Possibility to measure the length of adult leaves (the most external leaves) *in situ* to avoid sampling • ~~Classification~~ Absolute classification scale available for Po	• Strong seasonal variability • Strong individual variability and necessity to measure (and sample) an adequate number of shoots • Destructive sampling	Giraud (1977, 1979); Lopez y Royo et al. (2010b); Orfanidis et al. (2010); Annex 1
Descriptor	**Method**	**Expected response/factors**	**Destr**	**Target species**	**Advantages**	**Limits**	**References**
Necrosis on leaves (in %)	Percentage of leaves with necrosis, through observation in laboratory~~.~~	• Increase • Increased contaminants concentration	Yes	Po	• Easy, rapid, and low-cost	• Necrosis is very rare in some sectors of the Mediterranean (e.g., Corsica littoral) • Destructive sampling	Romero et al. (2007)
State of the apex	Percentage of leaves with broken apex	• Increase • Overgrazing, mechanical impacts (e.g., anchoring)	No	Po	• Easy, rapid, and low-cost • Specific marks ~~of~~ left by the bit of some animals are easily recognizable	• Not informative on~~f~~ the grazing pressure in the case of strong ~~hydrodynamism~~water movement and on old leaves	Boudouresque and Meinesz (1982)

Foliar production (in mg dry weight · shoot^{-1} yr^{-1})	For Po possibility, thanks to lepidochronology, to reconstruct number of leaves produced in one year, at present or in the past. For other species, measuring leaves through marking~~s~~ or by using the relationship bases length/leaves growth (Zm)	• Reduction • Nutrients deficit, increase in interspecific competition	Yes (Po) No (Zm)	All	• For Po lepidochronolo~~-~~gy allows assessments at all depths • Absolute ~~C~~classification scale available • For Zm the relationship bases length/leaves growth allows *in situ* non destructive measuring	• Long time to analyse ~~to acquire~~ • Monthly monitoring, or at least ~~for~~ every ~~4~~ season~~s~~ is necessary • Destructive sampling for Po	Pergent (1990); Gaeckle et al. (2006); Pergent et al. (2008)
Rhizome production (in mg dry weight · shoot^{-1} yr^{-1}) or elongation (in mm yr^{-1})	For Po possibility, thanks to lepidochronology, to reconstruct rate of growth or biomass per year	• Increase • Accumulation of sediments due to coastal development	Yes	Po	• Independent from season • ~~Classification~~ Absolute classification scale available for Po	• Increase in the ~~Interpretation sometimes difficult as r~~rhizome production ~~increase~~ can ~~be~~ also be observed in reference sites in the absence of human impacts • Destructive sampling	Pergent et al. (2008); Annex 1
Descriptor	**Method**	**Expected response/factors**	**Destr**	**Target species**	**Advantages**	**Limits**	**References**
Burial or baring of the rhizomes (in mm)	Measuring the degree of burial or baring of rhizomes *in situ*, or the percentage of buried or bared shoots on a given surface area	• Increase in burial for increased sedimentation (e.g., coastal development, dredging) • Increase in baring for deficit in the sediment load	No	All	• Easily measured *in situ* • Not destructive and low-cost • Independent from the season		Boudoresque et al. (2006)

Burial or baring of the rhizomes (in mm)	Measuring the degree of burial or baring of rhizomes in situ, or the percentage of buried or bared shoots on a given surface area	• Increase in burial for increased sedimentation (e.g., coastal development, dredging) • Increase in baring for deficit in the sediment load	No	All	• Eas measure in situ • Not destructive and low-cost • Independent from season		Boudoresque et al. (2006)
Cellular or physiological/biochemical level							
Nitrogen and phosphorus content (in % dry weight) in plant tissues **Descriptor**	Dosage through mass spectrometry and plasma torch in different plant tissues (both leaves and rhizomes) after acid mineralisation (e.g., in rhizome for Po)**Method**	• Increase • Nutriments enhancement**Expected response/factors**	Yes**Destr.**	All**Target species**	• Short response time to environmental changes • Absolute classification scale for Po**Advantages**	• Very expensive • Analytical equipment and specific competence necessary • Destructive sampling**Limits**	Romero et al. (2007); Annex 1**References**
Carbohydrate content (in % dry weight) in plant tissues and sediments	Dosage through spectrophotometry after alcohol extraction in different plant tissues (e.g., in rhizome for Po)	• Reduction • Human impacts	Yes	All	• Short response time to environmental changes • Absolute classification scale for Po	• Very expensive • Analytical equipment and specific competence necessary • Destructive sampling	Alcoverro et al. (1999, 2001); Romero et al. (2007); Annex 1
Physiological (cell)							
Trace metal content (in µg · g-1)Nitrogen and	Dosage through spectrometry in different plant tissues (both leaves and	• Increase • Increased concentration of metallic	YesYes	AllAll	• Short response time to environmental changes • Absolute classification scale for Po Short response	• Very expensive • Analytical equipment and specific competence necessary	Salivas-Decaux (2009); Annex 1Romero et al.

phosphorus content in plant (in % dry weight)	rhizomes) after acid mineralisationDosage through mass spectrometry and plasma torch in different plant tissues after acid mineralisation (e.g., rhizomes for Po)	contaminantsIncrease • Nutriments enhancement			time to environmental changes • Classification scale for Po	• Destructive samplingVery expensive • Analytical equipment and specific competence necessary • Destructive sampling	(2007); Annex 1
Descriptor	**Method**	**Expected response/factors**	**Destr**	**Target species**	**Advantages**	**Limits**	**References**
Nitrogen isotopic relationship ($d^{15}N$ in ‰) Carbohydrate content (in % dry weight) in plant and sediments	Dosage through mass spectrometer in different plant tissues after acid mineralisation (e.g., in rhizomes for Po)Dosage through spectrophotometry after alcohol extraction in different plant tissues (e.g., rhizomes for Po)	• Increase for nutriments enhancement from farms and urban effluents • Reduction for nutriments enhancement from fertilizersReduction • Human impacts	YesYes	PoAll	• Short response time to environmental changesShort response time to environmental changes • Classification scale for Po	• Very expensive • Analytical equipment and specific competence necessary • Destructive samplingVery expensive • Analytical equipment and specific competence necessary • Destructive sampling	Romero et al. (2007)Alcoverro et al. (1999, 2001); Romero et al. (2007); Annex 1
Trace metal content (in µg · g^{-1})	Dosage through spectrometry in different plant tissues after acid mineralisation	• Increase • Increased concentration of metallic contaminants	Yes	All	• Short response time to environmental changes • Classification scale for Po	• Very expensive • Analytical equipment and specific competence necessary • Destructive sampling	Salivas-Decaux (2009); Annex 1
Sulphur isotopic relationship ($d^{34}S$ in ‰)Nitrogen isotopic	Dosage through mass spectrometer in different plant tissues (e.g., rhizomes of Po) Dosage through mass spectrometer in	• Reduction • Human impacts Increase for nutriments enhancement from	YesYes	PoPo	• Short response time to environmental changesShort response time to environmental changes	• Very expensive • Analytical equipment and specific competence necessary • Destructive samplingVery expensive	Romero et al. (2007)Romero et al. (2007)

relationship (d^{15}N in ‰)	different plant tissues after acid mineralisation (e.g., rhizomes for Po)	farms and urban effluents • Reduction for nutriments enhancement from fertilizers				• Analytical equipment and specific competence necessary • Destructive sampling	
*Community*De	Method	Expected	Destr	Target	Advantages	Limits	References
Epiphytes biomass (in mg dry weight · shoots^{-1} or % dry weight · shoots^{-1}) and epiphytes cover (in %) on the leavesSulphur isotopic relationship (d^{34}S in ‰)	Measure of biomass (µg · shoots^{-1}) after scraping, drying and weighing; estimate the epiphytes cover on leaves under a binocular; indirect estimation of biomass from epiphytes coverDosage through mass spectrometer in different plant tissues (e.g., rhizomes of Po)	• Increase • Nutriments enhancement from rivers, high touristic frequentationReduction • Human impacts	YesYes	AllPo	• Easilyy to measured • Low-cost (biomass and cover) • Absolute classification scale available for Po • Early-warning indicator Short response time to environmental changes	• Time-consuming • Strong seasonal and spatial variability • Specific analytical equipment (nitrogen content) necessary • Destructive sampling Very expensive • Analytical equipment and specific competence necessary	Morri (1991); Pergent-Martini et al. (2005); Romero et al. (2007); Fernandez-Torquemada et al. (2008); Giovannetti et al. (2008, 2015)Romero et al. (2007)
Community							
Epiphytes biomass (in mg dry weight · shoots^{-1} or % dry weight · shoots^{-1}) and epiphytes	Measure of biomass (µg · shoots^{-1}) after scraping, drying and weighingMeasure of nitrogen content (in % dry weight). Measure using simple CHN analyser Estimate the epiphytes cover on leaves under a binocular	• Increase • Nutriments enhancement from rivers, high touristic frequentation	Yes	All	• Eas measure • Low-cost (biomass and cover) • Classification scale available for Po • Early-warning indicator	• Time-consuming • Strong seasonal and spatial variability • Specific analytical equipment (nitrogen content) necessary • Destructive sampling	Morri (1991); Pergent-Martini et al. (2005); Romero et al. (2007); Fernandez-Torquemada et al. (2008);

~~cover (in %) of leaves~~	~~Indirect estimation of biomass from epiphytes cover~~						~~Giovannetti et al. (2008, 2015)~~

~~62.~~68. The setting-up phase is the concrete operational phase of the monitoring program that starts with ~~the~~ data acquisition. The observations and samplings during the acquisition phase or data validation of the cartographical ~~surveys, could~~ surveys may also constitute an output of ~~a~~ the monitoring system (Kenny et al., 2003), and cartography could also represent a monitoring tool (Tab. 4; Boudouresque et al., 2006).

~~63.~~69. At the regional spatial scale, two main monitoring systems have been developed: 1) the seagrass monitoring system (SeagrassNet), which ~~was~~ has been established at ~~the~~ a worldwide scale at the beginning of the year 2000 and covers all the seagrass species (Short et al., 2002); and 2) the “Posidonia” monitoring network started at the beginning of the 1980s in the Mediterranean (Boudouresque et al., 2006), which is specific to *Posidonia oceanica* but can be adapted to other Mediterranean species and ~~to~~ for the genus *Posidonia* worldwide. The “Posidonia” monitoring network is still used today, with a certain degree of variability from one country to another and even more from a region to another, in at least nine Mediterranean countries and ~~in~~ over 350 sites (Buia et al., 2004; Boudouresque et al., 2006~~,~~; Romero et al., 2007; Fernandez-Torquemada et al., 2008; Lopez y Royo et al., 2010a). After the work carried out within the framework of the Interreg IIIB MEDOCC programme “Coherence, development, harmonization and validation of evaluation methods of the quality of the littoral environment by monitoring the *Posidonia oceanica* meadows”, and the “MedPosidonia” programme set up by RAC/SPA, an updated and standardized approach for the *P. oceanica* monitoring network has been tested and validated (UNEP/MAP-RAC/SPA, 2009). The main differences between the ~~former~~ two monitoring systems are:

- Within the framework of SeagrassNet, monitoring is done along three permanent transects, laid parallel to the coastline and positioned respectively (i) in the most superficial part of the meadow, (ii) in the deepest part, and (iii) at an intermediate depth between these two positions. The descriptors chosen (Short et al., 2002; Tab. 5) are measured at fixed points along each transect and every three months.

- Within the framework of the “Posidonia” monitoring network, measurements are taken (i) in correspondence of fixed markers placed along the lower limit of the meadow, (ii) at the upper limit, and (iii) at the intermediate and fixed depth of 15 m. The descriptors (Tab. 5) are measured every three years only if, after visual surveys, no visible changes in the geographical position of the limits are observed.

~~64.~~70. SeagrassNet allows ~~to~~ compar~~e~~ing the data obtained in the Mediterranean with the data obtained in other regions of the world, having a world-wide coverage o~~n~~f over 80 sites distributed in 26 countries (available at www.seagrassnet.org). However, this monitoring system is not suitable for large-size species (such as *Posidonia* genus) and for meadows where the lower limit is located beyond 25 m depth. This monitoring system has been set up only for one site in the Mediterranean (Pergent et al., 2007). The “Posidonia” monitoring network, in view of the multiplicity of descriptors identified (Tab. 5), allows comparing different meadows in the Mediterranean, ~~and also~~and evaluating the plant’s vitality and the quality of the environment ~~in which~~ where it grows. Other monitoring system, such as permanent transects with seasonal monitoring, or acoustic surveys, can be used in ~~particular~~ specific situations like the monitoring of lagoons ~~environments~~ (Pasqualini et al., 2006) or for the study of relict meadows (Descamp et al., 2009).

71. The sampling technique and the chosen descriptors define the nature of the monitoring (e.g., monitoring of chemical contamination ~~of~~ in the environment, discharge into the sea from a treatment plant, effects of beach nourishments, general evaluation of the meadow state of health) (Tab. 4). There are no ideal methods for mapping or universal descriptors for ~~the~~ monitoring ~~of~~ seagrass meadows, but rather a great diversity of efficient and complementary tools. They must be chosen depending on the objectives, the species present and the local context. Independently from the descriptors selected, particular attention must be paid to the validity of the measurements made (acquisition protocol, precision of the measurements, reproducibility; Lopez y Royo et al., 2010a). The following data processing and interpretation phase is thus fundamental to ensure the good quality of the monitoring programme.

Table 5: Descriptors measured within the framework of the SeagrassNet, the "Posidonia" monitoring Network, and the MedPosidonia monitoring programs (Pergent et al., 2007).

Descriptors	**SeagrassNet**	**"Posidonia" monitoring Network**	**MedPosidonia**
Light	×		
Temperature	×		×
Salinity	×		
Lower limit	Depth	Depth, type, and cartography	Depth, type, and cartography
Upper limit	Depth	Depth, type, and cartography	Cartography
Density	12 measurements along each transect	Measurement at each of the 11 markers	Measurement at each of the 11 markers
% plagiotropic rhizomes		Measurement at each of the 11 markers	Measurement at each of 11 markers
Baring of rhizomes		Measurement at each of the 11 markers	Measurement at each of the 11 markers
Cover	12 measures along transect	At each marker using video (50 m)	Measurement at each of the 11 markers
Phenological analysis	12 measures along transect	20 shoots	20 shoots
Lepidochronological analysis		10 shoots	10 shoots
State of the apex		20 shoots	20 shoots
Biomass (g DW)	Leaves		
Necromass	Rhizome and scales		
Granulometry of sediments		1 measurement	1 measurement
% organic material in sediment		1 measurement	1 measurement
Trace-metal content			Ag and Hg

72. As a final remark, the IMAP should also consider the long-term organic carbon stored in seagrass sediments from both *in situ* production by photosynthetic activity and sedimentation of particulate carbon from the water column, known as "Blue Carbon" (Nellemann et al., 2009). The estimation of the Blue Carbon should consider above and below ground living and dead biomass and soil fine and coarse carbon. Recent findings, however, suggested clearly that most of the carbon stored in seagrass is in the soil, being the fractions stored as living tissue virtually negligible. Hence, soil stocks rather than biomass stocks should be the focus of assessment in Mediterranean seagrass. International guidelines had been provided for this estimation from the Blue Carbon Initiative and IUCN (Howard et al., 2014, IUCN, 2021). Following this, soil carbon is determined by soil depth, bulk density and % of organic carbon in the first meter of the soil. Advanced techniques for large scale Blue Carbon inventories using high resolution sub-bottom profilers have been recently developed in the Mediterranean (Monnier et al., 2020). In the case additional carbon sequestration would like to be estimated, the methodology proposed by lepidochronology (i.e., the 'retro-datation' of *Posidonia* rhizomes) will provide estimations on the plant growth and accretion rates over a short timescale (although it is often very variable). The sequestration rate calculated using the accretion rate should be determined using C^{14} to date the age at which soil was laid down. The following parameters are useful for the estimation of carbon contents in plant tissues:

65. Estimating the production of carbon obtained by photosynthetic activity from *P. oceanica* meadows (above and belowground production) at the Mediterranean basin scale requires the following parameters (essential for the calculation of the Blue Carbon) from the lepidochronological analyses:

- Leaf Biomass Index (Leaf Standing Crop) (dry weight · m^{-2}): it is calculated by multiplying the average leaf biomass per shoot by the density of the meadow reported per square meter;
- Leaf Surface Index (Leaf Area Index) ($m^2 \cdot m^{-2}$): it is calculated by multiplying the average leaf area per shoot by the density of the meadow reported per square meter;
- Height of the leaf canopy to be estimated by means of acoustic, optical, and *in situ* measurements.

66.73. The methodological approaches for estimating Blue Carbon consider both the use of satellite images, acoustic surveys (multibeam, single beam, and sub bottom profiler), optical acquisitions, and measurements in situ and in the laboratory. Monitoring activities should also be planned on key typical species associated to seagrass meadows, such as for instance the bivalves *Pinna* spp. Given the critical situation of *P. nobilis* in the Mediterranean and the apparent incipient expansion of *P. rudis* within *P. oceanica* meadows, visual censuses of these species in monitored meadows should be seriously considered.

Table 5: Descriptors measured within the framework of the SeagrassNet, the "Posidonia" monitoring Network and the MedPosidonia monitoring programs (Pergent et al., 2007).

Descriptors	**SeagrassNet**	**"Posidonia" monitoring Network**	**MedPosidonia**
Light			
Temperature			
Salinity			
Lower limit	Depth	Depth, type and cartography	Depth, type and cartography
Upper limit	Depth	Depth, type and cartography	Cartography
Density	12 measurements along each transect	Measurement at each of the 11 markers	Measurement at each of the 11 markers
% Plagiotropic rhizomes		Measurement at each of the 11 markers	Measurement at each of 11 markers
Baring of rhizomes		Measurement at each of the 11 markers	Measurement at each of the 11 markers
Cover	12 measures along transect	At each marker using video (50 m)	Measurement at each of the 11 markers
Phenological analysis	12 measures along transect	20 shoots	20 shoots
Lepidochronological analysis		10 shoots	10 shoots
State of the apex		20 shoots	20 shoots
Biomass (g DW)	Leaves		
Necromass	Rhizome and scales		
Granulometry of sediments		1 measurement	1 measurement
% organic material in sediment		1 measurement	1 measurement

~~Trace-metal content~~			~~Ag and Hg~~

Data processing and interpretation

~~67.~~74. Measurements made *in situ* must be ~~analyzed~~analysed and archived. Samples collected during field activities must be properly stored for following laboratory analyses. Data interpretation needs expert judgment and evaluation and can be made by comparing the measured data with the data available in the literature, either directly or through classification scales. Checking that the results obtained respond to the monitoring objectives (reliability and reproducibility of the results, valid interpretations and coherence with the observations made) is another important step to validate monitoring effectiveness.

~~68.~~75. The huge increase of studies on *Posidonia oceanica* (over ~~2400~~ 2700 publications indexed in the Web of Science on April 2021) means that in the last few decades a growing number of interpretation scales have been set up for the most widely used descriptors for monitoring this species (e.g., Giraud, 1977; Meinesz and Laurent, 1978; Pergent et al., 1995b; Pergent-Martini et al., 2005; Montefalcone et al., 2006, 2007; Montefalcone, 2009; Salivas-Decaux et al., 2010; Tab. 4).

~~69.~~76. As for cartography, an integration of the monitoring data into a geo-referenced information system (GIS), which can be freely consulted (like MedGIS implemented by RAC/SPA and the "Seagrass Atlas of Spain" available at http://www.ieo.es/es/atlas-praderas-marinas), is to be recommended and should be encouraged, so that the data acquired becomes available to the wider public and can be of benefit to the maximum number of users.

Ecological indices

~~70.~~77. Ecological synthetic indices are today widespread for measuring the ecological status of ecosystems ~~in view~~given ~~of~~ the Good Environmental Status (GES) achievement or maintenance. Ecological indices succeed in "capturing the complexities of the ecosystem yet remaining simple enough to be easily and routinely monitored" and may therefore be considered "user-friendly" (Montefalcone, 2009 and references therein). They are anticipatory, integrative, and sensitive to stress and disturbance. Many ecological indices had been employed in ~~the~~ seagrass monitoring programs~~mes~~ in the past, e.g., the Leaf Area Index (Buia et al., 2004), the Epiphytic Index (Morri, 1991). Following the requirements of the WFD, the MSFD, and the EcAp in the European countries, many synthetic indices have been set up to provide, ~~on the basis of~~based on a panel of different descriptors, a global evaluation of the environmental quality based on the "seagrass" biological quality element. The most adopted indices in the regional/national monitoring programs are the following (Tab. 6):

- POSWARE (Buia et al., 2005)
- POMI (Romero et al., 2007)
- POSID (Pergent et al., 2008)
- Valencian CS (Fernandez-Torquemada et al., 2008)
- PREI (Gobert et al., 2009)
- BiPo (Lopez y Royo et al., 2009)
- Conservation Index (CI) (Moreno et al., 2001)
- Substitution Index (SI) (Montefalcone et al., 2007)
- Phase Shift Index (PSI) (Montefalcone et al., 2007)
- Patchiness Index (PI) (Montefalcone et al., 2010)

- EBQI (Personnic et al., 2014)

~~71.~~78. Most of the ecological indices integrate different ecological levels (Tab. 6). The POSWARE index is based on 6 descriptors working at the population and ~~individual~~ species levels. The multivariate POMI index is based on a total of 14 structural and functional descriptors of *Posidonia oceanica*, from cellular to community level. The POSID index is based on 8 descriptors working at the community, population, ~~individual~~ species and cellular levels. Some of the descriptors working at the cellular level and used for computing the POMI and the POSID index are very time-consuming (such as the chemical and biochemical composition and the contaminants in plant tissues), thus showing little usage in the *P. oceanica* monitoring programs (Pergent-Martini et al., 2005). The Valencian CS index integrates 9 descriptors from ~~individual~~ species to community level. The PREI index is based on 5 descriptors working at the population, ~~individual~~ species and community levels. The BiPo index is based only on 4 non-destructive descriptors at the population and ~~individual~~ species levels and is particularly well suited for the monitoring of protected species or within MPAs.

~~72.~~79. Some not-destructive ecological indices have been developed to work at the seascape ecological level, such as the Conservation Index (CI; Moreno et al., 2001), the Substitution Index and the Phase Shift Index (SI and PSI, respectively; Montefalcone et al., 2007), and the ~~P~~Patchiness Index (PI; Montefalcone et al., 2010). The CI measures the proportional abundance of dead matte relative to living *P. oceanica* and can be used as a perturbation index (Boudouresque et al., 2006), although dead matte areas may also originate from natural causes (e.g., ~~hydrodynamism~~water movement). The SI has been proposed for measuring the amount of replacement of *P. oceanica* by the other common native Mediterranean seagrass *Cymodocea nodosa* and by the three species of green algae genus *Caulerpa*: the native *Caulerpa prolifera* and the two alien invaders *C. taxifolia* and *C. cylindracea*. The SI, applied repeatedly in the same meadow, can objectively measure whether the substitution is permanent or progressive or, as hypothesized by Molinier and Picard (1952), will in the long term facilitate the reinstallation of *P. oceanica*. While the application of the CI is obviously limited to those seagrass species that form a matte, the SI can be applied to all cases of substitution between two different seagrass species and between an alga and a seagrass. The PSI is another synthetic ecological index that identifies and measures the intensity of the phase shift occurring within the seagrass ecosystem; it provides a synthetic evaluation of the irreversibility of changes undergone by a regressed meadow. The biological characteristics and the reproductive processes of *P. oceanica* are not conducive to a rapid re-colonisation of dead matte (Meinesz et al., 1991). If a potentiality of recovery still exists in a meadow showing few and small dead matte areas, a large-scale regression of *P. oceanica* meadow must therefore be considered almost irreversible on human-life time scales. The PI has been developed to evaluate the ~~level~~ degree of fragmentation of the habitat and uses the number of patches for measuring the fragmentation of seagrass meadows. All these seascape indices are useful tools for assessing the quality of coastal environments in their whole (as requested by the MSFD), not only for assessing the quality of the water bodies (as requested by the WFD).

~~73.~~80. One of the most recently proposed ~~index~~indices works at the ecosystem level (EBQI; Personnic et al., 2014). This index has been developed ~~on the basis of~~based on a simplified conceptual model of the *P. oceanica* ecosystem, where a set of 17 representative functional compartments have been identified. The quality of each functional compartment is then evaluated ~~through the selection~~by selecting ~~of~~ one or two specific descriptors (most of them not destructive) and the final index value integrates all compartment scores. Being an ecosystem-based index, it complies with the MSFD and the EcAp requirements. However, its complete ~~and thus~~but also complex formulation makes this index more time-consuming when compared to other indices.

~~74.~~81. Intercalibration trials between the POMI and the POSID indices have shown that there is coherence in the classification of the sites studied (Pergent et al., 2008). Applying the BIPO index to 9 Catalonia ~~Mediterranean~~ sites yielded~~s~~ an identical classification ~~of the Catalonia sites as the~~

classification to that obtained with the POMI index (Lopez y Royo et al., 2010c). Concurrent application of the POMI, PREI, BiPo, and Valencian CS in the Eastern Mediterranean Sea showed high comparability among indices (Gerakaris et al., 2017). -Finally, using both the POSID and the BiPo indices within the framework of the “MedPosidonia” programmmme, a similar classifications of the meadows studied wereas found (Pergent et al., 2008). A recent exercise to compare a number ofseveral descriptors and ecological indices working at different ecological levels (individualspecies, population, community, and seascape) in 13 *P. oceanica* meadows of the Ligurian Sea (NW Mediterranean) showed a low consistency among the four levels, and especially between the plant (e.g., leaves surface) and the meadows (e.g., shoot density, lower limit depth) descriptors. Also, the PREI index showed inconsistency with most of the compared descriptors (Karayali, 2017; Oprandi et al., 2019). In view of this result, the a combined concurrent use of more descriptors and indices, covering different levels of ecological complexity, should be preferred in any monitoring programme.

75.82. At the present state of knowledge, it is difficult to prefer one or another of these synthetic indices, as it has not yet been possible to compare all of them over several sites and to start wide intercalibration processes. As a general comment, those indices based on a high number of descriptors imply excessive costs in terms of acquisition time and the budget required (Fernandez-Torquemada et al., 2008), although the use of a comparatively lower number of descriptors can lead to an oversimplification, particularly in those situations where specific pressures should be linked to the meadow state of health.

Table 6: Descriptors used in the mostly adopted synthetic ecological indices mostly adopted in the regional/national monitoring programs to evaluate the environmental quality based on the "seagrass" biological quality element. The ecological complexity level at which each descriptor works is also indicated (i.e., physiologicalcellular, individualspecies, population, community, ecosystem, seascape).

Index	PhysiologicalCellular	IndividualSpecies	Population	Community	Ecosystem	Seascape
POSWARE		Width of the intermediate leaves; leaves production; rhizomes production and elongation	Shoot density; meadow cover			
POMI	P, N and sucrose content in rhizomes; $\delta^{15}N$ and $\delta^{34}S$ isotopic ratio in rhizomes; Cu, Pb, and Zn content in rhizomes	Leafves surface; percentage foliar necrosis	Shoot density; meadow cover; percentage of plagiotropic rhizomes	N content in epiphytes		
POSID	Ag, Cd, Pb, and Hg content in leaves	Leafves surface; Coefficient A; rhizomes elongation	Shoot density; meadow cover; percentage of plagiotropic rhizomes; depth of the lower limit	EpiphytesEpiphytes biomass		
Valencian CS		Leafves surface; percentage of foliar necrosis	Shoot density; meadow and dead matte cover; percentage of plagiotropic rhizomes; rhizome baring/burial	Herbivore pressure; leaf epiphyte's biomass		
PREI		Leafves surface; leafves biomass	Shoot density; lower limit depth and type	Leaf epiphytees biomass		
BiPo		Leafves surface	Shoot density; lower limit depth and type			
CI			Meadow and dead matte cover			Relative proportion between *Posidonia oceanica* and dead matte

SI			Meadow cover	Substitutes cover		Relative proportion between *P. oceanica* and substitutes
Index	**Cellular**	**Species**	**Population**	**Community**	**Ecosystem**	**Seascape**
PSI			Meadow and dead matte cover	Substitutes cover		Relative proportion of *P. oceanica*, dead matte and substitutes
PI						Number of seagrass patches
EBQI		Growth rate of vertical rhizomes	Shoot density; meadow cover		Biomass, density, and species diversity in all the compartments; grazing index	

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Annex 1.~~1~~

Absolute c~~C~~lassification scales of the ecological status available in literature for some descriptors of *Posidonia oceanica* meadow

Meadow (population level)

Type of the lower limit (UNEP/MAP-RAC/SPA, 2009)

	High	Good	Moderate	Poor	Bad
Lower limit	Progressive	Sharp HC	Sharp LC	Sparse	Regressive

Type of the limit	Main characteristics
Progressive	Plagiotropic rhizome beyond the limit
Sharp – High cover (HC)	Sharp limit with cover higher than 25%
Sharp – Low cover (LC)	Sharp limit with cover lower than 25%
Sparse	Shoot density lower than 100 shoots · m^{-2}, cover lower than 15%
Regressive	Dead matte beyond the limit

Depth of the lower limit (in m) (UNEP/MAP-RAC/SPA, 2009)

	High	Good	Moderate	Poor	Bad
Lower limit	> 34.2	34.2 to 30.4	30.4 to 26.6	26.6 to 22.8	< 22.8

Meadow cover at the lower limit (in percentage) (UNEP/MAP-RAC/SPA, 2009)

	High	Good	Moderate	Poor	Bad
Lower limit	> 35%	35% to 25%	25% to 15%	15% to 5%8	< 5%

Shoot density (number of shoots · m^2) (Pergent-Martini et al., 2005)

Depth (m)	High	Good	Moderate	Poor	Bad
1	> 1133	1133 to 930	930 to 727	727 to 524	< 524
2	> 1067	1067 to 863	863 to 659	659 to 456	< 456
3	> 1005	1005 to 808	808 to 612	612 to 415	< 415
4	> 947	947 to 757	757 to 567	567 to 377	< 377
5	> 892	892 to 709	709 to 526	526 to 343	< 343
6	> 841	841 to 665	665 to 489	489 to 312	< 312
7	> 792	792 to 623	623 to 454	454 to 284	< 284
8	> 746	746 to 584	584 to 421	421 to 259	< 259
9	> 703	703 to 547	547 to 391	391 to 235	< 235
10	> 662	662 to 513	513 to 364	364 to 214	< 214
11	> 624	624 to 481	481 to 338	338 to 195	< 195
12	> 588	588 to 451	451 to 314	314 to 177	< 177
13	> 554	554 to 423	423 to 292	292 to 161	< 161
14	> 522	522 to 397	397 to 272	272 to 147	< 147
15	> 492	492 to 372	372 to 253	253 to 134	< 134
16	> 463	463 to 349	349 to 236	236 to 122	< 122
17	> 436	436 to 328	328 to 219	219 to 111	< 111
18	> 411	411 to 308	308 to 204	204 to 101	< 101
19	> 387	387 to 289	289 to 190	190 to 92	< 92
20	> 365	365 to 271	271 to 177	177 to 83	< 83
21	> 344	344 to 255	255 to 165	165 to 76	< 76
22	> 324	324 to 239	239 to 154	154 to 69	< 69
23	> 305	305 to 224	224 to 144	144 to 63	< 63
24	> 288	288 to 211	211 to 134	134 to 57	< 57
25	> 271	271 to 198	198 to 125	125 to 52	< 52
26	> 255	255 to 186	186 to 117	117 to 47	< 47
27	> 240	240 to 175	175 to 109	109 to 43	< 43
28	> 227	227 to 164	164 to 102	102 to 39	< 39
29	> 213	213 to 154	154 to 95	95 to 36	< 36
30	> 201	201 to 145	145 to 89	89 to 32	< 32
31	> 189	189 to 136	136 to 83	83 to 30	< 30
32	> 179	179 to 128	128 to 77	77 to 27	< 27
33	> 168	168 to 120	120 to 72	72 to 24	< 24
34	> 158	158 to 113	113 to 68	68 to 22	< 22
35	> 149	149 to 106	106 to 63	< 63	
36	> 141	141 to 100	100 to 59	< 59	
37	> 133	133 to 94	94 to 55	< 55	
38	> 125	125 to 88	88 to 52	< 52	
39	> 118	118 to 83	83 to 48	< 48	
40	> 111	111 to 78	78 to 45	< 45	

Plagiotropic rhizome at the lower limit (in percentage) (UNEP/MAP-RAC/SPA, 2009)

	High	Good	Moderate	Poor	Bad
Lower limit	> 70%	70% to 30%	< 30%		

Plant (~~individual~~ species level)

Foliar surface (in cm² per shoot), between June and July (UNEP/MAP-RAC/SPA, 2009)

Depth (m)	High	Good	Moderate	Poor	Bad
15 m	> 362	362 to 292	292 to 221	221 to 150	< 150

Number of leaves produced per year (UNEP/MAP-RAC/SPA, 2009)

Depth (m)	High	Good	Moderate	Poor	Bad
15 m	> 8.0	8.0 to 7.5	7.5 to 7.0	7.0 to 6.5	< 6.5

Rhizome elongation (in mm per year) (UNEP/MAP-RAC/SPA, 2009)

Depth (m)	High	Good	Moderate	Poor	Bad
15 m	> 11	11 to 8	8 to 5	5 to 2	< 2

Cell (physiological/biochemical level): environment eutrophication

Nitrogen concentration in adult leaves (in percentage), between June and July (UNEP/MAP-RAC/SPA, 2009)

Depth (m)	High	Good	Moderate	Poor	Bad
15 m	< 1.9%	1.9% to 2.4%	2.4% to 3.0%	3.0% to 3.5%	> 3.5%

Organic matter in the sediment (in percentage, fraction 0.063 mm) (UNEP/MAP-RAC/SPA, 2009)

Depth (m)	High	Good	Moderate	Poor	Bad
15 m	< 2.5%	2.5% to 3.5%	3.5% to 4.6%	4.6% to 5.6%	> 5.6%

Cell (physiological/biochemical level~~physiological level~~): environment contamination

Argent c~~C~~oncentration (mg per g DW), blade of adult leaves, between June and July (Salivas-Decaux, 2009)

Depth (m)	High	Good	Moderate	Poor	Bad
15 m	< 0.08	0.08 to 0.22	0.23 to 0.36	0.37 to 0.45	> 0.45

Cadmium c~~C~~oncentration (mg per g DW), blade of adult leaves, between June and July (Salivas-Decaux, 2009)

Depth (m)	High	Good	Moderate	Poor	Bad
15 m	< 1.88	1.88 to 2.01	2.02 to 2.44	2.45 to 2.84	> 2.84

Mercury c~~C~~oncentration (mg per g DW), blade of adult leaves, between June and July (Salivas-Decaux, 2009)

Depth (m)	High	Good	Moderate	Poor	Bad
15 m	< 0.051	0.051 to 0.064	0.065 to 0.075	0.075 to 0.088	> 0.088

Plumb c~~C~~oncentration (mg per g DW), blade of adult leaves, between June and July (Salivas-Decaux, 2009)

Depth (m)	High	Good	Moderate	Poor	Bad
15 m	< 1.17	1.17 to 1.43	1.44 to 1.80	1.81 to 3.23	> 3.23

2. Guidelines for monitoring coralligenous and other calcareous bioconstructions in ~~in~~ the upper- ~~circallitoral~~circalittoral Mediterranean zone

Introduction

1. The calcareous formations of biogenic origin in the Mediterranean Sea are represented by coralligenous reefs, vermetid reefs, reefs of *Sabellaria* spp., serpulid reefs, cold water corals reefs in deep waters, ~~*Lithophyllumbyssoides*concrations~~encrusting Corallinales concretions/trottoirs made by *Lithophyllum byssoides*, *Titanoderma trochanter*, and *Tenarea tortuosa*, banks formed by the corals *Cladocora caespitosa*, *Astroides calycularis*, *Phyllangia americana mouchezii*, *Polycyathus muellerae*, reefs formed by the stylasteridae *Errina aspera*, bryozoan nodules and biostalactites within semi-dark and dark caves, ~~sabellariid and serpulid worm reefs,~~ and rhodoliths seabeds. Among all, coralligenous reefs (Fig. 1) and rhodoliths seabeds (Fig. 2) are the two most typical and abundant bioconstructed habitats that develop in the Mediterranean upper circalittoral zone (sometimes also in the lower littoral zone), built-up by coralline algal frameworks that grow in dim light conditions, for which inventorying and mapping methods, as well as monitoring protocols, still lack of homogeneity and standardization.

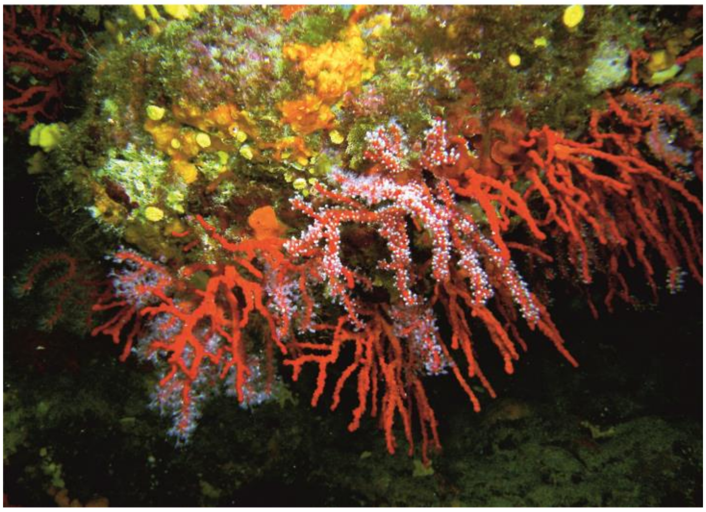


Figure 1: Coralligenous habitat dominated by the gorgonian *Paramuricea clavata* (upper panel © by Simone Musumeci), and facies with *Corallium rubrum* in enclave in the coralligenous (lower panel © Monica Montefalcone).

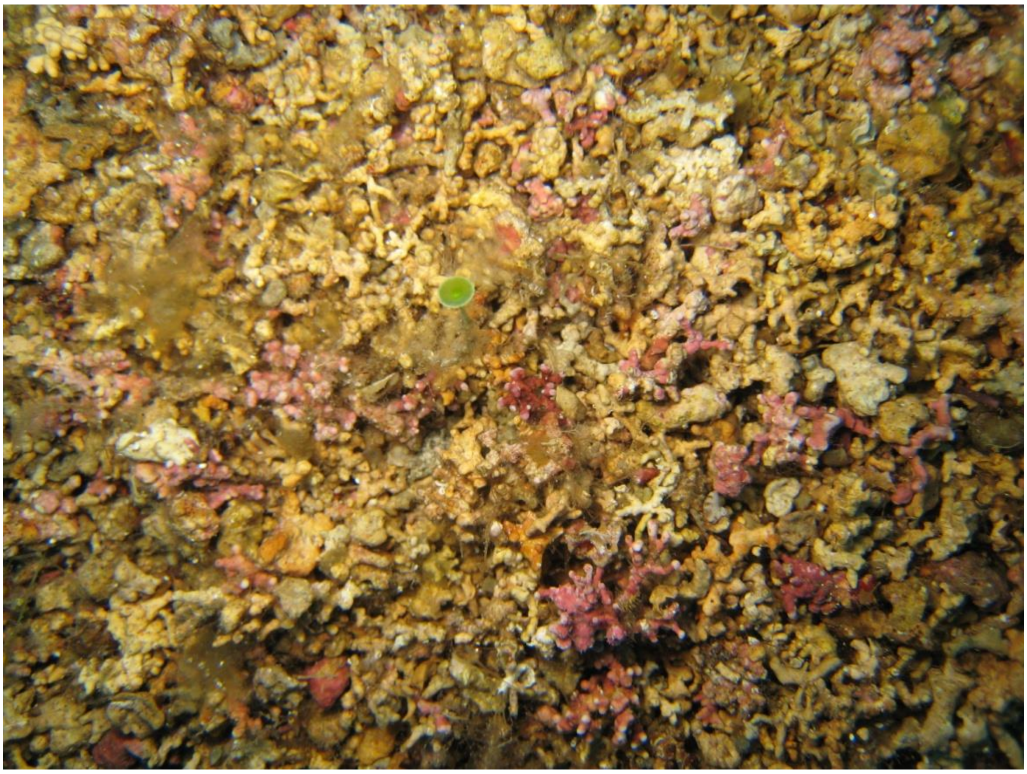


Figure 2: Rhodoliths habitat (photo from UNEP/MAP-RAC/SPA, 2015).

2. The most important and widespread bioconstruction in the Mediterranean Sea is represented by coralligenous reefs (UNEP/MAP-RAC/SPA, 2008), an endemic and characteristic habitat considered as the climax biocoenosis of in the upper circalittoral zone (Pérès and Picard, 1964). Coralligenous is characterised by high species richness, biomass, and carbonate deposition values comparable to tropical coral reefs (Bianchi, 2001), and with high economic values higher than seagrass meadows (Cánovas-Molina et al., 2014). Construction of coralligenous reefs started during the post-Würm transgression, about 15000 years ago, and developeds on rocky and biodetritic bottoms in relatively constant stable conditions of temperature, currents, and salinity.

3. Two main cCoralligenous reefs are distributed both on rocky and soft bottoms, developing different morphologiestypologies can be defined:, i) coralligenous developing on the upper circalittoral rocks and at the entrance of caves with (cliffs, or outcrops, banks, rims, atolls);, and ii) coralligenous developing over circalittoral soft/detritic bottoms creating biogenic platforms (Bonacorsi et al., 2012; Piazzi et al., 2019b). Coralligenous structure habitat results from the dynamic equilibrium between bioconstruction, mainly made by encrusting calcified Rhodophyta belonging to Corallinales and Peyssonneliales (such as species belonging to the genera *Lithophyllum*, *Lithothamnion*, *Mesophyllum*, *Neogoniolithon*, and *Peyssonnelia*), with an accessory contribution by serpulid polychaetes, bryozoans and scleractinian corals, and destruction processes (by borers and physical abrasion), which create a morphologically complex habitat where highly diverse benthic assemblages develop (Ballesteros, 2006). Light represents the main factor limiting bioconstruction, and coralligenous reefs are able tocan develop in dim light conditions (<3% of the surface irradiance), from about 20 m down to 120 m depth. Also, the upper mesophotic zone (where the light is still present, from 40 m to about 120 m depth), embracing the continental shelf, is shaped by extremely rich and diverse coralligenous assemblages dominated by animal forests that grow over biogenic rocky reefs.

4. Rhodoliths beds are composed by a variable thickness of free-living aggregations of live and dead thalli of calcareous red algae (mostly Corallinales, but also Peyssonneliales) and their fragments. They , createing a biogenic, unstable, three-dimensional habitat typically exposed to bottom currents, which harbours greater biodiversity in comparisoncompared to surrounding habitatsbottoms, and thus are viewed as an indicator of biodiversity hotspots. Rhodoliths beds They mostly (mainly?) occur on coastal detritic bottoms in the upper mesophotic circalittoral zone, between 40-60 m depth (Basso et al., 2016). Rhodoliths are made by slow growing organisms and can be long-lived (>100 years) (Riosmena-Rodríguez and Nelson, 2017). These algae can display a branching or a laminar appearance, can sometimes grow as nodules that cover all the seafloor, or accumulate within ripple marks. In the literature, the terms rhodoliths and maërl are often used as synonyms (UNEP/MAP-RAC/SPA, 2009). Maërl is the original Atlantic term to identify deposits of calcified non-nucleated algae mostly composed of *Phymatolithon calcareum* and *Lithothamnion corallioides*. Rhodoliths are intended as unattached nodules formed by calcareous red algae and their growths, showing a continuous spectrum of forms with size spanning from 2 to 250 mm of mean diameter. Thus, rhodoliths beds also includes maërl and calcareous *Peyssonnelia* beds, but the opposite is not true (Basso et al., 2016). Rhodoliths bed is recommended as a generic name to indicate those sedimentary bottoms characterised by any morphology and species of unattached non-geniculate calcareous red algae with >10% of live cover (Basso et al., 2016). The name maërl should be restricted to those rhodoliths beds that are composed of non-nucleated, unattached growths of branching, twig-like coralline algae.

5. Coralligenous reefs provide different ecosystem services to humans (Paoli et al., 2017), such as provisional (food, materials, habitat), regulating (carbon sequestration, nutrient recycling), and cultural services. but They are vulnerable to either global andor local impactspressures. Coralligenous is threatened by direct human activities, such as trawling, pleasure diving, illegal exploitation of protected species, artisanal and recreational fishery, aquaculture, and is also vulnerable to the indirect effects of climate change and global warming (e.g., positive thermal anomalies and ocean acidification) (UNEP/MAP-RAC/SPA, 2008). Some invasive algal species (e.g., *Womersleyella setacea*, *Acrothamnion preissii*, *Caulerpa cylindracea*) can also pose a severe threat to these communities, either by forming dense carpets or by increasing sedimentation rate.

6. Despite the occurrence of many species with high ecological value (some of which are also legally protected, e.g., *Savalia savaglia*, *Spongia (Spongia) officinalisSpongia officinalis*), coralligenous reefs were not listed among the priority habitats defined by the EU Habitat Directive (92/43/EEC), even if they can be included under the habitat "1170 Reefs" of thise Directive, and appear also in the Bern Convention. This implies that the most important Mediterranean bioconstruction still remainsremains without formal protection as it is not included within the list of Special ites of Areas of Community Interest Conservation (SACICs). Few years after the adoption of the Habitat Directive, coralligenous reefs were listed among the "special habitats types" needing rigorous protection by the Pprotocol concerning the sSpecial pProtected aAreas and bBiological dDiversity (SPA/BD Protocol) of the Barcelona Convention (1995). Only recently, in the frame of the "Action Plan for the Conservation of Coralligenous and other Mediterranean bio-constructions" (UNEP/MAP-RAC/SPA, 2008) adopted by Contracting Parties to Barcelona Convention in 2008 and updated in 2016, the legal conservation of coralligenous assemblages has been encouraged by the establishment of marine protected areas and the need for standardized programs for its monitoring has been emphasized. Coralligenous has also been included in the European Red List of marine habitats by IUCN, where the lower infralittoral coralligenous bioconcretions (code A5.6x) are classified as "near-threatened", and the circalittoral coralligenous bioconcretions (code A5.6y) as it is classified as "data deficient" (Gubbay et al., 2016), thus demonstrating the urgent need for thorough investigations and accurate monitoring plans. In the same year, the Marine Strategy Framework Directive (MSFD, 2008/56/EC) included "seafloor integrity" as one of the descriptors to be evaluated for assessing the Good Environmental Statuse of the marine environment. Biogenic structures, such as coralligenous reefs, have thus been recognized as important biological indicators of environmental quality.

7. Similarly, rhodolith~~s~~ seabeds are expected to be damaged by dredging, heavy anchors and mooring chains, and trawling and are adversely affected by rising temperatures and~~,~~ ~~and~~ ocean acidification ~~and trawling~~. Two maërl forming species, *Phymatolithon calcareum* and *Lithothamnion corallioides*, are protected under the EU Habitats Directive (92/43/EEC) in the Annex V and, in some locations, maërl is also a key habitat within the Annex I list of priority habitats of the Directive and therefore is given protection through the designation of Special Areas of Conservation (SACs). Moreover, a special plan for the legal protection of Mediterranean rhodoliths beds has been adopted within the framework of the "Action Plan for the Conservation of Coralligenous and other Mediterranean bio-constructions" (UNEP/MAP-SPA/RAC, 2017). Rhodolith~~s~~ seabeds have also been included in the Natura 2000 sites and in the Red List of Mediterranean threatened habitats by IUCN.

8. The Action Plan (UNEP/MAP-SPA/RAC, 2017) identified many priority actions for these two benthic habitats, which mainly concern:

(i) Increase the knowledge on the distribution (compiling existing information, carrying out field activities in new sites or in sites of particular interest) and on the composition (list of species) of these habitats;

(ii) Set up a standardized ~~spatio~~spatial-temporal monitoring protocol for coralligenous and rhodoliths habitats.

9. Detailed information on habitat geographical distribution and bathymetrical ranges is ~~a~~ prerequisite ~~knowledge~~ for ~~a~~ the sustainable use of marine coastal areas. Coralligenous and rhodoliths distribution maps are ~~thus~~ a fundamental prerequisite to any conservation action on these habitats and ~~on~~ their associated species (Azzola et al., 2021). The scientific knowledge concerning several aspects of biogenic concretions (e.g., taxonomy, processes, functioning, biotic relationships, and dynamics) ~~has been~~is currently increasing~~,~~. However, ~~but~~ it is still far away from the knowledge we have ~~from~~ on other coastal ecosystems, such as seagrass meadows, shallow coastal rocky reefs, etc. One of the major gaps concerning the current state of knowledge on coralligenous and rhodoliths habitats is the limited ~~spatio~~spatial-temporal studies on their geographical and depth distribution both at regional level and basin-wide scale. This information is essential ~~in order~~ to know the real extent of these habitats in the Mediterranean Sea and to implement appropriate management measures to guarantee their conservation (UNEP/MAP-SPA/RAC, 2017). Inventory and monitoring of coralligenous and rhodoliths raise several problems, due to their large bathymetric distribution and the consequent sampling constraints, ~~and~~ the ~~often limited~~often-limited accessibility, ~~their~~ heterogeneity, and the lack of standardized protocols used by different teams working in this field. The operational restrictions imposed by scuba diving (Gatti et al., 2012 and references therein) reduce the amount of collected data during each dive and increase the sampling effort. If some protocols for the inventory and monitoring of coralligenous habitat ~~do~~ exist, common methods for monitoring rhodoliths are comparatively less documented.

10. Responding to the need of practical guides aimed at harmonising existing methods for monitoring bioconstructed habitats ~~monitoring~~ and for subsequent comparison of results obtained by different countries, the Contracting Parties asked the Specially Protected Areas Regional Activity Centre (SPA/RAC) to improve the existing inventory tools and to propose a standardization of the mapping and monitoring techniques for coralligenous and rhodoliths. Thus, the main methods used in the Mediterranean for inventory and monitoring ~~of~~ the coralligenous habitat and other bioconstructions were summarised in the "Standard Methods for Inventorying and Monitoring Coralligenous and Rhodoliths Assemblages" (UNEP/MAP-RAC/SPA, 2015). These monitoring guidelines have been the ~~base~~ basis for the updating and harmonization process undertaken in this document.

11. For mapping coralligenous and other bioconstructed habitats, the previous Guidelines (UNEP/MAP-RAC/SPA, 2015) highlighted the following main findings:

- If underwater scuba diving is recommended often used for mapping and monitoring at small areasspatial scales and at shallower depths, it becomes unsuitable when the study area and/or the depth increase (usually at depths >40 m);

12. The use of aAcoustic survey methods (side scan sonar or multibeam echosounder) coupled with underwater visual observation systems (ROV, towed camera), which provide ground-truth data, becomes then dispensable at depths greater than 40 m.or underwater observation systems (ROV, towed camera) becomes then necessary. However, acoustic techniques must be always integrated and verified by a large number of "field" underwater data.

13.12. For monitoring the condition of coralligenous and other bioconstructed habitats, the previous Gguidelines (UNEP/MAP-RAC/SPA, 2015) highlighted the following main findings:

- Assessment of the condition of the populations is heavily dependent on the working scale and the resolution requested. Monitoring activities relies rely mainly on underwater scuba diving activities but given the above listed constraints, using other tools of investigation (e.g., ROV, towed camera) should be also considered because it they allows monitoring with less precision but on larger areas and at greater depths;

- Although the use of underwater photography or videovideorecording may be relevant, the use presence of specialists in taxonomy with a good experience in scuba diving surveying methods is often essential given the complexity of these habitats. If it is possible to estimate the aAbundance or coverage of specific taxa can be visually estimated underwater by standardized indiceson defined surfaces or along transects through standardized indices, detailed characterisations often require the use of square frames (quadrates), transects , or even the removal of all organisms on a given surface. The presences of broken individuals and of areas of necrosis are other factors to be considered;

- Monitoring of coralligenous habitat starts with the realisation of micro-mapping and then the application of applying descriptors and/or ecological indices. However, these descriptors vary widely from one team to another, as well as their measurement protocols;

- Monitoring of rhodoliths habitats can be done by underwater scuba diving, but as well as the byand visual observation inspection using ROVs or towed cameras and with the collection of collecting samples using dredges, grabs, or and box corers. are privileged because of the greater homogeneity of these populations. However At present, there is not yet any standardized method yet that has been widely accepted to date for monitoring rhodoliths, also because the action of hydrodynamics water movement may cause a shift of these habitats on the seabed making their inventory rather difficult.

14.13. In the framework of the Barcelona Convention Ecosystem Approach (EcAp) implementation and based on the recommendations raised during of the Mmeeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON), Biodiversity and Fisheries (Madrid, Spain, 28 February – 1 March 2017), the Contracting Parties requested SPA/RAC to develop standardized monitoring protocols to be used in the context of the Integrated Monitoring and Assessment Programme (IMAP),in order to ease the task for the countries when implementing their monitoring programmes.by The two considering the previous work guidelines elaborated published by SPA/RAC, the 'Standard methods for inventorying and monitoring coralligenous and rhodoliths assemblages'Guidelines for monitoring coralligenous and other bioconstructed habitats in Mediterranean (UNEP/MAP-RAC/SPA, 2015) and the 'Guidelines for inventorying and monitoring of dark habitats in the Mediterranean Sea' (SPA/RAC-UN Environment/MAP, OCEANA, 2017), have been, considered in the elaboration of this document. to be updated in the context of the IMAP common indicators in order to ease the task for the contries when implementing their monitoring programmes. A reviewing process on the available scientific literature, taking into accountconsidering the latest techniques and the recent works carried out by the scientific community at the international level, has also been also carried out. If standardized protocols for seagrass mapping and monitoring exist and are well-implemented, and ~~a number of~~several ecological indices have already been validated and inter-calibrated among different regions, this is not the case for coralligenous and rhodoliths habitats. In this document ~~a number of~~some ~~“minimal~~of the most adopted ~~”~~ descriptors ~~to be taken into account~~ for inventorying and monitoring the coralligenous and rhodoliths ~~populations~~ in the Mediterranean are described~~. The main methods adopted for their monitoring~~, with the relative advantages, restrictions, and conditions for their ~~of~~ use~~, are presented~~. Some of the ~~existing~~ monitoring methods for coralligenous have already been compared or cross-calibrated and results are ~~here briefly introducedreported~~briefly reported here. ~~and, finally, a~~A standardized ~~method~~ procedure recently proposed for coralligenous monitoring is also described.

Monitoring methods

a) COMMON INDICATOR 1: Habitat distributional range and extent

Approach

~~15.~~14. The CI1 ~~is aimed at providing~~aims to provide information about the geographical area in which coralligenous and rhodoliths habitats occur in the Mediterranean and the total extent of surfaces covered. Following the overall procedure suggested for mapping seagrass meadows in the Mediterranean, three main steps can be identified also for mapping bioconstructions (refer to the “Guidelines for monitoring marine vegetation in the Mediterranean” ~~in this document~~ for major details):

1) Initial planning, which includes the definition of the objectives ~~in order~~ to select the minimum surface to be mapped and the necessary resolution, tools, and equipment~~s~~;

2) Ground survey is the practical phase for data collection, it is the costliest phase as it generally requires field activities;

3) Processing and data interpretation requires knowledge and experience to ensure that data collected are usable and reliable.

Resolution

~~16.~~15. Measures of the total habitat extent may be subjected to high variability, as the final value is influenced by the methods used to obtain maps and by the resolution during both data acquisition and final cartographic restitution. Selecting an appropriate scale is ~~a~~ critical ~~stage~~ in the initial planning phase (Mc Kenzie et al., 2001). When large surface areas have to be mapped and global investigations carried out, an average precision and a lower detail ~~level~~ can be accepted, which means that the habitat distribution and the definition of its ~~extension limits~~boundaries are often only indicative. When smaller areas have to be mapped, ~~a~~ much higher precision and resolution ~~level is~~are required and it is easily achievable~~,~~ thanks to the high-resolution mapping techniques (e.g., multibeam echosounder) available to date. However, obtaining detailed maps is costly, thus practically impossible when time or resources are limited (Giakoumi et al., 2013). These detailed maps provide ~~an~~ accurate localisation of the habitat distribution and a precise definition of its ~~extension limits~~boundaries and total habitat extent, all features necessary for future control and monitoring purposes over ~~a period of~~ time. These high-resolution scales are also used to select remarkable ~~(great?)~~ sites where monitoring actions must be concentrated.

~~17.~~16. A scale of 1:10000 is the best choice for mapping rhodoliths beds at regional level. On this scale, it is possible to delimit areas down to about 500 m^2, which is a good compromise between precise rhodoliths beds delimitation and study effort on a regional basis. Conversely, a scale equal to

1:1000 (or larger) is suggested for detailed monitoring studies of selected rhodoliths beds, where the areal definition and the rhodoliths boundaries should be more accurately located and monitored through time. Two adjacent rhodoliths beds are considered separate if, at any point along their limits, a minimum distance of 200 m occurs (Basso et al., 2016).

~~18.~~17. Although we have an overall knowledge about the composition and ~~distribution~~ occurrence of coralligenous and rhodoliths habitats in the Mediterranean (Ballesteros, 2006; Relini, 2009; Relini and Giaccone, 2009; UNEP-MAP-RAC/SPA, 2009), the scarceness of fine-scale cartographic data on the ~~overall~~ geographical distribution of these habitats is one of the greatest lacunae from the conservation point of view. A first summary by Agnesi et al. (2008) highlighted the scarcity of available cartographic data, with less than 50 cartographies listed for the Mediterranean basin in that period. Most of the available maps are recent (less than ten years old) and are geographically disparate, mostly concerning the north-western Mediterranean basin. Another recent review (Martin et al., 2014) evidenced the occurrence of few datasets on coralligenous reefs and rhodoliths seabeds distribution, coming from 17 Mediterranean countries, and most of them being heterogeneous and with un-standardized legends, even within the same country. Updated data have also been collected in the last few years in some countries, thanks to the new monitoring activities afferent to the MSFD, and this information will become available in the coming years (see for instance Aguilar et al., 2018; SPA/RAC-UNEP/MAP, 2020).

~~19.~~18. Two global maps showing the distribution of coralligenous (Giakoumi et al., 2013) (Fig. 3) and maërl habitats (Martin et al., 2014) (Fig. 4) in the Mediterranean ~~have been~~were produced based on the review of available information. Coralligenous habitats cover a surface area of about 2763 km^2 in 16 Mediterranean countries, i.e. Albania, Algeria, Croatia, Cyprus, France, Greece, Italy, Israel, Lebanon, Libya, Malta, Monaco, Morocco, Spain, Tunisia, and Turkey. All other ecoregions presented lower coverage, with the Alboran Sea having the lowest. Very limited data were found ~~for~~ on the presence of coralligenous formations in the southern and the eastern coasts of the Levantine Sea, although recent information has become available from Lebanon (Aguilar et al., 2018; SPA/RAC-UNEP/MAP, 2020). Information was substantially greater for the northern than the southern part of the Mediterranean. The Adriatic and Aegean Seas presented the highest coverage in terms of presence of coralligenous formations, followed by the Tyrrhenian Sea and the Algero-Provencal Basin. This uneven distribution of data on coralligenous distribution in the Mediterranean is not only a matter of invested research effort or data availability, but also depends on the geomorphologic heterogeneity of the Mediterranean coastline and seafloor: the northern basin encompasses 92.3% of the Mediterranean rocky coastline, while the southern and the extreme south-eastern areas are dominated by sandy coasts (Giakoumi et al., 2013 and references therein). Hence, the extensive distribution of coralligenous in the Adriatic, Aegean, and Tyrrhenian Seas is highly related to the presence of extensive rocky coasts in these areas, with Italy, Greece, and Croatia covering 74% of the Mediterranean's rocky coasts.

~~20.~~19. Knowledge on rhodoliths/maërl seabeds was somewhat limited compared to what is available for coralligenous. Rhodoliths ~~Maërl~~ habitats cover a surface area of about 1654 km^2. Only sporadic and punctual information are available, mainly from the North Adriatic, the Aegean Sea~~s~~, and the Tyrrhenian Sea. Datasets are available for Greece, France (Corsica), Cyprus, Turkey, Spain, Lebanon, and Italy. Malta and Corsica~~, in particular, have~~ have significant datasets ~~for~~ on this habitat, as highlighted by fine-scale surveys in targeted areas (Martin et al., 2014).

~~21.~~20. These low-resolution global maps on coralligenous and rhodoliths distribution are still incomplete being the available information highly heterogeneous due to the high variability in ~~the~~ mapping and monitoring efforts across the Mediterranean basin; further mapping is thus required to determine the full extent of these highly variable habitats at the Mediterranean spatial scale. However, these global maps~~y~~ can be very useful for an overall knowledge of the bottom areas covered by coralligenous and rhodoliths, and to evaluate where surveys must be enforced in the future to collect missing data.

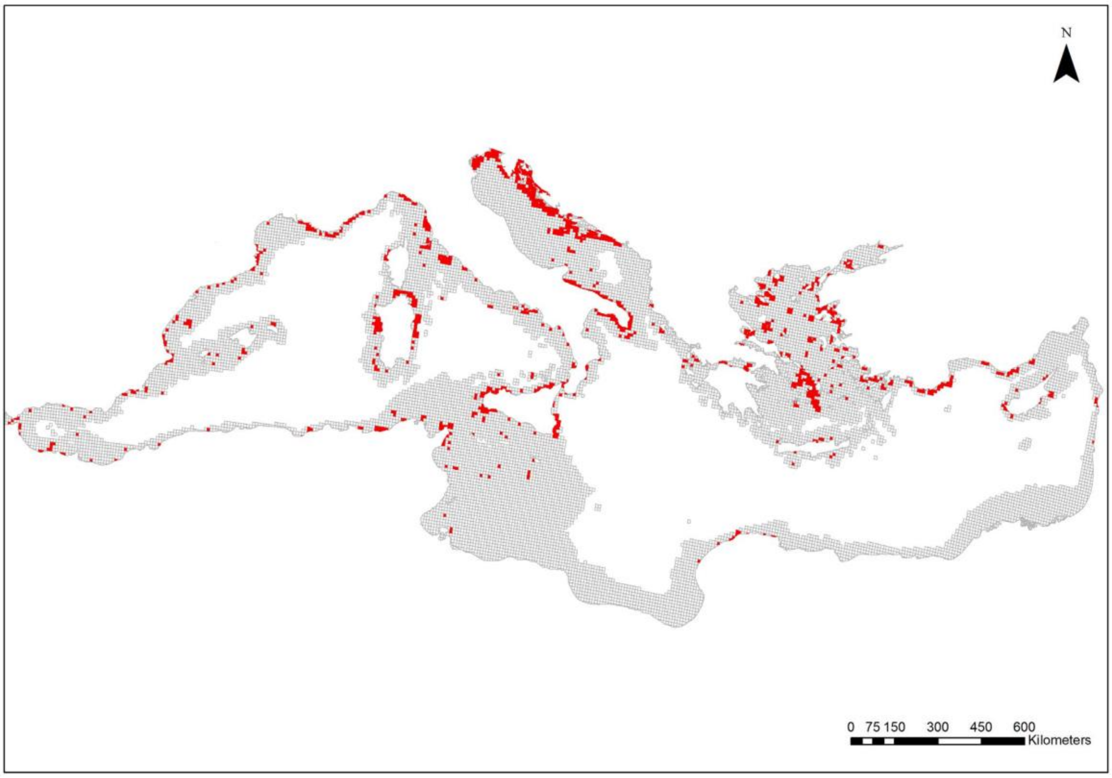


Figure 3: Global scale ~~D~~distribution of coralligenous habitat~~s~~ in the Mediterranean Sea (red areas) (from Giakoumi et al., 2013).

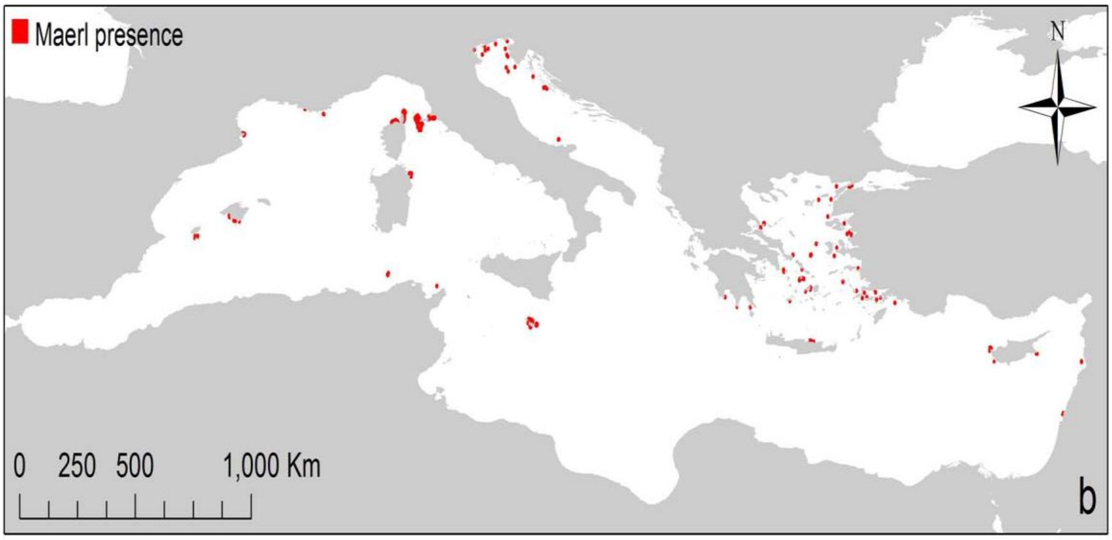


Figure 4: Global scale ~~D~~distribution of rhodoliths/maërl habitat~~s~~ in the Mediterranean Sea (red areas) (from Martin et al., 2014).

Methods

~~22.~~21. Definition of distributional ~~range~~ boundaries and extent of coralligenous and rhodolith~~s~~ habitats requires “traditional” habitat mapping techniques, ~~similar to~~like those used for seagrass meadows in deep waters (Tab. 1). ~~Indirect instrumental~~Remote sensing -mapping techniques and/or ~~direct~~ underwater ~~field~~ visual surveys ~~can be~~must be used and are often integrated. The simultaneous use of two or more mapping methods makes it possible to optimise the results being the information obtained complementary. The strategy to be adopted will ~~thus~~ depend on the ~~aim of the~~ study's aim and the area concerned, means, and time available ~~(The strategy to be adopted will depend on the study's aim and the area concerned, means, and time available ?)~~.

Underwater observations and sampling methods

~~23.~~22. Although underwater direct observation by scuba diving (e.g., visual assessments along transects~~using transects, permanent square frames~~) is often used for mapping small areas, this method of investigation quickly shows its limits when the study area ~~of study~~ and ~~the~~ depth increase significantly, even if the~~e technique~~ assessment can be ~~optimised~~ improved ~~for a general description of the site~~ through the integration with ~~a towed diver or~~ video transects ~~(Cinelli, 2009)~~. Direct underwater observations provide discrete punctual data that are vital for ground-truthing the instrumental surveys, and for the validation of modelled/interpolated continuous information (i.e., complete coverage of surface areas) obtained from data on limited portions of the study area or along the pathway. Field surveys must be sufficiently numerous and distributed appropriately to obtain the necessary precision, and especially in view of the high heterogeneity of the coralligenous and rhodoliths habitats.

~~24.~~23. *In situ* underwater observations represent the most reliable, although time-consuming, mapping technique of coralligenous habitat up to 30-40 m depth, according to local rules for safe scientific diving (Tab. 1). Surveys can be done along lines (transects)~~,~~ or over small surface areas (permanent ~~square frames~~quadrates) positioned on the seafloor and located to follow the limits of the habitat. ~~The~~ A transect consists of a marked line wrapped on a rib and laid on the bottom from fixed points and in a precise direction, typically perpendicular or parallel ~~with respect~~ to the coastline (Bianchi et al., 2004a). Any change~~s~~ in the habitat and ~~in~~ the substrate typology, within a belt at both sides of the line (considering a surface area of about 1-2 m per side), ~~are~~ is recorded on underwater slates. The information registered allows precise and detailed mapping of the sector studied (Tab. 1).

~~25.~~24. Scuba diving is also suggested as a safe and cost-effective tool to obtain a visual description and sampling of shallow rhodoliths beds up to 30-40 m depth, according to local rules for scientific diving (Tab. 1). Underwater observations are effective for a first characterisation of the aboveground facies of this habitat, ~~whilst to describe~~while describing the belowground community samples on the bottom become necessary. The surface of a living rhodoliths bed is naturally composed ~~of~~ (of)a variable amount of live thalli and their fragments, lying on a ~~variable~~ varying thickness of dead material and finer sediment. There ~~are~~ is no literature data about the required minimum spatial extent for a portion of the seafloor to be defined as a rhodoliths bed. A rhodoliths bed is defined as a habitat that is distinguished from the surrounding seafloor by having >10% of the mobile substrat~~eum~~ covered by live calcareous coralline algae as unattached branches and/or nodules (Basso et al., 2016). Live rhodoliths beds are naturally accompanied by a variable quantity of dead rhodoliths and their fragments; thus, a threshold of >50% of the surface covered by dead rhodoliths and their fragments is defined as the condition to identify a dead rhodoliths bed. A seafloor covered by incomplete algal coatings of lithic pebbles and shell remains should not be considered as a rhodoliths bed. The mandatory information needed for a first description of rhodoliths beds includes depth ranges, areal extent, occurrence of sedimentary structures on~~f~~ the seafloor (such as ripples, mega-ripples, and underwater dunes), thickness of live layer, ~~the~~ mean percentage cover of live thalli, live/dead rhodoliths ratio, dominant morphologies of rhodoliths (see Fig. 5). ~~and identification of the most common and volumetrically important species of calcareous algae. In this first description, the need for specialized taxonomists and the time-consuming laboratory analyses are kept to a minimum.~~

~~26.~~25. Recently an innovative tool, namely the BioCube, ~~which is~~ a 1 m high device that enables the acquisition of 80 cm × 80 cm frame photo-quadrates, has been implemented ~~for the characterisation~~to charecterise ~~of~~ the aboveground detritic and rhodoliths seabottoms without scuba diving (Astruch et al., 2019). Photo-quadrates were made with a digital video camera with 30 second-time lapse triggering. Another camera linked to a screen at the surface is fixed to the BioCube to control the workflow and the position of the frame in real time. During the data acquisition, a third camera is filming the surrounding ~~land~~seascape for complementary information on demersal fish and extent of assemblages.

26. Sampling methods from vessel~~s~~ involving blind grabs, dredges, and box corers in a number of randomly selected points within a study area can be used to check for the occurrence of deep rhodoliths beds (to ground-truth ~~of~~ the acoustic data) and for a complete taxonomical and structural description of the habitat (Tab. 1). The thickness of the live cover could be measured through the transparent or removable side of a box-corer. Alternatively, a sub-sample could be taken from the recovered box-core using a Plexiglas core of about 10 cm in diameter and at least 20 cm long. Box-coring with a cross-section ≥0.16 m^2 is recommended because it has the advantage of preserving the original substra~~tum~~te stratification. The use of destructive sampling methods from vessel for characterizing rhodoliths beds should be, however, as much as possible discouraged, in order to minimize the impact of the investigation.

27. The potential contribution of citizen science networks for mapping and monitoring coralligenous habitat should be mentioned (Gerovasileiou et al., 2017), especially for ~~the assessment~~assessing mass mortality events linked with global warming and heat waves (Garrabou et al., 2019). See for instance the initiatives available at http://cs.cigesmed.eu/en and https://t-mednet.org/mass-mortality/mass-mortality-events). The CIGESMED protocol, in particular, has already been applied in different parts of the Mediterranean (David et al., 2014; Çinar et al., 2020).

Remote sensing surveys

28. Being the ~~bioconstructed~~ biogenic coralligenous and rhodoliths habitats mainly distributed ~~in deep waters (~~down to ~~20~~ 30 m depth~~)~~, the remote sensing acoustic techniques (~~e.g.,~~ side scan sonar~~,~~ and multi-beam echosounder) ~~or~~ and the underwater video recording~~s~~ (through ROVs and~~,~~ towed cameras) are usually recommended (Georgiadis et al., 2009). The use of remote sensing allows characterising extensive coastal areas ~~for assessment of the~~ to define the overall spatial patterns of coralligenous and rhodoliths habitats. From maps obtained through remote sensing surveys, the presence/absence of the habitat, its ~~distributional~~ bathymetrical ranges, its boundaries, and the total habitat extent can be ~~easily~~ obtained. Acoustic methods are presently the most convenient technique for mapping rhodoliths beds, associated with ground-truthing by ROV and/or box-coring. The percentage cover of live thalli over a wide area can also be assessed from a ROV survey. Using acoustic techniques, associated with a good geo-location system, allows monitoring change in the extent of rhodoliths habitat over time (Bonacorsi et al., 2010).

29. Visual ~~O~~observations from the surface can be made by using imagery techniques such as photography and videorecording. Photographic equipment and cameras can be mounted on a vertical structure (sleigh or platform) or within remotely operated vehicles (ROVs). The camera on a vertical structure is submerged at the back of the vessel and is towed by the vessel that advances very slowly (under 1 knot), whil~~est~~e the ROVs have their own propulsion system and are remotely controlled from the surface. The use of towed ~~video cameras~~video cameras (or ROVs) during surveys makes it possible to see the images on the screen in real time, ~~to~~ identify specific features of the habitat, and ~~to~~ evaluate any change~~s~~ in the habitat or in ~~any~~ other characteristic elements of the seafloor. ~~, and~~T ~~t~~his preliminary video survey may be also useful to locate specific monitoring stations. Recorded images are then reviewed to obtain a cartographical restitution on a GIS platform for each ~~of the~~ area~~s~~ surveyed. To facilitate and ~~to~~ improve the results obtained with the camera, joint acquisition modules integrating the depth, images of the seafloor, and geographical positioning have been developed (UNEP/MAP-RAC/SPA, 2015).

30. Sonar provides images of the seafloor through the emission and reception of ultrasounds. Amongst the main acoustic mapping techniques available (Kenny et al., 2003), wide acoustic beam systems like the side scan sonar (SSS) and the multi-beam echosounder are usually employed in mapping coralligenous and rhodoliths habitats. All the acoustic mapping techniques are intrinsically affected by uncertainties due to manual classification of the different acoustic signatures

~~of~~ associated ~~to~~with substrate types on sonograms. Errors in sonogram~~s~~ interpretation may arise when two substrate types are not easily distinguished by the observer. Interpretation of remote sensing data requires extensive field calibration and the ground-truthing process remains essential. As the interpretation of sonograms is time-requiring, several automatic supervised processing techniques ~~were~~ have been recently proposed ~~in order~~ to rapidly automate the interpretation and the classification of acoustic signatures ~~sonograms~~ and to make this interpretation more reliable (Montefalcone et al., 2013 and references therein; Viala et al., 2021), also considering that current technology provides systems of neural networks and artificial intelligence to support these operations. These classification methods allow for ~~a~~ good discrimination between soft sediments and rocky reefs. Human eye, however, always remains the final judge.

Modelling

~~30.~~31. Modelling techniques can be used to fill the gaps in the knowledge of the spatial distribution of habitats by predicting the areas that are likely to be suitable for a community to live. Models are usually based on physical and environmental variables (e.g., water temperature, salinity, depth, water movement, nutrient concentrations, seabed types), which are typically easier to record and map at ~~the~~ regional and global scales, in contrast to data on species and habitats ~~data~~. A recent study showed~~s~~ the correlation between wind-wave energy at the ~~sea~~ bottom and the rhodoliths bed presence (Agnesi et al., 2020)~~.,~~ ~~i~~It also provided~~s~~ the confidence interval of this ~~enviromental~~environmental variable associated with the probability ~~to the~~ of rhodoliths beds to occur, ~~probability~~ therefore informing on the wave energy values required for the modelling in the off-shore ~~continenta therefore informing on wave energy values reuired for the modelling in the off-shore~~ continental shelf ~~(Agnesi et al., 2020)~~. Despite inherent limitations and associated uncertainties, predictive modelling is a cost-effective alternative to field surveys as it can help identifying and mapping areas where sensitive marine ecosystems may occur. Based on the spatial datasets available for coralligenous and rhodoliths populations, a predictive modelling was carried out to produce two continuous maps of these two habitats across the Mediterranean Sea (Martin et al., 2014). For coralligenous, bathymetry, slope of the seafloor, and nutrient input were the three main contributors to the model. Predicted areas with suitable conditions for the occurrence of coralligenous habitat have been ~~reported~~ defined in the North African coast, ~~for which~~ where there are no available cartographic data to date. For rhodoliths, phosphate concentration, geostrophic velocity of sea surface current, silicate concentration, and bathymetry were the four main contributors to the model. Given the ~~paucity~~ lack of occurrence data for this habitat across the Mediterranean, and especially in the North African coast~~,~~ and the ~~s~~Southern Levantine coast, the model output is relatively informative in highlighting several suitable areas where no cartographic data are available to date.

~~31.~~32. A recent application of predictive spatial modelling was done starting from a complete acoustic coverage of the seafloor ~~together~~ combined with ~~a comparatively low number of~~ sea-truthing~~s~~ underwater observations made by scuba diving (Vassallo et al., 2018). This approach was applied to the coralligenous reefs of the Marine Protected Area of Tavolara - Punta Coda Cavallo (NE Sardinia, Italy), through a fuzzy clustering on a set of *in situ* observations. The model allowed recognising and mapping the coralligenous habitat~~s~~ within the MPA and showed that the distribution of the habitat~~s~~ was mainly driven by the distance from coast, the depth, and the lithotypes. ~~Ano~~Other examples of habitat predictions can be found in Zapata-Ramírez et al. (2016) and Rossi et al. (2021).

Table 1: Synthesis of the main survey tools used for defining the Common Indicator 1_Habitat distributional range and extent for coralligenous and rhodoliths habitats. When available, the depth range, the surface area mapped, the spatial resolution, the efficiency (expressed as area mapped in km^2 per hour), the main advantages or the limits of each tool are indicated, with some bibliographical references.

Survey tool	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Underwater diving and visual surveys	0 m up to 40 m, according to local rules on safe scientific diving	Small areas, less than 250 m^2	From 0.1 m	0.0001 to 0.001 km²/hour	• Very great precision for in the identification (taxonomy) and distribution of species (micro-mapping) • Non-destructive • Low cost, easy to implement	• Small area inventoriied • Very time-consuming • Limited operational depth • Highly qualified scientific divers required (safety constraints) • Variable geo-referencing of the dive site	Piazzi et al. (2019a, and references therein)
Transects by towed divers	0 m up to 40 m, according to local rules on scientific diving	Intermediate areas (less than 1 km^2)	From 1 to 10 m	0.025 to 0.01 km²/hour	• Easy to implement and possibility of taking pictures • Good identification of populations • Non-destructive and low cost	• Time-consuming • Limited operational depth • Highly qualified divers required (safety constraints) • Variable geo-referencing of the diver route • Water transparency	Cinelli (2009)
Sampling from vessels with blind grabs, dredges, or box corers	0 m to about 50 m (until the lower limit of the rhodoliths habitatbed)	Intermediate areas (a few km^2)	From 1 to 10 m	0.025 to 0.01 km²/hour	• Very great precision for the identification (taxonomy) and distribution of species (micro-mapping) • All species taken into accountidentified • Possibility of *a posteriori* identification • Low cost, easy to implement	• Destructive method • Small area inventoriied • Need of Ssampling materials needed • Analyses on samples Work takes a lot of timevery time-consuming • Limited operational depth • Difficulty in collecting representative samples	UNEP/MAP-RAC/SPA (2015)

Survey tool	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Side scan sonar	8 m to over 120 m (until the lower limit of the coralligenous habitat)	From intermediate to large areas (50-100 km²)	<1 m	1 to 4 km²/hour	• Wide bathymetric range • Realistic representation of the seafloor • Good identification of the nature of the bottom and of assemblages (rhodoliths) • Quick execution • Very big mass of data • Non-destructive	• Flat (2D) picture to represent 3D complex habitats • Possible errors in sonograms interpretation • Acquisition of field data necessary to validate sonograms • High cost • Not effective for mapping vertical slopes	Cánovas-Molina et al. (2016b)
Side scan sonar	8 m to over 120 m (until the lower limit of the coralligenous habitat)	From intermediate to large areas (50-100 km²)	From ≤1 m	1 to 4 km²/hour	• Wide bathymetric range • Realistic representation of the seafloor • Good identification of the nature of the bottom and of assemblages (rhodoliths) with location of edges • Quick execution • Very big mass of data • Non-destructive	• Flat (2-D) picture to represent 3-D complex habitat • Possible errors in sonograms interpretation • Acquisition of field data necessary to validate sonograms • High cost • Not very used for mapping vertical slopes	CánovasMolina et al. (2016b)
Survey tool	**Depth range**	**Surface area**	**Resolution**	**Efficiency**	**Advantages**	**Limits**	**References**

Multi-beam echosounder	2 m to over 120 m (until the lower limit of the coralligenous habitat)	From small areas (a few hundred square meters) to large areas (50-100 km²)	From 50 cm (linear) and lower than few centimeteres	0.5 to 6 km²/hour	• Possibility of to obtaining 3-D picturerepresentation of the seafloor • Double information collected (bathymetry and seafloor image) • Very precise and wide bathymetric range • Quick execution • Very big mass of data • Non-destructive	• Less precise imaging recognition of the(nature of the seabed) than side scan sonar • Acquisition of field data necessary to validate the sonogramsinterpretation of acoustic data • High cost	Cánovas-Molina et al. (2016b)
Remote Operating Vehicle (ROV)	2 m to over 120 m (until the lower limit of the coralligenous habitat)	Small-intermediate areas (a few km²)	From 1 m to 10 m	0.025 to 0.01 km²/hour	• Non-destructive • Possibility of taking to collect pictures • Good identification of habitat and conspicuous species • Wide bathymetric range	• High cost	Cánovas-Molina et al. (2016a); Enrichetti et al. (2019)
Survey tool	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References

Towed camera	2 m to over 120 m (until the lower limit of the coralligenous habitat)	Intermediate-large areas (a fewsome km²)	From 1 m to 10 m	0.025 to 1 km²/hour	• Easy to implement and possibility to collect of taking pictures • Good identification of habitat and conspicuous species • Non-destructive • Large area covered	• Limited to homogeneous and horizontal bottoms • Slow recording and processing of information • Variable positioning (geo-referencing) • Water transparency • Hard to handle in in the case of heavy nautical heavy surface traffic	UNEP/MAP-RAC/SPA (2015)

Data interpretation

32.33. Once the surveying is completed, data collected need to be organized so in order to that they can be used in the future by everyone and can be appropriately archived and easily consulted. A clear definition of all metadata must be provided with the dataset in order toto ensure future integration with similar data from other sources. To produce a habitat map, Ffour important steps for the production of a habitat map must be followed:

a. Processing, analysis and classification of the biological data, and their correct and precise geolocation, through a process of interpretation of acoustic images when available;

b. Selecting the most appropriate physical layers (e.g., substrate, bathymetry, hydrodynamics);

c. Integration of biological data and physical layers, and use of statistical modelling to predict habitat distribution and interpolate punctual information;

d. The map produced must then be evaluated for its accuracy, i.e. its capacity to represent reality, and therefore its reliability.

34. During the first processing analysis and classification step, a standardised classification system must be used to label and classify benthic habitats on resulting maps and to ensure the uniformity and the readability of the final maps. The two recently updated lists of benthic marine habitat types should be consulted, which are: 1) the EUropean Nature Information System (EUNIS) proposed for the European seas (available at http://eunis.eea.europa.eu; Evans et al., 2016); and 2) the Barcelona Convention classification of marine benthic habitat types adopted for the Mediterranean region by the Contracting Parties (available at https://www.rac-spa.org/sites/default/files/doc_fsd/habitats_list_en.pdf; SPA/RAC-UN Environment/MAP, 2019a, b; Montefalcone et al., 2021). The two updated lists identify the specific coralligenous and rhodolith habitats that may be found from the infralittoral zone to the circalittoral zone, with their main characteristic associations and facies. The first original description of habitat types for the Mediterranean has been revised in 2015 (UNEP/MAP-RAC/SPA, 2015b), but a new updated interpretation manual of all the updated reference habitat types for the Mediterranean region is under elaboration, which also provides the criteria for their identification. Habitats of coralligenous and rhodoliths listed in the updated Barcelona Convention classification system are the following (SPA/RAC-UN Environment/MAP, 2019a, b):

the updated list of benthic marine habitat types for the Mediterranean region[1] should be consulted (UNEP/MAP-SPA/RAC, 2019) to recognize any specific habitat type (i.e., coralligenous or rhodoliths) and its main characteristic associations and facies. A description of these habitats and the criteria for their identification are also available in Bellan-Santini et al. (2002). Habitats that must be reported on maps are the following (UNEP/MAP-SPA/RAC, 2019):

INFRALITTORAL

MB1.5 Infralittoral rock

MB1.55 Coralligenous (enclave of circalittoral, see MC1.51)

CIRCALITTORAL

MC1.5 Circalittoral rock

[1]The updated list of benthic marine habitat types for the Mediterranean region is in a draft stage. It was endorsed by the 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 (Roma, Italy 22-23 January 2019). The draft updated list will be examined by the 14th Meeting of SPA/BD Focal Points (Portoroz, Slovenia, 18-21 June 2019) and submitted to the MAP Focal Points meeting and to the 21st Ordinary Meeting of the Contracting Parties, for adoption.

MC1.51 Coralligenous cliffs

MC1.51a Algal-dominated coralligenous

MC1.511a Association with encrusting Corallinales

MC1.512a Association with Fucales or Laminariales

MC1.513a Association with sciaphilic algae, (except Fucales, Laminariales, encrusting Corallinales, and Caulerpales)

MC1.514a Association with non-indigenous Mediterranean *Caulerpa* spp.

MC1.51b Invertebrate-dominated coralligenous

MC1.511b Facies with small sponges

MC1.512b Facies with large and erect sponges

MC1.513b Facies with Hydrozoa

MC1.514b Facies with Alcyonacea

MC1.515b Facies with Ceriantharia

MC1.516b Facies with Zoantharia

MC1.517b Facies with Scleractinia ~~MC1.51b Invertebrate-dominated coralligenous~~

MC1.518b Facies with Vermetidae and/or Serpulidae

MC1.519b Facies with Bryozoa

MC1.51Ab Facies with Ascidiacea

MC1.51c Invertebrate-dominated coralligenous covered by sediment

See MC1.51b for examples of facies

MC1.52 Continental shelf rock

MC1.52a Coralligenous outcrops

MC1.521a Facies with small sponges

MC1.522a Facies with Hydrozoa

MC1.523a Facies with Alcyonacea

MC1.524a Facies with Antipatharia

MC1.525a Facies with Scleractinia

MC1.526a Facies with Bryozoa

MC1.527a Facies with Polychaeta

MC1.528a Facies with Bivalvia

MC1.529a Facies with Brachiopoda

MC1.52b Coralligenous outcrops covered by sediment

See MC1.52a for examples of facies

MC1.52c Deep banks

MC1.521c Facies with Antipatharia

MC1.522c Facies with Alcyonacea

MC1.523c Facies with ScleractiniaMC1.511b Facies with small sponges (sponge ground, e.g. *Ircinia* spp.)

MC1.512b Facies with large and erect sponges (e.g. *Spongia lamella*, *Sarcotragus foetidus*, *Axinella* spp.)

MC1.513b Facies with Hydrozoa

MC1.514b Facies with Alcyonacea (e.g. *Eunicella* spp., *Leptogorgia* spp., *Paramuricea* spp., *Corallium rubrum*)

MC1.515b Facies with Ceriantharia (e.g. *Cerianthus* spp.)

MC1.516b Facies with Zoantharia (e.g. *Parazoanthus axinellae*, *Savalia savaglia*)

MC1.517b Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Leptopsammia pruvoti*, *Madracis pharensis*)

MC1.518b Facies with Vermetidae and/or Serpulidae

MC1.519b Facies with Bryozoa (e.g. *Reteporella grimaldii*, *Pentapora fascialis*)

MC1.51Ab Facies with Ascidiacea

MC1.51c Invertebrate-dominated coralligenous covered by sediment

See MC1.51b for examples of facies

MC1.52 Shelf edge rock

MC1.52a Coralligenous outcrops

MC1.521a Facies with small sponges (sponge ground)

MC1.522a Facies with Hydrozoa

MC1.523a Facies with Alcyonacea (e.g. *Alcyonium* spp., *Eunicella* spp., *Leptogorgia* spp., *Paramuricea* spp., *Corallium rubrum*)

MC1.524a Facies with Antipatharia (e.g. *Antipathella subpinnata*)

MC1.525a Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madracis pharensis*)

MC1.526a Facies with Bryozoa (e.g. *Reteporella grimaldii*, *Pentapora fascialis*)

MC1.527a Facies with Polychaeta

MC1.528a Facies with Bivalvia

MC1.529a Facies with Brachiopoda

MC1.52b Coralligenous outcrops covered by sediment

See MC1.52a for examples of facies

MC1.52c Deep banks

MC1.521c Facies with Antipatharia (e.g. *Antipathella subpinnata*)

MC1.522c Facies with Alcyonacea (e.g. *Nidalia studeri*)

MC2.5 Circalittoral biogenic habitat

MC2.51 Coralligenous platforms

MC2.511 Association with encrusting Corallinales

MC2.512 Association with Fucales

MC2.513 Association with non-indigenous Mediterranean Caulerpa spp.

MC2.514 Facies with small sponges

MC2.515 Facies with large and erect sponges

MC2.516 Facies with Hydrozoa

MC2.517 Facies with Alcyonacea

MC2.518 Facies with Zoantharia

MC2.519 Facies with Scleractinia

MC2.51A Facies with Vermetidae and/or Serpulidae

MC2.51B Facies with Bryozoa

MC2.51C Facies with Ascidiacea MC1.523c Facies with Scleractinia (e.g. *Dendrophyllia* spp.)

MC1.531d Facies with Heteroscleromorpha sponges

MC2.5 Circalittoral biogenic habitat

MC2.51 Coralligenous platforms

MC2.511 Association with encrusting Corallinales

MC2.512 Association with Fucales

MC2.513 Association with non-indigenous Mediterranean Caulerpa spp.

MC2.514 Facies with small sponges (sponge ground, e.g. Ircinia spp.)

MC2.515 Facies with large and erect sponges (e.g. Spongia lamella, Sarcotragusfoetidus, Axinella spp.)

MC2.516 Facies with Hydrozoa

MC2.517 Facies with Alcyonacea (e.g. Alcyonium spp., Eunicella spp., Leptogorgia spp., Paramuricea spp., Corallium rubrum)

MC2.518 Facies with Zoantharia (e.g. Parazoanthusaxinellae, Savaliasavaglia)

MC2.519 Facies with Scleractinia (e.g. Dendrophyllia spp., Madracispharensis, Phyllangiamouchezii)

MC2.51A Facies with Vermetidae and/or Serpulidae

MC2.51B Facies with Bryozoa (e.g. Reteporella grimaldii, Pentapora fascialis)

~~MC2.51C Facies with Ascidiacea~~

~~MC3.5 Circalittoral coarse sediment~~MC3.5 Circalittoral coarse sediment

MC3.51 Coastal detritic bottoms

MC3.511 Association with Laminariales

MC3.512 Facies with large and erect sponges

MC3.513 Facies with Hydrozoa

MC3.514 Facies with Alcyonacea

MC3.515 Facies with Pennatulacea

MC3.516 Facies with Polychaeta (*Salmacina-Filograna* complex included)

MC3.517 Facies with Bivalvia

MC3.518 Facies with Bryozoa

MC3.519 Facies with Crinoidea

MC3.51A Facies with Ophiuroidea

MC3.51B Facies with Echinoidea

MC3.51C Facies with Ascidiacea

MC3.52 Coastal detritic bottoms with rhodoliths

MC3.521 Association with maërl

MC3.522 Association with Peyssonnelia spp.

MC3.523 Association with Laminariales

MC3.524 Facies with large and erect sponges

MC3.525 Facies with Hydrozoa

MC3.526 Facies with Alcyonacea

MC3.527 Facies with Pennatulacea

MC3.528 Facies with Zoantharia

MC3.529 Facies with Ascidiacea

~~MC3.52 Coastal detritic bottoms with rhodoliths~~

~~MC3.521 Association with maërl (e.g. *Lithothamnion* spp., *Neogoniolithon* spp., *Lithophyllum* spp., *Spongitesfruticulosa*)~~

~~MC3.522 Association with *Peyssonnelia* spp.~~

~~MC3.523 Association with Laminariales~~

~~MC3.524 Facies with large and erect sponges (e.g. *Spongia lamella*, *Sarcotragusfoetidus*, *Axinella* spp.)~~

~~MC3.525 Facies with Hydrozoa~~

~~MC3.526 Facies with Alcyonacea (e.g. *Alcyonium* spp., *Paralcyoniumspinulosum*)~~

MC3.527 Facies with Pennatulacea (e.g. *Veretillumcynomorium*)

MC3.528 Facies with Zoantharia (e.g. *Epizoanthus* spp.)

MC3.529 Facies with Ascidiacea

33.35. The selection of physical layers to be shown on maps and to be used for following predictive statistical analyses may be an interesting approach within the general framework of mapping coralligenous and rhodolith habitats, reducing, as it would reduce the processing time. However, it is still of little use as only few physical parameters are able to clearly predict the distribution of these two habitats, e.g., bathymetry, slope of the seafloor, and nutrient input for coralligenous and phosphate concentration for coralligenous, geostrophic velocity of sea surface current, silicate concentration, and bathymetry for rhodoliths (Martin et al., 2014).

34.36. The data integration and modelling is are often a necessary step because indirect visual or remote sensing surveys from vessels are limited due to time and costs involved, and only rarely allow obtaining a complete coverage of the study area. Coverage under 100% automatically means that it is impossible to obtain get high resolution maps and therefore interpolation procedures have tomust be used, so that from partial surveys a lower resolution map can be obtained. Spatial interpolation is a statistical procedure for estimating data values at unsampled sites between locations where actual data have been collectedion locations. For elaborating the final distribution map of benthic habitats on a GIS platform, different spatial interpolation tools (e.g., Inverse Distance Weighted, Kriging) can be used and are provided by the GIS software. Even though this is rarely mentioned, it is important to provide information on the number and the percentage of data acquired on field and the percentage of interpolations run.

35.37. The processing and digital analysis of acoustic data on GIS allows creating charts where each tonality of grey is associated to with a specific texture representing a type of habitat or substrate, also on the basis of the *in situ* observations. Although remote sensing data must be always integrated by a great amount of field visual inspections for ground-truthing, especially given the 3-D distribution and complexity of the coralligenous seascape developing over hard substrates, high quality bathymetric data often constitutes an indispensable and appreciated element.

36.38. To facilitate the comparison among maps, the standardized red colour is generally used for the graphic representation of coralligenous and rhodolith habitats. On the resulting maps the habitat distributional range (its boundaries and bathymetric limits) and its total extent (expressed in square meters or hectares) can be defined. This ese maps could also be also compared with previous historical available data from literature to evaluate any changes experienced by benthic habitats over a period of time (Giakoumi et al., 2013). Using the overlay vector methods on GIS, a diachronic analysis can be done, where temporal changes are measured in terms of percentage gain or loss of the habitat extension, through the creation of concordance and discordance maps (Canessa et al., 2017).

37.39. Finally, reliability of the map produced should be evaluated. No evaluation scales of reliability have been proposed for coralligenous and rhodolithss habitat mapping; however, scales of reliability evaluation available for seagrass meadows can be adapted also for these two habitats (see the "Guidelines for monitoring marine vegetation in the MediterraneanGuidelines on marine vegetation" in this document for further details). These scales usually take into accountconsider the processing of sonograms, the scale of data acquisition and restitution, the methods adopted, and the positioning system.

b) COMMON INDICATOR 2: Condition of the habitat's typical species and communities

Approach

38.40. Monitoring are is necessary for conservation purposes, which require efficient management measures to ensure that marine benthic habitats, their constituent speciesspecies, and their associated communities are and remain in a satisfactorya good ecological status. The good state of health of both coralligenous and rhodolith habitats will then reflect the Good Environmental Status (GES) pursued by the Contracting Parties to the Barcelona Convention under the Ecosystem Approach (EcAp) and under the Marine Strategy Framework Directive (MSFD).

39.41. Monitoring the condition (i.e., the ecological status) of coralligenous and rhodolith habitats is today mandatory also because:

- Two maërl forming species, *Phymatolithon calcareum* and *Lithothamnion corallioides*, are protected under the EU Habitats Directive (92/43/ EEC) in the Annex V;
- Coralligenous reefs and rhodoliths seabeds are listed among the "special habitatshabitat types" needing rigorous protection by the pProtocol concerning the Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol) of the Barcelona Convention.

40.42. According to the EcAp, the CI2 fixed by the Integrated Monitoring and Assessment Programme and related Assessment Criteria (IMAP) guidelines and related to "biodiversity" (EO1) is aimed at providing information about the condition (i.e., ecological status) of coralligenous and rhodoliths habitats, as they being represent two of the main hotspots of biodiversity in the Mediterranean (UNEP/MAP, 2008). The MSFD (2008/56/EC) included both "biological diversity" (D1) and "seafloor integrity" (D6) as descriptors to be evaluated for assessing the GES of the marine environment. In this regard, biogenic structures, such as coralligenous reefs and rhodolith sseabeds, have been recognized as important biological indicators of environmental quality.

41.43. A defined and standardized procedure for monitoring the status of coralligenous and rhodoliths habitats, comparable to that provided for their mapping, should follow these three main steps:

a. Initial planning, to define objective(s), duration, sites to be monitored, descriptors to be evaluated, sampling strategy, human, technical and financial needs;

b. Setting-up the monitoring system and realisation of the monitoring program. This phase includes costs for going out to sea during field activities, equipment for sampling, and human resources. To ensure effectiveness of the program, field activities should be planned during a favourable season, and it would be preferred to repeat monitormonitoring during the same season;

c. MMonitoring over time and data analysis. During these activities, is a step where clear robust scientific competences are needed because the acquired data must be interpreted. Duration of the monitoring, in order to be useful, must be medium time at least.

42.44. The objectives of the monitoring are primarily linked with the conservation of bio-constructed genic habitats, but they also answer to the necessity of using them as ecological indicators of the marine environment quality. The main aims of the monitoring programs are generally:

- Preserve and conserve the heritage of bioconstructions, with the aim of ensuring thatto ensure that coralligenous and rhodoliths habitats are in a satisfactorya good ecological status (GES), and alsoand identify as early as possible any degradation of these habitats or any changes in their distributional range and extent. Assessment of the ecological status of these habitats allows measuring the effectiveness of local or regional policies in terms of management of the coastal environment;

- Build and implement a regional integrated monitoring system of the quality of the environment, as requested by the ~~Integrated Monitoring and Assessment Programme and related Assessment Criteria (~~IMAP~~)~~ during the implementation of the EcAp in the framework of the Mediterranean Action Plan (UNEP/MAP, 2008). The main goal of IMAP is to gather reliable quantitative and updated data on the status of marine and coastal Mediterranean environment.

~~43.~~ Evaluate effects of any coastal activity and construction likely to impact coralligenous and rhodolith~~s~~ habitats during environmental impact assessment (EIA) procedures. This specific kind of monitoring aims to establish the condition of the habitat at the time "zero" (i.e., before the beginning of activities), then the state of health of the habitat is monitored during the development of the work phase or at the end of the phase, to check for any impact on the environment evaluated as changes in the habitat state of health. The EIA procedure is not intended as a typical monitoring activity, although it provides the state of the system at the "zero" time, which can be very useful in the time series obtained during a monitoring programme. Unfortunately, most of the EIA studies are qualitative and are often performed by environmental consultants without specialized personnel, using unspecific guidelines and without following any standardised procedure, which prevent their use in effective monitoring programs.~~This type of monitoring aims to establish the condition of the habitat at the time "zero" before the beginning of activities, then monitor the state of health of the habitat during the development works phase or at the end of the phase, to check for any impacts.~~

45.

~~44.~~46. The objective(s) of the monitoring system ~~chosen~~ will influence the choices ~~of the monitoring criteria~~ in the following steps (e.g., duration, sites to be monitored, descriptors, and sampling methods; Tab. 2). The duration of the monitoring should be at least medium-long term (minimum 5-10 years long) for heritage conservation and for monitoring environmental quality ~~objectives~~. The interval of data acquisition could be annual, as most of the typical species belonging to coralligenous assemblages and to rhodolith~~s~~ beds display slow grow rates and long generation times. In general, and irrespective of the objective advocated, it is judicious to focus initially on a small number of sites that are easily accessible and that can be regularly monitored after short intervals of time. The sites chosen must be: i) representative of the portion of the coastal area investigated, ii) cover most of the possible range of environmental situations (e.g., depth range, slope, substrate type), and iii) include sensitive zones, stable zones, or reference zones with low anthropogenic pressures (i.e., MPAs) and possibly also areas with high pressure related to human activities for comparison. Then, with the experience gained by the surveyors and the means (funds) available, this network could be extended to a larger number of sites. For environmental impact assessment, short term monitoring (generally 1-2 years) is recommended and should be initiated before the interventions ("zero" time), and possibly continued during, or just after the conclusion of the works. A further ~~control~~ monitoring can be made one year after the conclusion. The ecological status of the site subjected to coastal interventions (i.e., the impact site) must be contrasted with the status of at least 2 reference/control sites.

~~45.~~47. To ensure the sustainability of the monitoring system, the following final remarks must be ~~taken into account~~considered:

- Identify the partners, competences and means available;
- Planning the partnership modalities (who is doing what? when? and how?);
- Ensure training for the stakeholders so that they can set up standardized procedures to guarantee the validity of the results, and so that comparisons can be made for a given site and among sites;
- Individuate a regional or national coordinator depending on the number of sites concerned for monitoring and their geographical distribution;

- Evaluate the minimum budget necessary for running the monitoring network (e.g., costs for permanent operators, temporary contracts, equipment, data acquisition, processing, and analysis).

Methods

~~46.~~48. Following the preliminary definition of the distributional range and extent of coralligenous and rhodolith~~s~~ habitats (the previous CI1), the assessment of the condition of the two habitats starts with an overall descriptive characterisation of the typical species and assemblages occurring within each habitat. Monitoring of these two habitats ~~basically~~ relies on underwater diving activities, although this technique gives rise to many operational constraints due to the conditions of the environment in which these habitats develop (e.g., great depths, weak luminosity, low temperatures, presence of currents, etc.). Underwater surveys ~~: it can~~ must ~~only~~ be done by confirmed and expert scientific divers (for safety), within a limited range of depths (from the surface down to the maximum depths of 30-40 m, according to local rules on safe scientific diving), and over a limited underwater time (Bianchi et al., 2004b; Tetzaff and Thorsen, 2005). ~~Adoption of~~Adopting ~~new~~ alternative visual investigation tools (e.g., ROVs) allows for a less precise assessment but over larger spatial scales. A first characterisation of the habitat (e.g., species present, abundance, vitality, etc.) can be done by direct visual underwater inspections, indirect ROVs or towed camera ~~video recordings~~video recordings, or sampling procedures with dredges, grabs or box corers in the case of rhodolith~~s~~ seabeds. The acoustic methods ~~that were~~ described above are totally inoperative for detailed characterisations of these habitats, especially for coralligenous. The survey method depends greatly on the scale of the work and the spatial resolution requested (Tab. 2). The complementarity~~ies~~ of these techniques must be ~~taken into account~~considered when planning an operational strategy (Cánovas-Molina et al., 2016b). A list of the main conspicuous species/taxa or morphological groups recognisable underwater, or on images, in the two habitats is presented in the Annex 1. This ~~species~~ list is not exhaustive but includes species/taxa frequently reported from coralligenous ~~habitat~~ and rhodolithes ~~beds~~ at the Mediterranean scale. Each Contracting Party can regularly improve these lists and chose the most appropriate species/taxa according to its ~~waters~~geographical situation.

~~47.~~49. The use of ROVs or towed cameras can be useful to optimise information obtained and sampling effort (in term of working time) and become essential for monitoring deep coralligenous assemblages and rhodolith~~s~~ seabeds that develop~~ing~~ in the upper mesophotic zone (down to 40 m depth), where scuba diving procedures are usually not recommended. High quality videos and photographs recorded by ROV or towed camera will be analysed in laboratory (also with the help of taxonomists) to list the main conspicuous species/taxa or morphological groups recognisable on images and to evaluate their abundance (coverage or surface area in cm^2). Videos and photographs can then be archived to create temporal datasets.

~~48.~~50. At shallower depths (up to about 30-40 m, and according to local rules for scientific diving), direct underwater visual surveys by scuba diving are strongly recommended. Good experience in underwater diving is requested to operate an effective work at these depths. Scientific divers annotate on their slates the list of the main conspicuous species/taxa characterising the assemblages. Given the complexity of the coralligenous habitat (3-D ~~distribution of species~~structure and high biodiversity), divers must be specialists in taxonomy of the main coralligenous species to ensure the validity of the information recorded underwater. Photographs or video collected with underwater cameras can be usefully integrated ~~to~~ into visual survey to speed the work (Gatti et al., 2015a). The use of operational taxonomical units (OTUs), or taxonomic surrogates such as morphological groups (lumping species, genera or higher taxa displaying similar morphological features; Parravicini et al., 2010), may represent a useful compromise when a consistent species distinction is not possible (either underwater or on photographs) or to reduce the surveying/analysis time.

~~49.~~51. For a rough and rapid characterisation of coralligenous assemblages, semi-quantitative evaluations often give sufficient information (Bianchi et al., 2004b):~~;~~ ~~thus,~~ it is possible to estimate the abundance (usually expressed as % cover) by standardized indices directly *in situ* or using photographs (UNEP/MAP-RAC/SPA, 2008). However, a high-quality and fine characterisation of the assemblages often requires ~~the use of~~ square frames (quadrates) of defined surface or transects (with or without photographs; Piazzi et al., 2018) to collect quantitative data on the assemblages' composition. ~~, or even t~~The sampling by scraping of all the organisms present over a given area ~~for~~ and further laboratory analyses (Bianchi et al., 2004b) represents an alternative ~~. D~~destructive procedure,~~s~~ ~~by scraping~~ which ~~however~~ should ~~/must~~ be avoided ~~beacause of the importance of~~ to preserve coralligenous ~~ation of this~~ habitat. ~~*are not usually recommended on coralligenous being a time-consuming technique and due to the limited available time underwater.*~~ *In situ* observation and sample~~s~~ must be done over defined and, possibly, standardized surface areas (Piazzi et al., 2018), and the number of replicates must be adequate and high enough to catch the heterogeneity of the habitat.

~~50.~~52. As well as the presence and abundance of a given species, assessing its vitality seems a particularly interesting parameter. The presence of broken individuals (especially of ~~the~~ branching colonies occurring in the intermediate and upper layers of coralligenous, such as bryozoans and~~,~~ gorgonians) and of signs of necrosis and bleaching are important elements to be taken into consideration to assess specific pressures, such as mechanical damages or effects of thermal anomalies (Garrabou et al., 1998, 2001, 2019; Gatti et al., 2012). Finally, the nature of the substrat~~eum~~ (silted up, roughness, interstices, exposure, slope), the temperature of the water, the vagile fauna associated, the coverage by ~~epibionta~~epibiont, and the presence of invasive species must also be considered to give a clear characterisation of bioconstructed habitats (Harmelin, 1990; Gatti et al., 2012).

Table 2: Synthesis of the main methods used to characterise coralligenous and rhodolith habitats in the Mediterranean, as the first necessary step for defining the Common Indicator 2_Condition of the habitat's typical species and communities. When available, the depth range, the surface area surveyed, the spatial resolution, the efficiency (expressed as area surveyed in km^2 per hour), the main advantages and the limits of each tool are indicated, with some bibliographic references.

Methods	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Remote Operating Vehicle (ROV) or towed camera	From 2 m to over 120 m	Small-Intermediate areas of about 1 km^2 (larger areas in the case of towed camera)	From 1 m to 10 m	0.025 to 0.01 km²/hour	• Non-destructive method • Possibility of collecting pictures • Wide bathymetric range • Good identification of facies and associations • Possibility of semi-quantitative/quantitative evaluation • Possibility to collect samples (for ROV)	• High cost, major means out at sea • Difficulty of observation and access according to the complexity of the habitat (multilayer assemblages) • Quali-quantitative assessments only on conspicuous species/taxaNeed of specialists in taxonomy	Cánovas-Molina et al. (2016a); Enrichetti et al. (2019); Piazzi et al. (2019b)
Underwater diving visual observation	0 m up to 40 m, according to local rules for scientific diving	Small areas (less than 250 m^2)	From 1 m	0.0001 to 0.001 km²/hour	• Non-destructive • Good precision in the identification (taxonomy) and characterisation of the habitat (also its 3D) • Low cost, easy to implement • Possibility to collect samples • Data already available after dive	• Small area inventoried • Very time-consuming underwater activities • Limited operational depths • Highly qualified scientific divers required • Subjectivity of the observer • Quali-quantitative assessments only on conspicuous species/taxa • Need of specialists in taxonomy	Gatti et al. (2012, 2015a); Piazzi et al. (2019a)

Methods	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Underwater sampling by scraping or collection	0 m up to 40 m, according to local rules for scientific diving	Small areas (less than 10 m^2)	From 1 m	0.0001 to 0.001 km^2/hour	• Very good precision in the identification (taxonomy) and characterisation of the habitat • All species identified • *A posteriori* identification • Low cost, Easy to implement	• Destructive method, usually not recommended • Very small area inventoriied • Sampling material needed • Limited operational depths • Highly qualified scientific divers required • Very time-consuming underwater activities • Analysis of samples in laboratory very time-consuming • Involvement of many taxonomists	Bianchi et al. (2004b)

Methods	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Underwater diving photography or video recording	0 m up to 40 m, according to local rules for scientific diving	Small areas (less than 250 m²)	From 0.1 m	0.0001 to 0.001 km²/hour	• Non-destructive • Good precision for in the identification (taxonomy) and characterisation of the habitat • *A posteriori* identification possible • Low cost, easy to implement • Possibility to collect samples • Possibility to create archives	• Need of specialists in taxonomy • Small area inventoriied • Photographs or and video analysis very time-consuming • Limited operational depths • Highly qualified scientific divers required • Tools to collect photos/video necessary Limited number of species/taxa observed • • Quali-quantitative assessments only on	Gatti et al. (2015b); Montefalcone et al. (2017); Piazzi et al. (2017a, 2019a); Çinar et al. (2020)
Methods	**Depth range**	**Surface area**	**Resolution**	**Efficiency**	**Advantages**	**Limits**	**References**
Sampling from vessels with blind grabs, dredges, or box corers	0 m to about 120 m (until the lower limit of the rhodoliths habitat)	Intermediate areas (a few km²)	From 1 to 10 m	0.025 to 0.01 km²/hour	• Very good precision for in the identification (taxonomy) and characterisation of the habitat • All species identified taken into account • • *A posteriori* identification • ELow cost, easy to implement	• Destructive method, usually not recommended • Small area inventoriied • Sampling material needed • Samples analysis in laboratory very time-consuming and costly • Difficulty in collecting representative samples •	UNEP/MAP-RAC/SPA (2015a)

~~51.~~53. E~~An e~~ffective monitoring should be done at defined intervals over ~~a period of~~ time, even if it could mean ~~a reduced number of~~fewer sites being monitored. The reference “zero-state” will be ~~then~~ contrasted with data coming from subsequent monitoring periods, always assuring reproducibility of data over time. Thus, the experimental design and protocol ~~has a~~have capital importance. The g~~G~~eographical position of surveys and sampling stations must be located with precision (using buoys on the surface and recording their coordinates with a ~~d~~GPS), and it often requires the use of mark~~sing~~ underwater (with fixed pickets into the rock) for positioning the ~~square frames~~ quadrates or transects in the exact original position (García-Gómez et al., 2020)~~.~~. Finally, even if it cannot be denied that there are logistical constraints linked to the underwater observation of coralligenous and rhodolith~~s~~ habitats, their long generation time enables sampling to be done at long intervals of time (> 1 year) to monitor them in the long term (Garrabou et al., 2002).

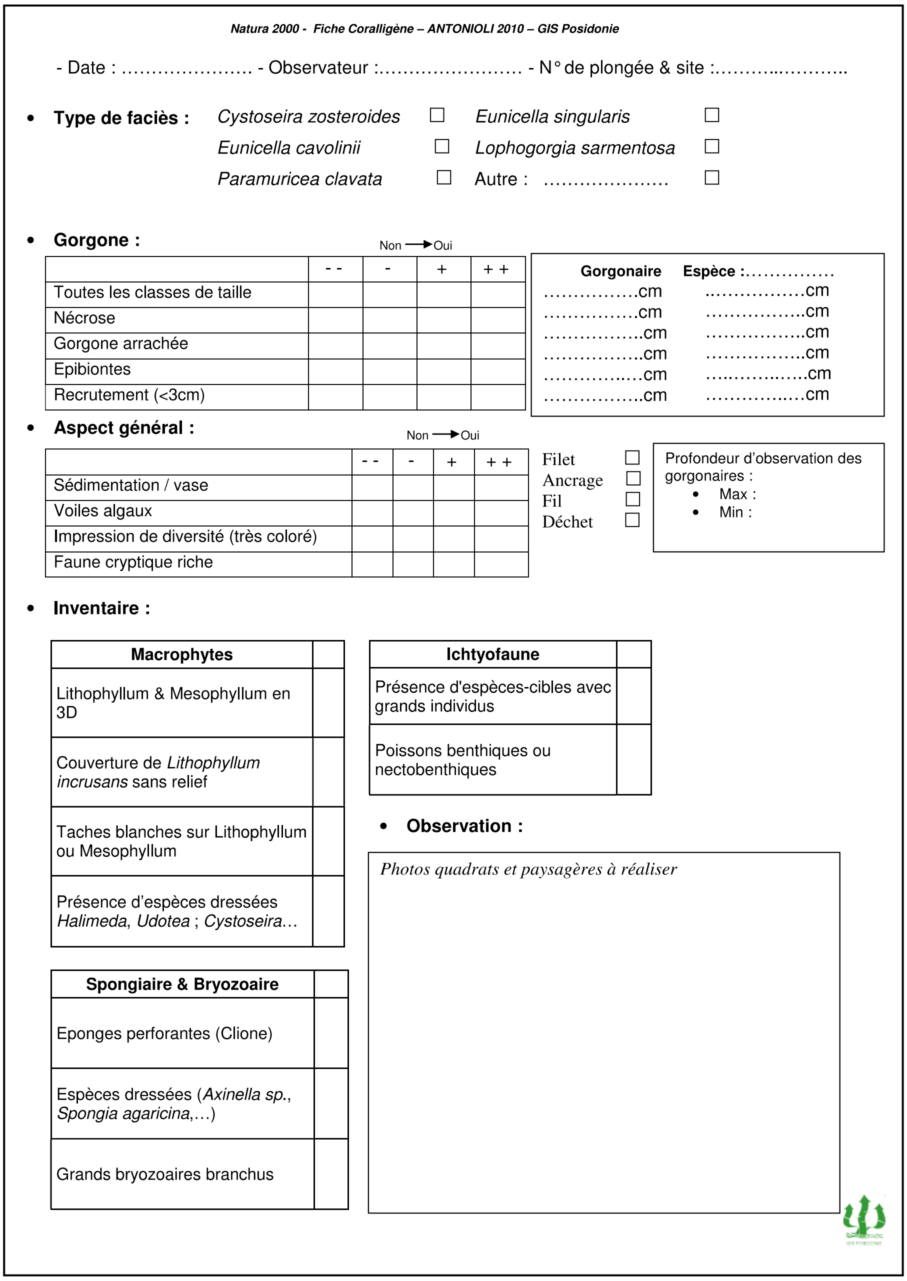
~~52.~~54. Although destructive methods (~~total~~ scraping of the substrate with all the organisms present over a given area, dredges, grabs, or box-corers) have long been used and recognized as the most suitable approach to describe the structure of assemblages and an irreplaceable method for exhaustive species lists, they are not desirable for long-term regular ~~monitorings~~monitoring (UNEP/MAP-RAC/SPA, 2008), and especially within MPAs. Moreover, identification of all organisms needs great taxonomic ~~expertise~~expertise and a long time to analyse samples, making it difficult to process the large number of replicates required for ecological studies and monitoring surveys. It is more suitable to ~~favour~~ favor non-destructive methods, like photographic sampling, ROV survey, or direct underwater observation in given areas (using ~~square frames~~ quadrates or transects) to collect quali-quantitative data. These methods do not require sampling of organisms and are therefore ~~absolutely appropriate~~appropriate for long-term monitoring. The ~~D~~different methods can be used either separately or together, according to the ~~aims~~ objective of the study, the area inventoried, and means available (Tab. 3). Non-destructive methods ~~are~~ have been increasingly used and, ~~–~~mainly for video and photographic sampling, ~~–~~ enjoy significant technological advances.

Table 3: Comparison ~~between~~ among three traditional methods used to monitor coralligenous and other bioconstructions (Bianchi et al., 2004b).

***In situ* sampling**	
Advantages	Taxonomical precision, objective evaluation, reference samples
Limits	High cost, slow laborious work, intervention of specialists, limited area inventoried, destructive method, depth-limitations when done by divers
Use	Studies integrating a strong taxonomical element
Video or photography	
Advantages	Objective evaluation, can be reproduced, reference samples, can be automated, speedy diving work, ~~big~~ large area inventor~~i~~ied, non-destructive method, no depth-limitations
Limits	Low taxonomical precision, problem of *a posteriori* interpretation of pictures
Use	Studies on the biological cycle or over-time monitoring, large depth-range investigated
Underwater visual observation	
Advantages	Low cost, results immediately available, large area inventoried, can be reproduced, non-destructive method
Limits	Risk of taxonomic subjectivity, slow diving work, depth-limitations
Use	Exploratory studies, monitoring of populations, bionomic studies

55. Differently from seagrass, the descriptors used to evaluate the status of coralligenous assemblages vary greatly from one team to another and from one region to another, as well as their measuring protocols (Piazzi et al., 2019a and references therein). A first standardized sheet for coralligenous monitoring was created in the context of the Natura 2000 program~~me~~s, which solved

only partially the issues about comparability among data (Fig. 5). However, methods and descriptors ~~taken into account~~considered must be the subject of a standardized protocol. Although many disparities among data acquisition methods still occur, an integrated and standardized procedure named STAR (STAndaRdized coralligenous evaluation procedure) for monitoring the condition of coralligenous reefs has recently been proposed (Piazzi et al., 2019a; Gennaro et al., 2020).



Natura 2000 - Fiche Coralligène – ANTONIOLI 2010 – GIS Posidonie

- Date : …………………. - Observateur :…………………… - N° de plongée & site :……………………

- **Type de faciès :**

Cystoseira zosteroides	☐	*Eunicella singularis*	☐
Eunicella cavolinii	☐	*Lophogorgia sarmentosa*	☐
Paramuricea clavata	☐	Autre : …………………	☐

- **Gorgone :**

Non ⟶ Oui

	- -	-	+	+ +
Toutes les classes de taille				
Nécrose				
Gorgone arrachée				
Epibiontes				
Recrutement (<3cm)				

Gorgonaire	Espèce :……………
…………….cm	…………….cm
…………….cm	…………….cm
…………….cm	…………….cm
…………….cm	…………….cm
…………….cm	…………….cm
…………….cm	…………….cm

- **Aspect général :**

Non ⟶ Oui

	- -	-	+	+ +
Sédimentation / vase				
Voiles algaux				
Impression de diversité (très coloré)				
Faune cryptique riche				

Filet ☐
Ancrage ☐
Fil ☐
Déchet ☐

Profondeur d'observation des gorgonaires :
- Max :
- Min :

- **Inventaire :**

Macrophytes	
Lithophyllum & Mesophyllum en 3D	
Couverture de *Lithophyllum incrusans* sans relief	
Taches blanches sur Lithophyllum ou Mesophyllum	
Présence d'espèces dressées *Halimeda*, *Udotea* ; *Cystoseira*…	

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

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

- **Observation :**

Photos quadrats et paysagères à réaliser

Figure 5: Example of a standardized sheet for coralligenous monitoring created in the context of the Natura 2000 programmes by GIS Posidonie (Antonioli, 2010).

A standardized protocol for monitoring shallow water (up to 40 m depth) coralligenous ~~habitat~~reefs

~~53.~~56. The protocol STAR (STAndaRdized coralligenous evaluation procedure) (Piazzi et al., 2019a; Gennaro et al., 2020) has been proposed for monitoring the ecological status of coralligenous reefs to obtain information about most of the descriptors ~~used~~ adopted ~~by~~ in the different ecological indices that have been developed ~~adopted~~ to date ~~on coralligenous reefs~~, through a single sampling effort and data analysis. The CIGESMED protocol, applied in different parts of the Mediterranean (David et al., 2014; Çinar et al., 2020), should also be mentioned.

~~54.~~57. Monitoring plans should at first distinguish between the two major bathymetrical ranges where coralligenous reefs develop, i.e., the shallow and the deep reefs, within and deeper than about 40 m depth respectively (UNEP/MAP-RAC/SPA, 2008). In fact, shallow and deep coralligenous habitats can show different structure of assemblages, and they are usually subject to different types of anthropogenic pressures. Shallow reefs can be effectively surveyed by scuba diving, allowing obtaining information about descriptors that cannot be evaluated or measured through any other instrumental methods (Gatti et al., 2012, 2015a). Deep coralligenous reefs can be surveyed only by means of ROV inspections.

~~55.~~58. Season: coralligenous assemblages comprise mostly organisms with long life cycles that are subjected to less evident seasonal changes (mainly in water temperature) than shallower assemblages. In contrast, several temporal changes throughout the year have been observed for macroalgal assemblages, and some seasonal erect algae and filamentous species constituting turfs decrease in cover during the cold season. In addition, coralligenous assemblages are often subjected to the invasion of alien macroalgae and most of the invasive macroalgae display seasonal dynamics, thus contributing to modify the structure of coralligenous assemblages. The most widespread invasive species on coralligenous reefs are the turf-forming Rhodophyta *Womersleyella setacea* and the Chlorophyta *Caulerpa cylindracea*. These two species reach their highest abundance between the end of summer and autumn. The seasonal dynamics of native and invasive macroalgae thus suggest planning monitoring activities between April and June, and no more ~~that~~than once per year.

~~56.~~59. Depth and slope: the depth range where coralligenous reefs can develop changes with latitude and characteristics of the water. Moreover, different kinds of assemblages may develop within the depth range of shallow coralligenous reefs. The slope of the rocky substrate is also important to determine the structure of coralligenous assemblages. ~~In order to~~To define a standardized sampling procedure suitable to collect comparable data, the range of sampling depth and substrate inclination must be fixed. In this context, a depth of around 35 m on a vertical substrate (i.e., slope 85-~~–~~90°) can be considered as optimal to ensure the presence of coralligenous assemblages in most of the Mediterranean Sea, including the southern areas in oligotrophic waters. Vertical rocky substrates at about 35 m depth can also be easily found near the coast, which is in the zone mostly subjected to anthropogenic impacts.

~~57.~~60. Sampling design, sampling surface, and number of replicates: Coralligenous assemblages show a homogeneous structure when subjected to similar environmental conditions, at least within the same geographic area. They are thus characterised by low variability at spatial scales between hundreds of metres to kilometres, while variability at smaller spatial scales (from metres to tens of metres) is usually high (Abbiati et al., 2009; Ferdeghini et al., 2000; Piazzi et al., 2016). These findings suggest planning sampling designs focusing on high replication at small scales (i.e., tens of metres), whereas intermediate or large scales (i.e., hundreds of metres to kilometres respectively) will require fewer replicates.

~~58.~~61. The sampling surface is related to the number of replicates and represents an important factor to be considered. A minimum surface suitable to sample coralligenous assemblages has never been established unambiguously, so different replicated sampling surfaces have been proposed depending on the methods adopted (Piazzi et al., 2018 and references therein). Researchers agree that the replicated sampling surface ~~has to~~must be larger than that utilized for shallow Mediterranean rocky habitats (i.e., ≥400 cm^2; Boudouresque, 1971), since the abundance of large colonial animals that characterise coralligenous assemblages could be underestimated when using small sampling areas (Bianchi et al., 2004b). Independent of the number of replicates, most of the proposed approaches suggest a total sampling area ranging between 5.6 and 9 m^2. Parravicini et al. (2009) reported that a sufficiently large sampling surface is more important than the specific method (e.g., visual quadrates or photography) to measure human impacts on Mediterranean rocky reef communities. Larger sampling areas with a lower number of replicates are used for seascape approaches (Gatti et al., 2012). On the contrary, most of the proposed sampling techniques for ~~biocoenotic~~biocenotic approaches consider a greater number of replicates with a comparatively smaller sampling area, usually disposed along horizontal transects (Kipson et al., 2011, 2014; Deter et al., 2012; Teixidó et al., 2013; Cecchi et al., 2014; Piazzi et al., 2015; Sartoretto et al., 2017~~;~~) or in a square design (3 × 3 square structure) (Çinar et al., 2020). A comparison between these two sampling designs tested in the field showed no significant differences (Piazzi et al., 2019a), suggesting that both approaches can be usefully employed. Thus, three areas of 4 m^2 located tens of metres apart should be sampled, and a minimum of 10 replicated photographic samples of 0.2 m^2 each should be collected in each area by scientific divers, for a total sampling surface area of 6 m^2. This design can be repeated depending on the size of the study site and allows for the analysis of ~~the~~ data through both seascape and ~~biocoenotic~~biocenotic approaches (see the 'Ecological Indices' paragraph below).

~~59.~~62. Sampling techniques: coralligenous assemblages have been usually studied by destructive methods employing the total scraping of the substrate, by photographic methods associated with determination of taxa and/or morphological groups and by visual census techniques. The best results can be obtained integrating photographic sampling and *in situ* visual observations. The former is the most cost-effective method that requires less time spent underwater and allows collecting the large number of samples required for community analysis in a habitat with high spatial variability at small spatial scales. The latter method, using ~~square frames~~frames ~~-~~enclosing a standard area of the substrate, has been shown equally effective, but requires longer working time underwater (Parravicini et al., 2010), which may represent a limiting factor at ~~the~~ depths where coralligenous assemblages thrive. A rapid visual assessment (RVA) method has been proposed for a seascape approach (Gatti et al., 2012, 2015a). RVA allows capturing additional information compared ~~with~~ to the photographic technique, such as the size of colonies of erect species and the thickness and consistency of the calcareous accretion (see the 'Descriptors' paragraph below). A combination of photographic and visual approaches, using photographic sampling to assess the structure of assemblages and integrating information by collecting a reduced amount of data with the RVA method (i.e., the size of colonies of erect species and the thickness and consistency of the calcareous accretion) is thus suggested.

~~60.~~63. Photographic samples analysis: the analysis of photographic samples can be performed by different methods (Piazzi et al., 2019a and reference therein); the use of a very dense grid (e.g., 400 cells) or the manual contouring techniques through appropriate ~~softwares~~software may be useful ~~in order to~~to reduce the subjectivity of the operator's estimate.

~~61.~~64. Descriptors:

- *Sediment load.* Coralligenous reefs are particularly exposed to sediment deposition, especially of fine sediments. Both correlative and experimental studies have demonstrated that the increase of sedimentation rate can lead to changes in the structure of coralligenous assemblages, facilitating the spread of more tolerant and opportunistic species and causing the reduction of both α- and β-diversity. Increased sedimentation may affect coralligenous assemblages by covering sessile organisms, clogging filtering apparatus and inhibiting the rate of recruitment, growth, and metabolic processes. Moreover, sediment re-suspension can increase water turbidity, limiting algal production, and can cause death and removal of sessile organisms through burial and scouring. Thus, the amount of sediment deposited on coralligenous reefs has been considered by several researchers (Deter et al., 2012; Gatti et al., 2012, 2015a) and represents a valuable information, together with biotic descriptors, to assess the ecological quality of a study area. The amount of sediment may be indirectly evaluated as percentage cover o~~i~~n photographic samples, as this method showed consistent results with those obtained through underwater ~~techniques~~ measurements of~~ing~~ ~~directly~~ the sediment deposition (i.e., by a suction pump).

- *Calcareous accretion*. The calcareous accretion of coralligenous reefs may be impaired by human-induced impacts. The growth of the calcareous organisms that deposit calcium carbonate on coralligenous reefs is a slow process that can be easily disrupted by environmental alterations. Thus, the thickness and consistency of the calcareous deposit can be considered an effective indicator of the occurrence of a positive balance in the bioconstruction process (Gatti et al., 2012, 2015a). The thickness and consistency of the calcareous deposit can be measured underwater through a hand-held penetrometer, with six replicated measures in each of the three areas of about 4 m^2 and located tens of metres apart. For each measure, the hand-held penetrometer marked with a millimetric scale must be pushed into the carbonate layer, allowing the direct measurement of the calcareous thickness. By definition, a penetrometer measures the penetration of a device (a thin blade in this case) into a substrate, and the penetration will depend on the force exerted and on the strength of the material. In the case of a hand-held penetrometer, the force is that of the diver, and thus cannot be measured properly and provides a semi-quantitative estimate only. Supposing that the diver always exerts approximately the same force, the measure of the penetration will provide a rough estimate of the thickness of the material penetrated. A null penetration is indicative of a hard rock and suggests that the biogenic substrate is absent or the ~~bioconstructional~~bioconstruction process is no longer active; a millimetric penetration indicates the presence of active bioconstruction resulting in a calcareous biogenic substrate; and a centimetric penetration reveals a still unconsolidated bioconstruction.

- *Erect anthozoans*. The long-living erect anthozoans, such as gorgonians, are considered key species in coralligenous reefs, as they contribute to the typical three-dimensional structure of coralligenous assemblages, providing biomass and biogenic substrat~~es~~a and contributing greatly to the aesthetic value of the Mediterranean sublittoral seascape. However, presence and abundance of these organisms may not necessarily be related to environmental quality, but rather to specific natural factors acting at the local scale (Piazzi et al., 2017a). Accordingly, coralligenous reefs without erect anthozoans may anyway possess a good ecological quality status. Most erect species are, however, affected by local or global physical and climatic factors, such as global warming, ocean acidification and increased water turbidity, independent of local measures of protection. Several human activities acting locally, such as fishing, anchoring or scuba diving, may also damage erect species. Thus, where erect anthozoans are structuring elements of coralligenous assemblages, they can be usefully adopted as ecological indicators through the measure of different variables. The size (mean height) and the percentage of necrosis and epibiosis of erect anthozoans should be assessed through the RVA visual approach, measuring the height of the tallest colony for each erect species, and estimating the percentage cover of the colonies showing necrosis and epibiosis signs in each of the three areas of about 4 m^2 and located tens of metres apart.

- *Structure of assemblages*. Coralligenous assemblages are considered very sensitive to human induced pressures (Piazzi et al., 2019a and references therein). Correlative and experimental studies highlighted severe shifts in the structure of coralligenous assemblages subjected to several kinds of stressors. The most effective bioindicators used to assess the ecological quality of coralligenous reefs are erect bryozoans, erect anthozoans, and sensitive macroalgae, such as Udoteaceae, Fucales, and erect Rhodophyta. On the other hand, the dominance of algal turfs, hydroids and encrusting sponges seems to indicate degraded conditions. Thus, the presence and abundance of some taxa/morphological groups may be considered as an effective indicator of the ecological status of coralligenous assemblages. A value of sensitivity level (SL) has been assigned to each taxon/morphological group ~~on the basis of~~based on its abundance in areas subjected to different levels of anthropogenic stress, with SL values varying within a numerical scale from 1 to 10, where low values correspond to the most tolerant organisms and high values to the most sensitive ones (Piazzi et al., 2017a; Fig. 6). Recently, a method has been proposed to distinguish and measure sensitivity to disturbance (DSL) and sensitivity to stress (SSL), ~~,~~ the former causing mortality or physical damage and the latter physiological alteration, of the sessile organisms thriving in coralligenous assemblages (Montefalcone et al., 2017). Discriminate effects of stress from effects of disturbance may allow a better understanding of the impacts of human and natural pressures on coralligenous reefs.

The percentage cover of the conspicuous taxa/morphological groups can be evaluated ~~for~~ on each photographic sample. The cover values (in %) of each taxon/morphological group are then classified in eight classes of abundance (Boudouresque, 1971): (1) 0 to ≤0.01%; (2) 0.01 to ≤0.1%; (3) 0.1 to ≤1%; (4) 1 to ≤5%; (5) 5 to ≤25%; (6) 25 to ≤50%; (7) 50 to ≤75%; (8) 75 to ≤100%). The overall SL of a sample is then calculated by multiplying the value of the SL of each taxon/group (Fig. 6) for its class of abundance and then summing up all the final values. Coralligenous assemblages are characterised by high biodiversity that is mostly related to the heterogeneity of the biogenic substrate, which increases the occurrence of microhabitats and exhibits distinct patterns at various temporal and spatial scales. A decrease in species richness (i.e., α-diversity) in stressed conditions has been widely described for coralligenous reefs (Balata et al., 2007), but also the number of taxa/morphological groups per sample can be considered a further effective indicator of ecological quality. Thus, the richness (α-diversity, i.e., the mean number of the taxa/groups per photographic sample) should be computed.

Taxon/group	SL
Algal turf	1
Hydrozoans (e.g. *Eudendrium* spp.)	2
Pseudochlorodesmis furcellata	2
Perforating sponges (e.g. *Cliona* spp.)	2
Dyctiotales	3
Encrusting sponges	3
Encrusting bryozoans	3
Encrusting ascidians (also epibiontic)	3
Encrusting Corallinales, articulated Corallinales	4
Peyssonnelia spp.	4
Valonia spp., *Codium* spp.	4
Sponges prostrate (e.g. *Chondrosia reniformis, Petrosia ficiformis*)	5
Large serpulids (e.g. *Protula tubularia, Serpula vermicularis*)	5
Parazoanthus axinellae	5
Leptogorgia sarmentosa	5
Flabellia petiolata	6
Erect corticated terete Ochrophyta (e.g. *Sporochnus pedunculatus*)	6
Encrusting Ochrophyta (e.g. *Zanardinia typus*)	6
Azooxantellate individual scleractinians (e.g. *Leptopsammia pruvoti*)	6
Ramified bryozoans (e.g. *Caberea boryi, Cellaria fistulosa*)	6
Palmophyllum crassum	7
Arborescent and massive sponges (e.g. *Axinella polypoides*)	7
Salmacina-Filograna complex	7
Myriapora truncata	7
Erect corticated terete Rodophyta (e.g. *Osmundea pelagosae*)	8
Bushy sponges (e.g. *Axinella damicornis, Acanthella acuta*)	8
Eunicella verrucosa, Alcyonium acaule	8
Erect ascidians	8
Corallium rubrum, Paramuricea clavata, Alcyonium coralloides	9
Zooxantellate scleractinians (e.g. *Cladocora caespitosa*)	9
Pentapora fascialis	9
Flattened Rhodophyta with cortication (e.g. *Kallymenia* spp.)	10
Halimeda tuna	10
Fucales (e.g. *Cystoseira* spp., *Sargassum* spp.), *Phyllariopsis brevipes*	10
Eunicella singularis, Eunicella cavolini, Savalia savaglia	10
Aedonella calveti, Reteporella grimaldii, Smittina cervicornis	10

Figure 6: Values of the sensitivity level (SL) assigned to each of the main taxon/morphological group in the coralligenous assemblages (Piazzi et al., 2017a).

- *Spatial heterogeneity*. Coralligenous assemblages are also characterised by a high variability at small spatial scale, and consequently by high values of β-diversity, which is linked to the patchy distribution of the organisms. Under stressed conditions, the importance of biotic factors in regulating ~~an~~ the distribution of organism~~'~~s ~~distribution~~ decreases, and their occurrence and abundance mostly follow the gradient of stress intensity (Balata et al., 2005). The loss of structuring perennial species and the proliferation of ephemeral algae lead to widespread biotic homogenization (Balata et al., 2007; Gatti et al., 2015b, 2017), and to a consequential reduction of β-diversity (Piazzi et al., 2016).

Thus, the β-diversity of assemblages may be considered a valuable indicator of human pressure on coralligenous reefs. β-diversity, in general, can be calculated through different methods; in the case of coralligenous assemblages, variability of species composition among sampling units (heterogeneity of assemblages) has been measured in terms of multivariate dispersion calculated ~~on the basis of~~as the distance from centroids (Piazzi et al., 2017a) through permutational analysis of multivariate dispersion (PERMDISP). Thus, any change~~s~~ in the compositional variability displayed by PERMDISP may be directly interpretable as changes ~~of~~ in the β-diversity.

Protocol for monitoring deep water mesophotic (down to 40 m depth) coralligenous ~~habitat~~reefs

~~62.~~65. The use of unmanned vehicles, such as ROVs, may be considered suitable to survey deep coralligenous reefs in mesophotic environments, down to 40 m depth (UNEP/MAP-RAC/SPA, 2008; Cánovas-Molina et al., 2016a; Ferrigno et al., 2017). The Italian MSFD protocol (MATTM/ISPRA, 2016) for monitoring mesophotic coralligenous and rocky reefs includes a standard sampling design conceived to gather various quantitative components, such as the occurrence and extent of the habitat (either biogenic or rocky reefs), the siltation level, and the abundance, condition, and population structure of habitat-forming megabenthic species (i.e., animal forests), as well as presence and typology of marine litter.

~~63.~~66. Three replicated video-transects, each at least 200 m long, should be collected in each area investigated (Enrichetti et al., 2019). Footages can be obtained by means of a ROV, equipped with a ~~high definition~~high-definition digital camera, a strobe, a high-definition ~~video camera~~video camera, lights, and a 3-jaw grabber. The ROV should also host an underwater acoustic positioning system, a depth sensor, and a compass to obtain georeferenced tracks to be overlapped to multi-beam maps when available. Two parallel laser beams (90° angle) can provide a scale for size reference. ~~In order to~~To guarantee the best quality of video footages, ROV is expected to move along linear tracks, in continuous recording mode, at constant slow speed (< 0.3 ms^{-1}) and at a constant height from the bottom (< 1.5 m), thus allowing for adequate illumination and facilitating the taxonomic identification of the megafauna. Transects are then positioned along dive tracks by means of a GIS software editing. Each video transect is analysed through any of the ROV-imaging techniques, using starting and ending time of the transect track as reference. Visual census of megabenthic species is carried out along the complete extent of each 200 m-long transect and within a 50 cm-wide visual field, for a total of 100 m^2 of bottom surface covered per transect.

~~64.~~67. From each transect the following parameters are measured on videos:

- Extent of hard bottom, calculated as percentage of total video time showing this type of substrat~~eum~~ (rocky reefs and biogenic reefs) and subsequently expressed in m^2;

- Species richness, considering only the conspicuous megabenthic sessile and sedentary species of hard bottom in the intermediate and canopy layers (*sensu* Gatti et al., 2015a). Organisms are identified to the lowest taxonomic level and counted. Fishes and encrusting organisms are not considered, as well as typical soft-bottom species. Some hard-bottom species, especially cnidarians, can occasionally invade soft bottoms by settling on small hard debris dispersed in the sedimentary environment. For this reason, typical hard-bottom species (e.g., *Eunicella verrucosa*) encountered ~~on~~ in highly silted environments have to be considered in the analysis;

- Structuring species are counted, measured (height expressed in cm) and the density of each structuring species is computed and referred to the hard-bottom surface (as n° of colonies or individuals · m^{-2});

- The percentage of colonies with signs of epibiosis, necrosis and directly entangled in lost fishing gears are calculated individually for all structuring anthozoans;

- Marine litter is identified and counted. The final density (as n° of items · m^{-2}) is computed considering the entire transect (100 m^2).

~~65.~~68. Within each transect, 20 random high-~~-~~definition photographs targeting hard bottom must be obtained, and for each of them four parameters are estimated, following an ordinal scale. Modal values for each transect are calculated. Evaluated parameters on photos include:

- Slope of the substrat~~eum~~e: 0°, <30° (low), 30°-80° (medium), >80°(high);
- Basal living cover, estimated considering the percentage of hard bottom covered by organisms of the basal (encrusting species) and intermediate (erect species but smaller than 10 cm in height) layers: 0, 1 (<30%), 2 (30-60%), 3 (>60%);
- Coralline algae cover (indirect indicator of biogenic reef), estimated considering the percentage of basal living cover represented by encrusting coralline algae: 0, 1 (sparse), 2 (abundant), 3 (very abundant);
- Sedimentation level, estimated considering the percentage of hard bottom covered by sediments: 0%, <30% (low), 30-60% (medium), >60% (high).

Protocol for monitoring rhodolith~~s~~ ~~habitat~~beds

~~66.~~69. A standardized and common sampling method for monitoring rhodolith~~s~~ ~~sea~~beds is not available to date (UNEP/MAP-RAC/SPA, 2008). Mediterranean rhodolith~~s~~ ~~sea~~beds ~~appear to possess~~ seem to display more diverse ~~species~~ assemblages of coralline and peyssonneliacean alga~~l~~e species than their Atlantic counterparts, and to be structured by a suite of combinations of rhodolith shapes and coralline compositions: from monospecific branched growth-forms, to multispecific rhodoliths (Basso et al., 2016). Therefore, the monitoring protocols available for sampling and monitoring rhodoliths in shallow subtidal waters of the Atlantic Ocean cannot be applied as such and require calibrati~~ng~~on to the Mediterranean specificities.

~~67.~~70. A recent proposal of protocol for monitoring rhodolith~~s~~ beds can be found in Basso et al. (2016). Monitoring of ~~the~~ rhodolith~~s~~ habitats can be done by underwater diving and direct visual observation, with sampling and following taxa identification in laboratory, as well as by blind sampling from vessel using grabs, dredges, and box corers (Tab. 4). ~~However, s~~Surveys using ROVs and towed cameras are also effective because of the great homogeneity of this habitat, although they do not provide a complete quantitative information on composition and abundance of rhodolith community as that provided by destructive sampling techniques. ~~sampling from vessels using blind grabs, dredges or box corers (Tab. 4).~~ Monitoring should address all the variables already described for the first descriptive characterisation of the habitat, with the addition of ~~the~~ a full quantitative description of the rhodolith~~s~~ community composition, through periodical surveys, including number of typical or indicator species. A decrease in rhodolith~~s~~ beds extent, live/dead rhodoliths ratio, live rhodoliths percentage cover, associated with changes in the composition of the macrobenthic community (calcareous algal engineers and associated taxa) may reveal potential negative impacts acting on rhodolith~~s~~ beds. All possible variations in growth form, shape, and internal structure of rhodoliths have been simplified in a scheme with three major categories as focal points along a continuum: 1) compact and nodular pralines;~~,~~ 2) larger and vacuolar box work rhodoliths;~~,~~ and 3) unattached branches (Fig. 7~~5~~). Each of the three end-members within rhodoliths morphological variability corresponds to a typical (but not exclusive) group of composing coralline algal species and associated biota and it is possibly correlated with environmental variables, among which substrat~~ume~~e instability (mainly due to ~~hydrodynamics~~water movement) and sedimentation rate are the most obvious. Thus, the indication of the ~~percentage~~ cover (in %) by the three live rhodoliths categories at the surface of each rhodolith~~s~~ bed~~s~~ is a proxy of the rhodolith~~s~~ habitat structural and ecological complexity. The high species diversity hosted by rhodolith~~s~~ beds requires time-consuming and expensive laboratory analysis for species identification. Videos and photos ~~provide~~allow for a less fine assessment on the composition ~~information~~ o~~n~~f rhodolith~~s~~ community ~~composition owing~~ due to the absence of conspicuous, easy-to-detect species. Moreover, since most coralline algal species belong to ~~a~~ few genera only, the use of taxonomic ranks higher than species is not useful.

Table 4: Comparison ~~between~~ among four traditional methods used to monitor rhodolith~~s~~ habitat.

Underwater visual observation	
Advantages	Low cost, results immediately available, non-destructive method, reference samples, taxonomical precision, information on the distribution of species
Limits	Work limited as regards to depth, small area inventoried
Use	Exploratory studies, monitoring of assemblages, bionomic studies
Blind sampling (dredges, grabs, ~~or~~ and box corers)	
Advantages	E~~Low cost, e~~asy to implement, taxonomical precision, reference samples, analysis ~~of~~ on the substrat~~um~~e (granulometry, calcimetry, % of organic matter), large depth-range investigated
Limits	Low precision of observation, several replicates needed, limited area inventoried, destructive method, high costs for taxonomic analysis
Use	Localised studies integrating a taxonomical element, validation of acoustic methods
ROV and towed camera	
Advantages	Objective evaluation, reference samples (images), large area inventoried, non-destructive method, information on the distribution of conspicuous species, large depth-range investigated
Limits	High cost, low taxonomical precision, problem of *a posteriori* interpretation of images, observation only of the superficial layer~~s~~, little information on the substrat~~e~~um and on the basal layer
Use	Studies on distribution and temporal ~~monitoring~~change, validation of acoustic methods
Acoustic methods	
Advantages	Very large areas inventoried, information on ~~hydrodynamics~~ water movement (sedimentary figures), can be reproduced, non-destructive method, large depth-range investigated
Limits	High cost, uncertainties in the ~~interpreting of~~ sonograms interpretation~~s~~, additional validation (inter-calibration), observation only of the superficial layer~~s~~, no taxonomical information
Use	Studies over large spatial scales, monitoring of populations, bionomic studies

~~68.~~71. When necessary, for a detailed characterization of rhodolith communities, a minimum of three box-cores with opening ≥0.16 m^2 should be collected in each rhodolith~~s~~ bed at the same depth, and to a depth of about 20 cm of sediment. One additional box-corer sample must be collected within the rhodolith~~s~~ area with the highest percentage of live cover (~~on the basis of~~based on preliminary ROV surveys that remain necessary to pilot blind samplings from vessel), and the others as far as possible from it, following the depth gradient in opposite directions of the maximum rhodolith~~s~~ bed extension. In many instances grab samples could be useful, but attention must be paid to seafloor surface disruption and mixing, and the possible loss of material during recovery. In those extreme cases of very coarse material preventing box-core penetration and closure, a grab could be used instead, although it cannot preserve stratification. Once the box-core is recovered a colour photograph of the whole surface of the box-core, at a high enough resolution to recognise the morphology of single live rhodoliths and other conspicuous organisms, must be collected. In addition, the possible occurrence of heavy overgrowths of fleshy algae that may affect rhodoliths growth rate must be reported. The following descriptors must then be assessed: 1) visual estimation of the percentage cover of live red calcareous algae; 2) visual estimation of the live/dead rhodoliths ratio calculated for the surface of the box-core; 3) visual assessment of the rhodolith~~s~~ morphologies characterising the sample (Fig. 7~~5~~); 4) measurement of the thickness of the live rhodoliths layer. According to the specific objective of investigation, ~~T~~the sediment sample ~~is~~ can then be washed through a sieve (e.g., 0.5 mm mesh) and the sample treated with Rose Bengal to stain living material before being preserved for sorting under a microscope for taxa identification. All live calcareous algae and accompanying phytobenthos and zoobenthos ~~should~~ could be identified and quantified, ~~in order to~~to ~~allow for the detection of~~detect variability in space and time, and for any change~~s~~ after possible impacts. Algal species must be evaluated using a semi-quantitative approach (classes of abundance of algal coverage: absent, 1-20%, 21-40%, 41-60%, 61-80%, >81%). For molecular investigations, samples from voucher rhodolith~~s~~ morphotypes should be air-dried, and then preserved in silica gel. The sediment sample should be analysed for grain-size (mandatory), and carbonate content.

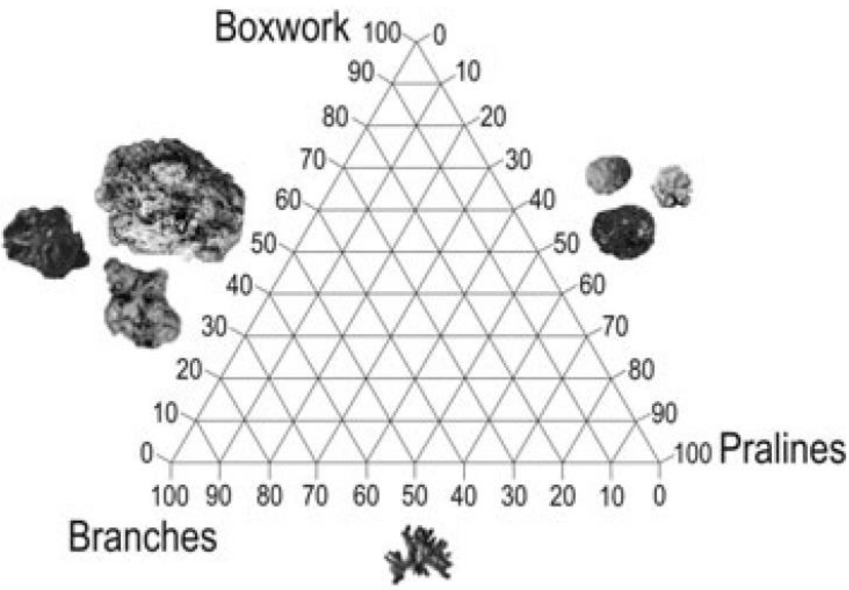


Figure 7~~5~~: T~~t~~ernary diagram for the description of the rhodoliths ~~bed~~ tridimensionality. The percentage cover of each rhodolith~~s~~ morphotype, relative to the total rhodoliths cover, can be plotted on the correspondent axis. The three main rhodolith~~s~~ morphotypes (box_work_rhodoliths, pralines~~,~~ and unattached branches) are intended as focal points of a continuum, to which any possible rhodolith~~s~~ morphology can be approximately assigned. From Basso et al. (2016).

Ecological i~~I~~ndices

~~69.~~72. At present, an ecological index to evaluate the status of rhodolith beds has not been proposed yet. On the contrary, ~~T~~to assess the ecological status of coralligenous reefs, several ecological indices have been developed based on different approaches (Kipson et al., 2011, 2014; Teixidó et al., 2013; Zapata-Ramírez et al., 2013; David et al., 2014; Féral et al., 2014; Piazzi et al., 2019a), which are summarised in Table 5. Most of the ecological indices available for monitoring shallow (up to about 40 m depth) coralligenous reefs require underwater surveys by scuba diving. These indices ~~have been developed following different approaches and~~ adopt distinct descriptors and sampling techniques, thus hampering the comparison of data and results, and requiring inter-calibration procedures. However, as described before, the protocol STAR (STAndaRdized coralligenous evaluation procedure; Piazzi et al., 2019a; Gennaro et al., 2020) has been recently proposed as an effective procedure to obtain standardized data on most of the descriptors adopted in the different ecological indices through a single sampling effort and a shared data analysis. Detailed descriptions of the sampling tools and the methodologies ~~adopted~~ needed to apply~~for~~ each ecological index listed in Table 5 can be found in the relative bibliographic references.

~~70.~~73. ESCA (Ecological Status of Coralligenous Assemblages; Cecchi et al., 2014; Piazzi et al., 2015, 2017a, 2021), ISLA (Integrated Sensitivity Level of coralligenous Assemblages; Montefalcone et al., 2017), and CAI (Coralligenous Assessment Index; Deter et al., 2012) indices are based on a ~~biocoenotic~~biocenotic approach where coralligenous assemblages are investigated in terms of composition and abundance of all species for ESCA and ISLA, and of percentage cover of mud and builder organisms (i.e., Corallinales, bryozoans, and scleractinians) for CAI.

~~71.~~74. EBQI (Ecosystem-Based Quality Index; Ruitton et al., 2014) adopts a trophic web approach at the ecosystem level, in which the different functional components are identified, and an ecological status index is measured for each of them.

~~72.~~75. COARSE (COralligenous Assessment by ReefScape Estimate; Gatti et al., 2012, 2015a) uses a seascape approach to provide information about the structure of coralligenous reefs ~~in order to~~to assess the seafloor integrity. Since the coralligenous is characterised by high heterogeneity, extreme patchiness and coexistence of several biotic assemblages, a seascape approach seems to be the most reasonable solution for its characterisation.

~~73.~~76. OCI (Overall Complexity Index; Paoli et al., 2016) combines measures of structural and functional complexity, while the INDEX-COR (Sartoretto et al., 2017) integrates three descriptors (the sensitivity of taxa to organic matter and sediment deposition, the observable taxonomic richness, and the structural complexity of assemblages) to assess the health stat~~us~~e of coralligenous assemblages.

~~74.~~77. Inter-calibrations among some of the above listed ecological indices have already been carried out. Comparison between ESCA and COARSE (Montefalcone et al., 2014; Piazzi et al., 2014, 2017a, 2017b), which are the two indices with the greatest number of successful applications to date (Piazzi et al., 201~~1~~7b, 2021), in 24 sites of the NW Mediterranean Sea showed that the two indices provided different but complementary information to determine the intrinsic quality of coralligenous reefs and to detect the effects of human pressures on the associated assemblages. The concurrent use of ESCA and COARSE ~~can~~ is thus ~~be~~ effective in providing information about the alteration of ecological quality of coralligenous reefs. A recent comparison among ESCA, ISLA, and COARSE has also been carried out (Piazzi et al., 2018), which proved that the main differences among indices are linked to the different approaches used, ~~and that~~ with ESCA and ISLA showing the~~ed~~ highest ~~ly~~ consistency ~~results~~ being based on a ~~biocoenotic~~biocenotic approach. Finally, CAI, ESCA, COARSE, and INDEX-COR have been compared in 21 sites along the southern coasts of France (Gatti et al., 2016). Results showed that the four indices are not always concordant in indicating the ecological quality of coralligenous habitats, some metrics being more sensitive than others to the increasing pressure levels.

~~75.~~78. Comparatively ~~F~~fewer efforts have been made to ~~define~~ propose ecological indices for mesophotic environments based on ROV footages, resulting in three seascape indices (Tab. 6), namely MAES (Mesophotic Assemblages Ecological Status; Cánovas-Molina et al., 2016a), CBQI (Coralligenous Bioconstructions Quality Index; Ferrigno et al., 2017), and MACS (Mesophotic Assemblages Conservation Status; Enrichetti et al., 2019). MACS is a new multi-parametric index that is composed ~~by~~ of two independent units, the Index of Status (*Is*) and the Index of Impact (*Ii*) following a DPSIR (Driving forces - ~~—~~Pressures ~~—~~- Status ~~—~~- Impacts ~~—~~- Response) approach. The MACS index integrates three descriptors included in the MSFD and listed by the Barcelona Convention to define the environmental status of seas, namely biological diversity, seafloor integrity, and marine litter. The *Is* depicts the ~~biocoenotic~~biocenotic complexity of the investigated ecosystem, whereas the *Ii* describes ~~the~~ its impacts. ~~affecting it.~~ Environmental status is the outcome of the status of benthic communities plus the effects ~~amount (the number?)~~ of impacts ~~(effects)~~ upon them: the integrated MACS index measures the resulting environmental status of deep coralligenous habitats reflecting the combination of the two units and their ecological significance. The MACS index has been effectively calibrated on 14 temperate mesophotic reefs of the Ligurian and Tyrrhenian seas, all characterised by the occurrence of temperate reefs ~~but~~ and subjected to different environmental conditions and levels of human pressures.

Final remarks

~~76.~~79. Inventorying and monitoring the condition of coralligenous reefs and rhodolith~~s~~ seabeds in the Mediterranean constitutes a unique challenge given the ecological and economic importance of these habitats and the threats that hang over their continued existence. Long ignored due to their difficult accessibility and the limited means of investigation, today these habitats are widely included in monitoring programs to assess environmental quality.

~~77.~~80. A standardized approach must be encouraged for monitoring the condition of coralligenous reefs and rhodolith~~s~~ seabeds, and in particular:

- Knowledge on coralligenous reefs and rhodolith~~s~~ seabeds distribution should be continuously enhanced at the Mediterranean scale, especially in the ~~its E~~eastern basin, and reference areas/sites should be individuated;

- Long chronological dataset must be envisaged, and a network of Mediterranean experts settled up;

- Monitoring networks, locally managed and coordinated on a regional scale, should be started, and the standardized protocols here proposed should be applied to the entire Mediterranean both on coralligenous reefs and rhodolith~~s~~ seabeds.

Table 5: Descriptors used in the ecological indices mostly adopted in the regional/national monitoring programs to evaluate environmental quality of shallow water (up to 40 m depth) coralligenous ~~habitat~~ reefs and based on different approaches.

Index	Method	Image analysis	Descriptors
~~Biocoenotic~~*Biocenotic*			
ESCA	Photographic samples: 30 photographic quadrates (50 cm × 37.5 cm) in two areas hundreds of metres apart	Software Image J’ for the estimation of the % cover of the main taxa and/or morphological groups of sessile macro-invertebrates and macroalgae	3 descriptors: Sensitivity Level of all species (SL); α diversity (diversity of assemblages); β diversity (heterogeneity of assemblages)
ISLA	Photographic samples: 30 photographic quadrates (50 cm × 37.5 cm) in two areas hundreds of metres apart	Software Image J’ for the estimation of the % cover of the main taxa and/or morphological groups of sessile macro-invertebrates and macroalgae	2 descriptors: Integrated Sensitivity Level of all species (ISL), i.e. Sensitivity Level to sstress (SSL) and Sensitivity Level to disturbance (DSL)
CAI	Photographic samples: 30 photographic quadrates (50 cm×50 cm) along a 40 m long transect	Software CPCe 3.6 for the estimation of the % cover by each species	3 descriptors: % cover of mud; % cover of builders; % cover of bryozoans
Ecosystem			
EBQI	Direct *in situ* observations and samples. A simplified conceptual model of the functioning of the ecosystem with 10 functional compartments		11 descriptors: % cover of builders; % cover of non-calcareous species; abundance of filter and suspension feeders; occurrence of bioeroders and density of sea urchins; abundance of browsers and grazers; biomass of planktivorous fish; biomass of predatory fish; biomass of piscivorous fish; Specific Relative Diversity Index for fish; % cover of benthic detritus matter; density of detritus feeders
Seascape			
COARSE	Direct *in situ* observations with the Rapid Visual Assessment (RVA): 3 replicated visual estimations over an area of about 2 m^2 each		9 descriptors, 3 per each layer: Basal layer: % cover of encrusting calcified rhodophyta, non-calcified encrusting algae, encrusting animals, turf-forming algae and sediment; amount of boring species marks; thickness and consistency of calcareous layer with a hand-held penetrometer (5 replicates) Intermediate layer: specific richness; n° of erect calcified organisms; sensitivity of bryozoans Upper layer: total % cover of species; % of necrosis of each population; maximum height of the tallest specimen

Index	**Method**	**Image analysis**	**Descriptors**
Integrated			
INDEX-COR	Photographic samples and direct observations: 30 photographic quadrates (60 cm × 40 cm) along two 15 m long transects (15 photos per transect); visual census of marine litter, conspicuous benthic sessile and mobile species (echinoderms, crustacean decapods, and nudibranchs), estimation of the % cover of gorgonians and sponges, % of necrotic gorgonian colonies	Free software photoQuad, using the uniform point count technique	3 descriptors: Taxa Sensitivity level (TS) to organic matter and sediment input; taxonomic richness of conspicuous taxa that ~~were~~ are recognizable visually on photo-quadrates and *in situ*; structural complexity of the habitat, defined from the % cover of the taxa belonging to basal and intermediate layers estimated from the photo-quadrates and the % cover of gorgonians and large sponges observed *in situ* along the transects for the upper layer
OCI	Available detailed maps of benthic habitats		Surface area covered by coralligenous obtained from maps; list of the main taxonomic groups found in the habitat; biomass per unit area of each taxonomic group obtained from the literature. These descriptors are used to compute exergy and specific exergy as a measure of structural complexity, whilst throughput and information as a measure of functional complexity

Table 6: Descriptors used in the ecological indices mostly adopted in the regional/national monitoring programs to evaluate environmental quality of deep water (from about 40 m to about 120 m depth) coralligenous habitat reefs occurring in the shallow mesophotic zone.

Index	**Method**	**Image analysis**	**Descriptors**
Seascape			
MAES	ROV survey: 500 m long video transects per area and 20 random high-resolution photographs frontally on the seafloor	VLC program for video and Image J' software for photos	6 descriptors: n° of megabenthic taxa; % biotic cover in the basal layer; density of erect species; average height and % cover of the dominant erect species; % of colonies with epibiosis/necrosis; density of marine litter
CBQI	ROV survey and photographs	VisualSoft software for video and DVDVideoSoft software to obtain random frames every 10 seconds for quantitative analysis	9 descriptors: % cover of coralligenous on the bottom; n° of morphological groups; density of fan corals; % of colonies with epibiosis/necrosis; % of colonies with covered/entangled signs; % of fishing gear; depth; slope; substrate type
MACS	ROV survey: three replicated video transects, each at least 200 m long, and 20 random high-resolution photographs frontally on the seafloor	VLC program for video and Image J' software for photos	12 descriptors: species richness of the conspicuous megabenthic sessile and sedentary species in the intermediate and canopy layers; % cover of basal encrusting species; % cover of coralline algae; dominance of structuring species; density of structuring species; height of structuring species; % cover of sediment; % of colonies with signs of epibiosis; % of colonies with signs of necrosis; % of colonies –directly entangled in lost fishing gears; density of marine litter; typology of marine litter

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Annex 2.1

List of the main species to be considered in the inventorying and monitoring of coralligenous and rhodoliths habitats (from UNEP/MAP-RAC/SPA, 2015). Each Contracting Party can regularly improve these lists and chose the most appropriate species according to its geographical situation.

Coralligenous
(*invasive; **disturbed or stressed environments, when abundant; * protected species)**

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

Animal builders
Foraminifera
Miniacina miniacea Pallas, 1766

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

Polychaeta
Serpula spp.
Protula tubularia (Montagu, 1803)
Spirobranchus polytrema Philippi, 1844
~~*Serpula* spp.~~
Spirorbis sp.
~~*Spirobranchus polytrema* Philippi, 1844~~

Cnidaria
Caryophyllia (Caryophyllia) inornata (Duncan, 1878)
Caryophyllia (Caryophyllia) smithii Stokes & Broderip, 1828
Cladocora caespitosa Linnaeus, 1767
Dendrophyllia ramea Linnaeus, 1758
Dendrophyllia cornigera Lamarck, 1816
Hoplangia durotrix Gosse, 1860
Leptopsammia pruvoti Lacaze-Duthiers, 1897
~~*Hoplangia durotrix* Gosse, 1860~~
Madracis pharensis (Heller, 1868)
Polycyathus muellerae Abel, 1959
~~*Cladocora caespitosa* Linnaeus, 1767~~
Phyllangia americana mouchezii Lacaze-Duthiers, 1897
~~*Dendrophyllia ramea* Linnaeus, 1758~~
~~*Dendrophyllia cornigera* Lamarck, 1816~~

Bioeroders
Sponges
Clionidae (*Cliona*, *Pione*)

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

Molluscs
~~*Rocellaria dubia* (Pennant, 1777)~~
Hiatella arctica Linnaeus, 1767
Lithophaga lithophaga Linnaeus, 1758***
Petricola lithophaga (Retzius, 1788)
Rocellaria dubia (Pennant, 1777)

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

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

O~~o~~ther relevant species
~~(*invasive; **disturbed or stressed environments-usually, when abundant)~~
Algae
Green algae
Caulerpa cylindracea Sonder, 1845*
Caulerpa taxifolia (M. Vahl) C. Agardh, 1817*
Codium bursa (Olivi) C. Agardh, 1817**
Codium fragile (Suringar) Hariot, 1889*
Codium vermilara (Olivi) Chiaje, 1829**
Flabellia petiolata (Turra) Nizamuddin, 1987
Halimeda tuna (J. Ellis & Solander) J.V. Lamouroux, 1816
Palmophyllum crassum (Naccari) Rabenhorst, 1868
~~*Caulerpa cylindracea* Sonder, 1845~~
~~*Caulerpa taxifolia* (M. Vahl) C. Agardh, 1817*~~
~~*Codium bursa* (Olivi) C. Agardh, 1817**~~
~~*Codium fragile* (Suringar) Hariot, 1889*~~
~~*Codium vermilara* (Olivi) Chiaje, 1829**~~

Brown algae
Acinetospora crinita (Carmichael) Sauvageau, 1899**
Cystoseira dubia ~~-~~Valiante, 1883***
Cystoseira montagnei var. *compressa* (Ercegovic) M. Verlaque, A. Blanfuné, C.F. Boudouresque, T. Thibaut & L.N. Sellam, 2017
Cystoseira zosteroides (Turner) C. Agardh, 1821***
Dictyopteris lucida M.A. Ribera Siguán, A. Gómez Garreta, Pérez Ruzafa, Barceló Martí & Rull Lluch, 2005**
Dictyota spp.**
Halopteris filicina (Grateloup) Kützing, 1843
~~*Cystoseira montagnei* var. *compressa* (Ercegovic) M. Verlaque, A. Blanfuné, C.F. Boudouresque, T. Thibaut & L.N. Sellam, 2017~~
Laminaria rodriguezii Bornet, 1888***
~~*Halopteris filicina* (Grateloup) Kützing, 1843~~
Phyllariopsis brevipes (C. Agardh) E.C. Henry & G.R. South, 1987
Stictyosiphon adriaticus Kützing, 1843**
Stilophora tenella (Esper) P.C. Silva in P.C. Silva, Basson & Moe, 1996**
~~*Stictyosiphon adriaticus* Kützing, 1843**~~
~~*Dictyopteris lucida* M.A. Ribera Siguán, A. Gómez Garreta, Pérez Ruzafa, Barceló Martí & Rull Lluch, 2005**~~
~~*Dictyota* spp.**~~
Stypopodium schimperi (Kützing) M. Verlaque & Boudouresque, 1991*
~~*Acinetospora crinita* (Carmichael) Sauvageau, 1899**~~
~~*Stilophora tenella* (Esper) P.C. Silva in P.C. Silva, Basson & Moe, 1996**~~
~~*Stictyosiphon adriaticus* Kützing, 1843**~~

“Yellow” algae (Pelagophyceae)
Nematochrysopsis marina (J. Feldmann) C. Billard, 2000**

Red algae
Acrothamnion preissii (Sonder) E.M. Wollaston, 1968*
Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon, 1845*
Cryptonemia lomation (Bertoloni) J. Agardh, 1851

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

Animals

Sponges

Acanthella acuta Schmidt, 1862
Agelas oroides Schmidt, 1864
Aplysina aerophoba Nardo, 1843***
Aplysina cavernicola Vacelet, 1959***
Axinella spp.***
Calyx nicaeensis (Risso, 1827)
Chondrosia reniformis Nardo, 1847
Clathrina clathrus Schmidt, 1864
Cliona viridis (Schmidt, 1862)
Crambe crambe (Schmidt, 1862)
Dysidea spp.
Fasciospongia cavernosa (Schmidt, 1862)
Haliclona (Reniera) mediterranea Griessinger, 1971
Haliclona (Soestella) mucosa Griessinger, 1971
Haliclona (Halichoclona) fulva (Topsent, 1893)
Hemimycale columella Bowerbank, 1874
Ircinia oros Schmidt, 1864
Ircinia variabilis Schmidt, 1862
Oscarella spp.
Petrosia (Petrosia) ficiformis (Poiret, 1789)
Phorbas tenacior Topsent, 1925
Sarcotragus foetidus Schmidt, 1862~~fasciculatus(Pallas, 1766)~~
Sarcotragus spinosulus Schmidt, 1862
Spirastrella cunctatrix Schmidt, 1868
Spongia (Spongia) officinalis Linnaeus, 1759***
Spongia (Spongia) lamella Schulze, 1879***

Cnidaria

Aglaophenia kirchenpaueri (Heller, 1868)
Alcyonium acaule Marion, 1878
Alcyonium palmatum Pallas, 1766
Antipathes spp.***
Callogorgia verticillata Pallas, 1766
Cerianthus lloydii Gosse, 1859
Cerianthus membranaceus (Gmelin, 1791)
Corallium rubrum Linnaeus, 1758***
Desmophyllum dianthus (Esper, 1794)

Ellisella paraplexauroides Stiasny, 1936
Eunicella spp.
Leptogorgia sarmentosa Esper, 1789
Madracis pharensis (Heller, 1868)
Paramuricea clavata Risso, 1826
~~*Eunicella* spp.~~
~~*Leptogorgia sarmentosa* Esper, 1789~~
~~*Madracis pharensis* (Heller, 1868)~~
~~*Ellisella paraplexauroides* Stiasny, 1936~~
~~*Antipathes* spp.~~
Parazoanthus axinellae Schmidt ,1862
Savalia savaglia Bertoloni, 1819***
~~*Callogorgia verticillata* Pallas, 1766~~

Polychaeta

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

Bryozoans

Chartella tenella Hincks, 1887
Hornera frondiculata (Lamarck, 1816)***
Margaretta cereoides Ellis & Solander, 1786
~~*Hornera frondiculata* (Lamarck, 1816)***~~

Tunicates

Aplidium spp.
~~*Pseudodistoma cyrnusense* Pérès, 1952~~
~~*Aplidium* spp.~~*Cystodytes dellechiajei* (Della Valle, 1877)
Halocynthia papillosa Linnaeus, 1767
Herdmania momus (Savigny, 1816)
Microcosmus sabatieri Roule, 1885
Pseudodistoma cyrnusense Pérès, 1952
~~*Halocynthia papillosa* Linnaeus, 1767~~

Molluscs

Cerithium scabridum Philippi, 1848*
Charonia lampas Linnaeus, 1758***
Charonia variegata Lamarck, 1816
~~*Pinna rudis* Linnaeus, 1758***~~
~~*Naria spurca* (Linnaeus, 1758)~~
~~*Cerithium scabridum* Philippi, 1848*~~
Luria lurida Linnaeus, 1758***
Naria spurca (Linnaeus, 1758)
Pinna rudis Linnaeus, 1758***

Decapoda

Dardanus arrosor (Herbst, 1796)
Maja squinado Herbst, 1788***
Palinurus elephas Fabricius, 1787***
Pilumnus hirtellus (Linnaeus, 1761)
Scyllarides latus Latreille, 1803***
~~*Maja squinado* Herbst, 1788***~~

Echinodermata

Antedon mediterranea Lamarck, 1816

~~*Hacelia attenuata* Gray, 1840~~
Centrostephanus longispinus Philippi, 1845***
Diadema setosum (Leske, 1778)*
Echinaster (Echinaster) sepositus (Retzius, 1783)
Hacelia attenuata Gray, 1840
Holothuria (Panningothuria) forskali Delle Chiaje, 1823
Holothuria (Platyperona) sanctori Delle Chiaje, 1823
Synaptula reciprocans (Forsskål, 1775)

Pisces
Anthias anthias (Linnaeus, 1758)
Coris julis (Linnaeus, 1758)
Chromis chromis (Linnaeus, 1758)
Epinephelus spp.***

Mycteroperca rubra Bloch, 1793
Pterois miles (Bennett, 1828)*
Sargocentron rubrum (Forsskål, 1775)*
Seriola dumerili (Risso, 1810)
Siganus luridus (Rüppell, 1829)*
Siganus rivulatus Forsskål & Niebuhr, 1775*
Sparisoma cretense (Linnaeus, 1758)
Sciaena umbra Linnaeus, 1758***
Scorpaena scrofa Linnaeus, 1758
Raja spp.***
Torpedo spp.
Mustelus spp.
Phycis phycis Linnaeus, 1766
Serranus cabrilla Linnaeus, 1758
Scyliorhinus canicula Linnaeus, 1758

Rhodoliths

(*invasive; **disturbed or stressed environments, when abundant; * protected species(*invasive; **disturbed or stressed environments usually, when abundant). Species that can be dominant or abundant are preceded by #)**

Algae

Red algae (calcareous)

Lithophyllum cabiochae (Boudouresque et Verlaque) Athanasiadis
Lithophyllum stictiforme (J.E. Areschoug) Hauck, 1877
Lithothamnion minervae Basso, 1995
#*Lithophyllum racemus* (Lamarck) Foslie, 1901
Lithophyllum stictiforme (J.E. Areschoug) Hauck, 1877
#*Lithothamnion corallioides* (P.L. Crouan & H.M. Crouan) P.L. Crouan & H.M. Crouan, 1867***
Lithothamnion minervae Basso, 1995
#*Lithothamnion valens* Foslie, 1909
#*Peyssonnelia crispate* Boudouresque & Denizot, 1975
#*Peyssonnelia rosa-marina* Boudouresque & Denizot, 1973
#*Phymatolithon calcareum* (Pallas) W.H. Adey & D.L. McKibbin ex Woelkering & L.M. Irvine, 1986
#*Spongites fruticulosa* Kützing, 1841
#*Tricleocarpa cylindrica* (J. Ellis & Solander) Huisman & Borowitzka, 1990
Lithophyllum cabiochae (Boudouresque et Verlaque) Athanasiadis
Lithophyllum stictiforme (J.E. Areschoug) Hauck, 1877
Lithothamnion minervae Basso, 1995
Mesophyllum alternans (Foslie) Cabioch & Mendoza, 1998
Mesophyllum expansum (Philippi) Cabioch & Mendoza, 2003
Mesophyllum philippii (Foslie) W.H. Adey, 1970
Neogoniolithon brassica-florida (Harvey) Setchell & L.R. Mason, 1943
Neogoniolithon mamillosum (Hauck) Setchell & L.R. Mason, 1943
#*Peyssonnelia crispate* Boudouresque & Denizot, 1975
Peyssonnelia heteromorpha (Zanardini) Athanasiadis, 2016
#*Peyssonnelia rosa-marina* Boudouresque & Denizot, 1973
#*Phymatolithon calcareum* (Pallas) W.H. Adey & D.L. McKibbin ex Woelkering & L.M. Irvine, 1986***
#*Spongites fruticulosa* Kützing, 1841
Sporolithon ptychoides Heydrich, 1897
#*Tricleocarpa cylindrica* (J. Ellis & Solander) Huisman & Borowitzka, 1990
Peyssonnelia heteromorpha (Zanardini) Athanasiadis, 2016
Sporolithon ptychoides Heydrich, 1897

Red algae (non buildersnon-builders)

#*Osmundaria volubilis* (Linnaeus) R.E. Norris, 1991
#*Phyllophora crispa* (Hudson) P.S. Dixon, 1964
Peyssonnelia spp. (non calcareous)
Acrothamnion preissii (Sonder) E.M. Wollaston, 1968*
Alsidium corallinum C. Agardh, 1827
Cryptonemia spp.
Felicinia marginata (Roussel) Manghisi, Le Gall, Ribera, Gargiulo & M. Morabito, 2014
Gloiocladia microspora (Bornet ex Bornet ex Rodríguez y Femenías) N. Sánchez & C. Rodríguez-Prieto ex Berecibar, M.J. Wynne, Barbara & R. Santos, 2009
Gloiocladia repens (C. Agardh) Sánchez & Rodríguez-Prieto, 2007
Gracilaria spp.

Halymenia spp.
Kallymenia spp.
Leptofauchea coralligena Rodríguez-Prieto & De Clerck, 2009
Nitophyllum tristromaticum J.J. Rodríguez y Femenías ex Mazza, 1903
Osmundea pelagosae (Schiffner) K.W. Nam, 1994
#*Osmundaria volubilis* (Linnaeus) R.E. Norris, 1991
Peyssonnelia spp. (non-calcareous)
#*Phyllophora crispa* (Hudson) P.S. Dixon, 1964
Phyllophora heredia (Clemente) J. Agardh, 1842
Rhodophyllis divaricata (Stackhouse) Papenfuss, 1950
Rytiphlaea tinctoria (Clemente) C. Agardh, 1824
Sebdenia spp.
Vertebrata byssoides (Goodenough & Woodward) Kuntze, 1891
Vertebrata subulifera (C. Agardh) Kuntze, 1891
Womersleyella setacea (Hollenberg) R.E. Norris, 1992*

Green algae
~~# *Flabellia petiolata* (Turra) Nizamuddin, 1987~~
Caulerpa cylindracea Sonder, 1845*
Caulerpa taxifolia (M. Vahl) C. Agardh, 1817*
Codium bursa (Olivi) C. Agardh, 1817
Flabellia petiolata (Turra) Nizamuddin, 1987
Microdictyon umbilicatum (Velley) Zanardini, 1862
Palmophyllum crassum (Naccari) Rabenhorst, 1868
Umbraulva dangeardii M.J. Wynne & G. Furnari, 2014

Brown algae
Arthrocladia villosa (Hudson) Duby, 1830
~~# *Laminaria rodriguezii* Bornet, 1888~~
~~# *Sporochnus pedunculatus* (Hudson) C. Agardh, 1817~~
Acinetospora crinita (Carmichael) Sauvageau, 1899**
Carpomitra costata (Stackhouse) Batters, 1902
Cystoseira abies-marina (S.G. Gmelin) C. Agardh, 1820
Cystoseira foeniculacea (Linnaeus) Greville, 1830
Cystoseira foeniculacea f. *latiramosa* (Ercegovic?) A. Gómez Garreta, M.C. Barceló, M.A. Ribera & J.R. Lluch, 2001
Cystoseira montagnei var. *compressa* (Ercegovic) M. Verlaque, A. Blanfuné, C.F. Boudouresque, T. Thibaut & L.N. Sellam, 2017
Cystoseira zosteroides (Turner) C. Agardh, 1821***
Dictyopteris lucida M.A. Ribera Siguán, A. Gómez Garreta, Pérez Ruzafa, Barceló Martí & Rull Lluch, 2005
Dictyota spp.
Halopteris filicina (Grateloup) Kützing, 1843
Laminaria rodriguezii Bornet, 1888***
Lobophora variegata (J.V. Lamouroux) Womersley ex E.C.Oliveira, 1977

Nereia filiformis (J. Agardh) Zanardini, 1846
Phyllariopsis brevipes (C. Agardh) E.C. Henry & G.R. South, 1987
Spermatochnus paradoxus (Roth) Kützing, 1843
Sporochnus pedunculatus (Hudson) C. Agardh, 1817
Stictyosiphon adriaticus Kützing, 1843
Stilophora tenella (Esper) P.C. Silva, 1996
Zanardinia typus (Nardo) P.C. Silva, 2000

Animals

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

Cnidaria
Adamsia palliata (Müller, 1776)
Alcyonium palmatum Pallas, 1766
~~# *Eunicella verrucosa* Pallas, 1766~~
~~# *Paramuricea macrospina* Koch, 1882~~
Aglaophenia spp.
~~*Adamsia palliata* (Müller, 1776)~~
Calliactis parasitica Couch, 1838
Cereus pedunculatus Pennant 1777
Cerianthus membranaceus (Gmelin, 1791)
Eunicella verrucosa Pallas, 1766
Funiculina quadrangularis Pallas, 1766
Leptogorgia sarmentosa Esper, 1789
Nemertesia antennina Linnaeus, 1758
Paramuricea macrospina Koch, 1882
Pennatula spp.
Veretillum cynomorium Pallas, 1766
Virgularia mirabilis Müller, 1776

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

Bryozoans
Cellaria fistulosa Linnaeus, 1758
Hornera frondiculata (Lamarck, 1816)
Pentapora fascialis Pallas, 1766
Turbicellepora spp.

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

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

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

UNEP

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

22 May 2021
Original: English

Fifteenth Meeting of SPA/BD Focal Points

Videoconference, 23-25 June 2021

Agenda Item 7: Status of implementation of the Ecosystem Approach (EcAp) Roadmap

7.1. Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Appendix B: Monitoring and Assessment Scales, Assessment Criteria, Thresholds and Baseline Values for the IMAP Common Indicators 3, 4 and 5 related to Marine Mammals

UNEP/MAP
SPA/RAC-Tunis, 2021

In charge of the study at SPA/RAC

Mehdi Aissi, Project officer, EcAp/IMAP
Asma Yahyaoui, Associate project officer, EcAp/IMAP
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Report prepared by:

Caterina Fortuna and Léa David, Marine mammals' experts

Acknowledgment

This report was prepared with the participation and voluntary contribution of a pool of Mediterranean experts namely: Rimel Ben Messaoud, Ali Cemal Gucu, Arda Tonay, Souad Lamouti, Giulia Mo, Vincent Ridoux, Aviad Scheinin, José Antonio Vázquez Bonales, the members of the ACCOBAMS Scientific Committee (particularly, Simone Panigada, Ayaka Amaha Ozturk and Joan Gonzalvo) and the Biodiversity Online Working Group (OWG) on Marine mammals namely : Ferdinand Bego, Draško Holcer, Srđana Rožić, Martina Marić, Mohamed Said Abdelwarith, Jérôme Spitz, Marianna Giannoulaki , Giancarlo Lauriano, Giulia Mo, Gaby Khalaf, Milad Fakhry, Rita Mouawad, Mirko Djurovic, Tilen Genov, Camilo Saavedra, Jose Antonio Vázquez, José Carlos Báez, Mehmet Arda TONAY, Amaha Ozturk AYAKA, Meltem OK

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LEXICON

1. Definitions used in Summary Tables

Primary monitoring tool or scale: "Primary" here means the necessary (mandatory) monitoring tool and scale to assess EcAp/IMAP GES Common Indicators for marine mammals as approved by the Parties. Establishing primary monitoring tools does not impede contracting parties to use additional methods ("secondary" or new tools), knowing that those will answer other questions than those related to EcAp and IMAP reporting.

Secondary monitoring tool or scale: "Secondary" does not mean the "second-best" method or monitoring scale, but it indicates a method that applied to a different scale allows gathering complementary data that helps filling knowledge gaps, which will help correcting adaptive processes as, in this case, EcAp and MSFD. These "secondary" methods and scales are important in the long-term, but do not allow to assess EcAp/IMAP GES Common Indicators for marine mammals.

Voluntary monitoring tool: These are other data collection tools that can be used for marine mammals, better if applying existing guidelines (UNEP MAP 2019) and in an international cooperation programme. Even though they will not produce useful information to assess the GES in the short-, medium- or long-term, they can produce useful information to manage human-uses of the sea at a national or smaller scale.

2. Acronyms

A: Adriatic sub-region.
ACCOBAMS: Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area.
AL: Aegean-Levantine sub-region.
BC: Barcelona Convention.
CCI: Candidate Common Indicator.
CI: Common Indicator.
CORMONs: Correspondence Groups on Monitoring.
EcAp: Barcelona Convention Ecosystem Approach policy.
EO: EcAp/IMAP Ecological Objective.
EU: European Union.
FAO: Food and Agriculture Organization of the United Nations.
GFCM: General Fisheries Commission for the Mediterranean.
GSA: Geographical Subareas.
HD: Habitats Directive.
HELCOM: Convention on the Protection of the Marine Environment of the Baltic Sea Area - Helsinki Convention.
ICES: International Council for the Exploration of the Sea.
ICM: Ionian and Central Mediterranean sub-region.
IMAP: Barcelona Convention Integrated Monitoring and Assessment Programme.
IWC: International Whaling Commission.
MEDPOL: Programme for the Assessment and Control of Marine Pollution in the Mediterranean.
MAP: Mediterranean Action Plan.
MSFD: Marine Strategy Framework Directive.
OSPAR: Convention for the Protection of the Marine Environment of the North-East Atlantic.
PAP/RAC: Priority Actions Programme Regional Activity Centre.
RSMS: Regional Strategy for the conservation of Monk Seal in the Mediterranean.
SAP BIO: Strategic Action Programme for the conservation of Biological Diversity.
SPA/RAC: Regional Activity Centre for Specially Protected Areas Special.
STECF: Scientific, Technical and Economic Committee for Fisheries.
UNEP/MAP: United Nations Environment Programme /Mediterranean Action Plan.
WGBYC: Working Group on Bycatch of Protected Species.
WM: Western Mediterranean sub-region.

EXECUTIVE SUMMARY

This document was prepared in the framework of the EcAp process to propose refinement to the monitoring and assessment scales and propose reference and thresholds values for the IMAP Common Indicator (CI) 3 (*Species distributional range*), CI 4 (*Population abundance of selected species abundance*) and CI 5 (*Population demographic characteristics*) for marine mammal species, it also considers CI 12 (*Bycatch of vulnerable and non-target species*) because of its strong connection with CI 3, CI 4 and CI5.

This document summarizes background information on these CIs, including material on reference values, thresholds and targets, monitoring and assessment scales and GES definitions contained in the Barcelona Convention Decisions, and the necessary explanatory material. It also includes relevant material discussed and/or approved in the context of the EU Habitats Directive (HD) and Marine Strategy Framework Directive (MSFD), OSPAR, HELCOM and even some EU Mediterranean National prospective.

Early drafts were thoroughly discussed with a pool of Mediterranean experts composed by Rimel Ben Messaoud, Ali Cemal Gucu, Arda Tonay, Souad Lamouti, Giulia Mo, Vincent Ridoux, Aviad Scheinin, José Antonio Vázquez Bonales and revised accordingly. The final draft of this document benefited from revisions suggested by members of the ACCOBAMS Scientific Committee (particularly, Simone Panigada, Ayaka Amaha Ozturk and Joan Gonzalvo) and the Biodiversity Online Working Group (OWG) on Marine mammals.

The main products of this work are: (a) the Summary Tables (pages 32-38), (b) a list of recommended revisions to Appendix 1 of the Annex to the Decision IG.22/7 on '*Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria*' (Annex 1 to this document) and (c) a list of recommendations on future work to be carried out within the EcAp/IMAP revision and implementation.

Particularly, the **Summary Tables** summarize the current state of play and contain our proposals in regard to IMAP CI 3, 4, 5 and 12, GES objectives and targets for marine mammals. In particular, they provide background information on agreed EcAp Common Indicators, Ecological Objectives (EO), GES definitions and GES target and few proposals for changes and/or updates. They also include proposal on refining scales of monitoring for marine mammals and identify adequate scales for the most relevant species in the Mediterranean context. Finally, they contain proposals on assessment scales and criteria, including methods to set threshold and potential reference values.

The "**Recommendations for future work**", to be addressed in the context of the IMAP revision process, focus on the following issues:

- To ensure consistency or, at least, to ensure complementarity of EcAp/IMAP GES definitions, targets and IMAP monitoring and assessment scales with SAP BIO (Decision IG.24/7).
- To coordinate technical work on several aspects needing streamlining and regional agreement among experts, including:
  - The definition of specific aspects of CIs of reference values and parameters for the assessment for marine mammals, prior the next assessment (2023).
  - The appropriate level of significance for thresholds and reference values before the next assessment (2023).
  - The consideration of the potential impact of constantly changing baselines and on allowing the use of constantly decreasing trends within a specific time-window for CI3, CI4 and CI5.
  - The elaboration of initial reference maps for C3 and estimates of C4 and C5 for all possible species.
- To develop the Common Indicator 12 (bycatch) under EO1 rather than EO3, in cooperation with relevant agreements and organisations (e.g., for marine mammals: ACCOBAMS and Pelagos Agreement), in line with the MSFD D1C1 approach.

1. INTRODUCTION

1.1 Working methods to compile this report

1. Even though the priority of this report is to refine monitoring and assessment scales and define reference values and thresholds for EcAp/IMAP Common Indicator (CI) 3 (*Species distributional range*), CI4 (*Population abundance of selected species abundance*) and CI5 (*Population demographic characteristics*) for marine mammal species, it also considers CI12 (*Bycatch of vulnerable and non-target species*) because its strong connection with CI3, CI4 and CI5. It summarizes background information on these CIs, including material on reference values, thresholds and targets, monitoring and assessment scales and GES definitions contained in the Barcelona Convention Decisions, and the necessary explanatory material. It also includes relevant material discussed and/or approved in the context of the EU Habitats Directive (HD) and Marine Strategy Framework Directive (MSFD), OSPAR, HELCOM and even some EU Mediterranean National prospective. Finally, it contains some information on Candidate CIs (CCI), namely CCI24 (*Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles*), CCI26 (*Proportion of days and geographical distribution where loud, low, and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animal*) and 27 (*Levels of continuous low frequency sounds with the use of models as appropriate*), which are relevant to marine mammals (e.g., on marine litter and acoustic pollution).

2. There are also pieces of preliminary boxed text identified as "***Recommendation for future work***". These highlight preliminary ideas on actions that must be taken immediately after having agreed the Assessment framework for marine mammals, possibly before the next assessment (2023).

3. The draft report has been prepared by Caterina Fortuna and Léa David. The first draft of each section has been then circulated to a group of Mediterranean experts acting as external reviewers. These experts are: Rimel Ben Messaoud, Ali Cemal Gucu, Souad Lamouti, Giulia Mo, Vincent Ridoux, Aviad Scheinin, Arda Tonay, José Antonio Vázquez Bonales.

4. A consolidated draft was shared with the ACCOBAMS Scientific Committee. Then, the revised draft was further discussed by the Biodiversity Online Working Group (OWG) on marine mammals before its finalization and submission to the CORMON meeting on Biodiversity and Fisheries.

1.2 Background material on relevant aspects of the EcAp/IMAP discussion in the European context

5. In the following sections, you find a compilation of material regarding definitions, reference values, thresholds for marine mammals mostly in the context of the HD and MSFD discussions. This material (which might disappear or become an appendix) is meant to inform the selection of proposed options on equivalent topics in the context of EcAp and IMAP discussions.

6. The **Summary Tables** (in A3 format, see pages 32-38) at the end of these introductory material are the main output of this report, as they summarize the current state of the play and contain our proposals.

1.2.1 EU MSFD AND BARCELONA CONVENTION ECAP/IMAP MEDITERRANEAN SUB-REGIONS

1. EcAp sub-regions are the same as European Union (EU) Marine Strategy Framework Directive (MSFD) Mediterranean sub-regions: Western Mediterranean (WM), Ionian and Central Mediterranean (ICM), Adriatic (A) and Aegean-Levantine (AL). See the map below.

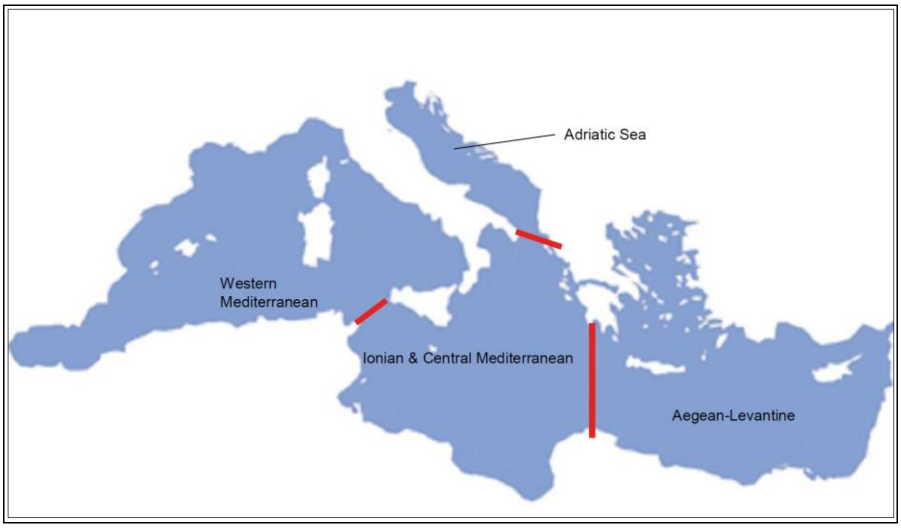
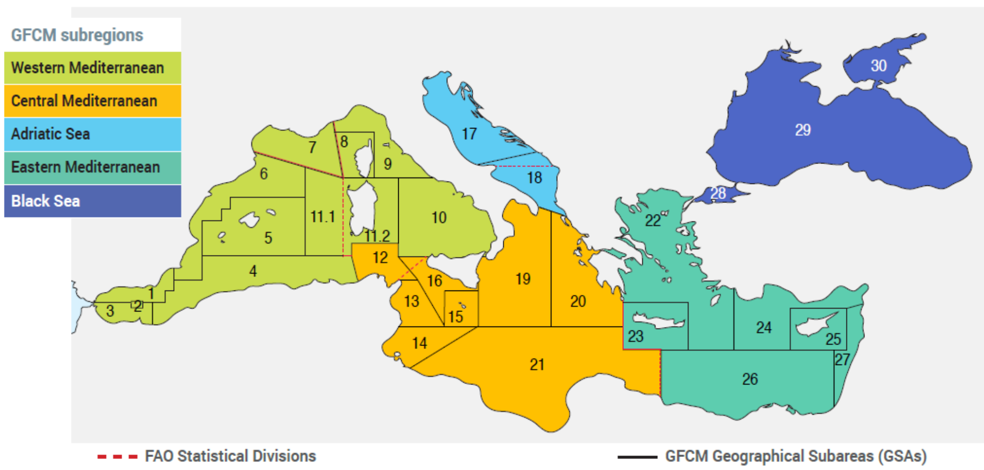


Figure 1: EcAp subregions

2. Sub-divisions are not yet defined; although some countries (e.g., Spain) have subdivisions and management units used within the MSFD.

3. In terms of sub-areas/management units already identified by other relevant organization (i.e. organizations dealing with pressures that might affect marine mammal species), the General Fisheries Commission for the Mediterranean (GFCM) Geographical Subareas (GSAs) exist and are relevant for the EcAp/IMAP assessment when considering Common Indicator 12 on bycatch mortality and its impact on species and their populations. Therefore, **the GFCM GSAs should be taken into due consideration** when designing substrata for the ACCOBAMS Survey Initiative (ASI)-like surveys, so that species abundance estimates can be provided in relation to these GSAs to assess bycatch mortality of marine mammals and other species of conservation concern.



GFCM GSAs

01 - Northern Alboran Sea	07 - Gulf of Lion	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus
02 - Alboran Island	08 - Corsica	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant
03 - Southern Alboran Sea	09 - Ligurian Sea and Northern Tyrrhenian Sea	15 - Malta	21 - Southern Ionian Sea	27 - Eastern Levant Sea
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - South of Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Islands	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic Sea	23 - Crete	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant Sea	30 - Azov Sea

Figure 2: General Fisheries Commission for the Mediterranean (GFCM) Geographical Subareas (GSA) *(Source: http://www.fao.org/gfcm/about/area-of-application/en/)*

1.2.2 GES definitions and GES target in the HD, MSFD and EcAp

4. Table 1 shows a comparison of definitions of conservation status/GES (state) and targets in the EU HD, MSFD and EcAp/IMAP contexts. It is worth noting that the HD focuses on habitats and species, whereas the MSFD focuses on the whole marine ecosystem.

Table 1 - Comparison of definitions of conservation status/GES (state) and targets in the EU HD, MSFD and BC EcAp/IMAP contexts

Conservation status in the EU HD: "state" definition	**Conservation status of a species in the EU HD: "state" targets**
The '*conservation status of a species*' is taken as '*favourable*' when (Article 1i): • population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, **and** • the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, **and** • there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis. Conservation Status is defined as: • **Favourable** (FV) describes the situation where species can be expected to prosper without any change to existing management or policies. FV is coded as GREEN. • **Unfavourable-Inadequate** (U1): describes situations where a change in management or policy is required to return the species to FV status, but there is no danger of extinction in the foreseeable future. U1 is coded as AMBER. • **Unfavourable-Bad** (U2): is for species in serious danger of becoming extinct (at least regionally). U2 is coded as RED. • **Unknown** (XX) class which can be used where there is insufficient information available to allow an assessment. XX is coded as GREY.	• **Favourable Reference Range (FRR)**: **Range** within which all significant ecological variations of species are included for a given biogeographical region and which is **sufficiently large to allow the long term survival** of the species. • **Favourable Reference value (FRV)** must be **at least the range (in size and configuration)** when the Directive **came into force**; if the range was insufficient to support a favourable status, the reference for favourable range should take account of that and should be larger (in such a case information on historic distribution may be found useful when defining the favourable reference range); 'best expert judgement' may be used to define it in absence of data. **Favourable Reference Population (FRP):** Population in a given biogeographical region considered the minimum necessary to ensure the long-term viability of the species; favourable reference value must be at least the size of the population when the Directive came into force; information on historic distribution/population may be found useful when defining the favourable reference population; 'best expert judgement' may be used to define it in absence of other data.
Good Environmental Status in the EU MSFD: "state" definition	**Good Environmental Status in the EU MSFD: "state" targets**
Art, 3.5 states that "*'good environmental status'* [GES] *means the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and* ***the use of the marine environment is at a level that is sustainable****, thus* ***safeguarding the potential for uses and activities*** *by current and future generations, i.e.:* *(a) the structure, functions and processes of the constituent marine ecosystems, together with the associated physiographic, geographic, geological and climatic factors,* ***allow those ecosystems to function fully and to maintain their resilience to human-induced environmental change****.* ***Marine species and habitats are protected****,* ***human-induced decline of biodiversity is prevented,*** *and diverse biological components function in balance;* *(b) hydro-morphological, physical and chemical properties of the ecosystems, including those properties which result from human activities in the area concerned, support the ecosystems as described above. Anthropogenic inputs of substances and energy, including noise, into the marine environment do not cause pollution effects*".	Relevant **qualitative descriptors** for determining GES (MSFD Annex I): *(1) Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. [**D1**]* *(4) All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity. [**D4**]* *(8) Concentrations of contaminants are at levels not giving rise to pollution effects. [**D8**]* *(10) Properties and quantities of marine litter do not cause harm to the coastal and marine environment. [**D10**]* *(11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment. [**D11**]* In MSFD Annex III, among listed characteristics, pressures and impacts there are the following relevant definitions: ***Characteristics***: "*a description of the population dynamics, natural and actual range and status of species of marine*

Art. 10: "*[…] When devising those targets and indicators, Member States shall take into account the continuing application of relevant existing environmental targets laid down at national, Community or international level in respect of the same waters, ensuring that these targets are mutually compatible and that relevant transboundary impacts and transboundary features are also taken into account, to the extent possible*	*mammals and reptiles occurring in the marine region or subregion"*. ***Pressures and impacts***: "*Biological disturbance:* […] *selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing*)".
Good Environmental Status in the Barcelona Convention EcAp: "state" definition	**Good Environmental Status in the Barcelona Convention EcAp: "state" targets**
EcAp aim to "A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations". The EcAp ecological vision: • To protect, allow recovery and, where practicable, restore the structure and function of marine and coastal ecosystems thus also protecting biodiversity, in order to achieve and maintain good ecological status and allow for their sustainable use. • To reduce pollution in the marine and coastal environment so as to minimize impacts on and risks to human and/or ecosystem health and/or uses of the sea and the coasts. • To prevent, reduce and manage the vulnerability of the sea and the coasts to risks induced by human activities and natural events.	**Ecological Objective 1 - Biological diversity (EO1):** "*Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic, and climatic conditions*". The term '*maintained*' is key and its condition is determined by three factors: i. No further loss of the diversity within species, between species and of habitats/communities and ecosystems at ecologically relevant scales. ii. Any deteriorated attributes of biological diversity are restored to and maintained at or above target levels, where intrinsic conditions allow. iii. Where the use of the marine environment is sustainable. **Ecological Objective 3 (EO3) - Harvest of commercially exploited fish and shellfish** ("*Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock*") is relevant for marine mammals because of Common Indicator 12: Bycatch of vulnerable and non-target species (EO1 and EO3). **Ecological Objective 4 (EO4) - Marine food webs:** "*Alterations to components of marine food webs caused by resource extraction or human-induced environmental changes do not have long-term adverse effects on food web dynamics and related viability*". In this EO marine mammals are considered under various functional groups. **Ecological Objective 9 (EO9) - Pollution:** "*Contaminants cause no significant impact on coastal and marine ecosystems and human health*" **Ecological Objective 10 (EO10) - Marine litter** is relevant for marine mammals because of Candidate Indicator 24 (Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles). **Ecological Objective 11 (EO11) - Energy including underwater noise** is relevant for some cetacean species because of two Candidate Indicators 26 (Proportion of days and geographical distribution where loud, low, and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animal) and 27 (Levels of continuous low frequency sounds with the use of models as appropriate).

Key: EU HD= European Habitats Directive (Council *Directive* 92/43/EEC). **Sources:** Habitats Directive (Council *Directive* 92/43/EEC); Evans & Arvela (2011); Commission Decision (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardized methods for monitoring and assessment and repealing Decision 2010/477/EU.

1.2.3 Conservation status, reference values, thresholds and targets definitions in the HD and MSFD

5. In the context of the MSFD discussions, there is an ongoing effort to streamline definitions and approaches when setting **reference points** and **thresholds,** within and across descriptors. In practice, this means efforts to maintaining consistency in approaches by setting clear definitions. It has been concluded that this can be achieved only with a strong engagement in coordinating efforts at regional level (*see, for example, discussion at the MSFD workshop on cross-cutting issues on 30 September 2020*) and spelling out more clearly the official terminology.

1.2.3.1 Habitats Directive context

6. Under the EU HD, each Member State can set its own definitions of favourable status of conservation, reference points and thresholds, which then apply within its territorial waters. Definitions can change over time if an appropriate rationale is provided.

7. Concerning the distribution of species, HD art. 17 guidelines suggest that when estimating what they call **Favourable Reference Range** (FRR) for a species, the following factors should be considered:

- Current range.
- Potential extent of range taking into account physical and ecological conditions (such as climate, geology, soil, altitude).
- Historic range and causes of change.
- Area required for viability of habitat type/species, including consideration of connectivity and migration issues.
- Variability including genetics.

8. Concerning the species abundance, when setting the **Favourable Reference Population** (FRP) it is suggested to keep in mind the following background information and parameters:

- Historic distribution and abundances.
- Potential range.
- Biological and ecological conditions.
- Migration routes and dispersal ways.
- Gene flow or genetic variation including clines.
- Population should be sufficiently large to accommodate natural fluctuations and allow a healthy population structure.

9. Palialexis and colleagues observe that there are two approaches to set FRP (DG Environment, 2017):

- Model-based methods are built on biological considerations, such as those used in Population Viability Analysis (PVA) or on other estimates of Minimum Viable Population (MVP) size.
- Reference-based approaches that are founded on an indicative historical baseline corresponding to a documented (or perceived by conservation scientists) good condition of a particular species or restoring a proportion of estimated historical losses.

10. Data availability and quality determines the selection of the proper approach between reference-based and model-based (DG Environment, 2017).

11. The data used to estimate population size can be grouped in the following categories in the HD reporting (DG Environment, 2017):

- Complete survey or a statistically robust estimate
- Estimate based on partial data with some extrapolation and/or modelling
- Estimate based on expert opinion with no or minimal sampling
- Absent data
- Minimum viability population < FRP < potential population.

1.2.3.1.1 Trends

12. Under the HD, the period for **short-term trend** is recommended to be 12 years (two reporting cycles). The short-term trend should be used for the status assessment. The direction of the short- term trend can be: i) stable; ii) increasing; iii) decreasing; or iv) unknown. The percentage change over the period reported, if it can be quantified should be given as a precise figure (e.g., 27 %) or a banded range (e.g. 20-30 %) (ETC/BD, 2011; DG Environment, 2017). The **long-term trend** is recommended to be evaluated over a period of 24 years (four reporting cycles).

1.2.3.1.2 Mapping

13. For mapping purposes, it is advised to use the ETC/BD to 10 x 10 km for visualisation, ETRS 89 LAEA grid; allowing to submit maps of 50 x 50 km for exceptional cases such as, for example, widely ranging but data poor cetaceans. In this sense, it is advisable to keep this in mind when defining the monitoring scales, to avoid in the medium-term too many empty cells.

1.2.3.1.2 Assessment matrix and definition of conservation objectives

14. Table 2 (**HD evaluation matrix**) is a modified version of table 3 in Palialexis *et al*. 2019. It summaries all relevant definitions of HD Conservation Status reference thresholds.

Table 2 - HD evaluation matrix of Conservation Status of species *(modified)*

***Species* Parameter**	**Favourable** ('green')	**Unfavourable - Inadequate** ('amber')	**Unfavourable - Bad** ('red')	**Unknown**
Range (within the concerned biogeographical region)	**Stable** (loss and expansion in balance) or increasing **AND not < 'favourable reference range'.**	Any other combination.	**Large decline**: = to a loss of > 1% per year within period specified by MS **OR** > 10% < favourable reference range.	No or insufficient reliable information available to assess it.
Population	Population(s) **not < 'favourable reference population'** **AND** reproduction, mortality and age structure **not deviating from normal** (if data available).	[**Moderate decline** = to a loss of less than 1 % per year and ≤ 'favourable reference population'; **OR** a **large decline** = to a loss of > than 1 % per year and ≥ 'favourable reference population'; **OR** population size is < than 25 % below favourable reference population; **OR** age structure somehow different from a natural, self-sustaining population].	**Large decline**: = to a loss of > 1% per year (**indicative value MS may deviate from if duly justified**) within period specified by MS **AND** < 'favourable reference population' **OR** > 25% < favourable reference population **OR** reproduction, mortality and age structure strongly deviating from normal.	No or insufficient reliable information available to assess it.
Habitat for the species	Area of habitat is sufficiently large (and stable or increasing) **AND** habitat quality is suitable for the long-term survival of the species.	Any other combination.	Area of habitat is clearly not sufficiently large to ensure the long-term survival of the species **OR** Habitat quality is bad, clearly not allowing long term survival of the species.	No or insufficient reliable information available to assess it.
Future prospects (as regards to	**Main pressures and threats** to the species	Any other combination.	Severe influence of pressures and threats to	No or insufficient reliable information

population, range & habitat availability)	**not significant**; **species** will remain **viable on the long-term.**		the species; very bad prospects for its future, long-term viability at risk.	available to assess it.
Overall CS assessment	All 'green' **OR** three 'green' **AND** one 'unknown'.	**One or more** 'amber' **but no** 'red'.	**One or more** 'red'.	**Two or more** 'unknown' combined with green **OR** all "unknown".
Source: Modified from Table 3 in Palialexis *et al*. 2019 on definitions of HD parameters and list the threshold values set for the identification of the Conservation Status of each parameter.				

15. When discussing **reference values**, we should consider:
- using reference conditions/reference state (based on current conditions of sites considered to be in reference state, historical data or modelling);
- using a baseline condition set at a specified date in the past (i.e. the entering into force of HD);
- using a baseline condition set as 'current' state.

16. For **targets**:
- use of directional/trend-based targets (either purely a direction of change or incorporating a rate of desired change from a baseline);
- use of baseline value as the target;
- use of deviation (in absolute value terms or percentage change terms) from a specified given baseline;
- use of limits or thresholds (in relation to a specified baseline).

17. There are various ways to set conservation targets that are under discussion/consideration. For example, modelling carrying capacity, based on parameters of life history, and setting a target as a deviation from this total carrying capacity to allow for "sustainability" (e.g., 80%). IWC is using this method to manage aboriginal whaling sustainably or setting levels of pressure in line with agreed deviations from modelled carrying capacity (e.g., the Harbour porpoise EcoQO which sets a 1.7% limit for anthropogenic removal (including bycatch) so that a target population of at least 80% of carrying capacity is maintained).

1.2.3.2 Relevant indicators (i.e. criteria) in the MSFD context

18. In Table 3 are shown extracts of text on relevant criteria for marine mammals from "*Criteria and methodological standards, specifications and standardised methods for monitoring and assessment of essential features and characteristics and current environmental status of marine waters under point (a) of Article 8(1) of Directive 2008/56/EC"* (Commission Decision (EU) 2017/84).

Table 3 - Extract on relevant criteria for marine mammals from Commission Decision (EU) 2017/848

Criteria elements	Criteria	Methodological standards
Species of mammals, which are at risk from incidental by-catch in the region or subregion. *Member States shall establish that list of species through regional or subregional cooperation.*	**D1C1 - Primary**: The **mortality rate per species from incidental by-catch** is below levels which threaten the species, such that its long- term viability is ensured. *Member States shall establish the threshold values for the mortality rate from incidental by-catch per species, through regional or subregional cooperation.* Note: For D1C1, data shall be provided per species per fishing metier for each ICES area or GFCM Geographical Sub-Area or FAO fishing areas for the Macaronesian biogeographic region, to enable its aggregation to the relevant scale for the species concerned, and to identify the particular fisheries and fishing gear most contributing to incidental catches for each species. References to: • Article 25(5) of Regulation (EU) No 1380/2013	*Scale of assessment:* As used for assessment of the corresponding species or species groups under criteria D1C2-D1C5. *Use of criteria:* The extent to which good environmental status has been achieved shall be expressed for each area assessed as follows: • the mortality rate per species and whether this has achieved the threshold value set. This criterion shall contribute to assessment of the corresponding species under criterion D1C2.

	• Table 1D of the Annex to Commission Implementing Decision (EU) 2016/1251. • Regulation (EC) No 199/2008	
Species groups, as listed under Table 1 and if present in the region or subregion. *Member States shall establish a* ***set of species representative of each species group****, selected according to the criteria laid down under 'specifications for the selection of species and habitats',* ***through regional or subregional cooperation****. These shall include the mammals and reptiles listed in Annex II to Directive 92/43/EEC and may include any other species, such as those listed under Union legislation (other Annexes to Directive 92/43/EEC, Directive 2009/147/EC or through Regulation (EU) No 1380/2013) and international agreements such as Regional Sea Conventions.*	**D1C2 - Primary**: • The **population abundance** of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured. *Member States shall establish threshold values for each species through regional or subregional cooperation, taking account of natural variation in population size and the mortality rates derived from* ***D1C1****,* ***D8C4*** *and* ***D10C4 and other relevant pressures****.* *For species covered by Directive 92/43/EEC, these values shall be consistent with the Favourable Reference Population values established by the relevant Member States under Directive 92/43/EEC.* **D1C3** - **Secondary** for marine mammals: • The **population demographic characteristics** (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures. *Member States shall establish threshold values for specified characteristics of each species through regional or sub-regional cooperation, taking account of adverse effects on their health derived from* ***D8C2****,* ***D8C4 and other relevant pressures****.* **D1C4** - **Primary for** species covered by Annexes II *[i.e.* ***bottlenose dolphins****,* ***harbor porpoise****,* ***monk seal]****,* IV *[****all cetaceans****]* or V to Directive 92/43/EEC and **secondary for other species**: • The **species distributional range and**, where relevant, **pattern** is in line with prevailing physiographic, geographic and climatic conditions. *Member States shall establish threshold values for each species through regional or sub-regional cooperation. For species covered by Directive 92/43/EEC, these shall be consistent with the Favourable Reference Range values established by the relevant Member States under Directive 92/43/EEC.* **D1C5** - **Primary for** species covered by Annexes II *[i.e.* ***bottlenose dolphins****,* ***harbor porpoise****,* ***monk seal]****,* IV and V to Directive 92/43/EEC and **secondary for other species**: • The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species.	*Scale of assessment:* Ecologically-relevant scales for each species group shall be used, as follows: • for deep-diving toothed cetaceans, baleen whales: region, • for small toothed cetaceans: subregion for Mediterranean Sea, • for seals: subregion Mediterranean Sea. *Use of criteria:* The status of each species shall be assessed individually, on the basis of the criteria selected for use, and these shall be used to express the extent to which good environ- mental status has been achieved for each species group for each area assessed, as follows: (a) the assessments shall express the value(s) for each criterion used per species and whether these achieve the threshold values set; (b) the overall status of species covered by Directive 92/43/EEC shall be derived using the method provided under that Directive. The overall status for commercially-exploited species shall be as assessed under Descriptor 3. For other species, the overall status shall be de- rived using a method agreed at Union level, taking into account regional or subregional specificities; (c) the overall status of the species group, using a method agreed at Union level, taking into account regional or subregional specificities.
Criteria elements	**Criteria**	**Methodological standards**
Litter and micro-litter classified in the categories 'artificial polymer materials' and 'other', assessed in any species from the following groups: birds, mammals, reptiles, fish or invertebrates.	**D10C3 - Secondary**: • The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned. *Member States shall establish threshold values for these levels through regional or subregional cooperation.*	The use of criteria D10C1, D10C2 and D10C3 in the overall assessment of good environmental status for Descriptor 10 shall be agreed at Union level. The outcomes of criterion D10C3 shall also contribute to assessments under Descriptor 1, where appropriate.

Member States shall establish that list of species to be assessed through regional or subregional cooperation.		
Criteria elements	**Criteria**	**Methodological standards**
Species of birds, mammals, reptiles, fish or invertebrates which are at risk from litter. *Member States shall establish that list of species to be assessed through regional or subregional cooperation.*	**D10C4 - Secondary**: • The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects. *Member States shall establish threshold values for the adverse effects of litter, through regional or subregional cooperation.*	*Scale of assessment:* As used for assessment of the species group under Descriptor 1. *Use of criteria:* The extent to which good environmental status has been achieved shall be expressed for each area assessed as follows: — for each species assessed under criterion D10C4, an estimate of the number of individuals in the assessment area that have been adversely affected. The use of criterion D10C4 in the overall assessment of good environmental status for Descriptor 10 shall be agreed at Union level. The outcomes of this criterion shall also contribute to assessments under Descriptor 1, where appropriate.
Anthropogenic impulsive sound in water.	**D11C1 — Primary:** • The spatial distribution, temporal extent, and levels of anthropogenic impulsive sound sources do not exceed levels that adversely affect populations of marine animals. *Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities.*	*Scale of assessment*: Region, subregion or subdivisions. *Use of criteria*: The extent to which good environmental status has been achieved shall be expressed for each area assessed as follows: (a) for D11C1, the duration per calendar year of impulsive sound sources, their distribution within the year and spatially within the assessment area, and whether the threshold values set have been achieved; (b) for D11C2, the annual average of the sound level, or other suitable temporal metric agreed at regional or subregional level, per unit area and its spatial distribution within the assessment area, and the extent (%, km^2) of the assessment area over which the threshold values set have been achieved. The use of criteria D11C1 and D11C2 in the assessment of good environmental status for Descriptor 11 shall be agreed at Union level. The outcomes of these criteria shall also contribute to assessments under Descriptor 1.
Anthropogenic continuous low-frequency sound in water.	**D11C2 — Primary:** • The spatial distribution, temporal extent and levels of anthropogenic continuous low-frequency sound do not exceed levels that adversely affect populations of marine animals. *Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities.*	

Species groups	
Ecosystem component	*Species groups*
Mammals	Small-toothed cetaceans Deep-diving toothed cetaceans Baleen whales Seals
Specifications and standardised methods for monitoring and assessment relating to theme 'Species groups of marine birds, mammals, reptiles, fish and cephalopods' 1. Species may be assessed at population level, where appropriate. 2. Wherever possible, the assessments under Directive 92/43/EEC, Directive 2009/147/EC and Regulation (EU) No 1380/2013 shall be used for the purposes of this Decision: […] (b) for mammals, reptiles and non-commercial fish, the criteria are equivalent to those used under Directive 92/43/EEC as follows: D1C2 and D1C3 equate to 'population', D1C4 equates to 'range' and D1C5 equates to 'habitat for the species'; 3. Assessments of the adverse effects from pressures under criteria D1C1, D2C3, D3C1, D8C2, D8C4 and D10C4, as well as the assessments of pressures under criteria D9C1, D10C3, D11C1 and D11C2, shall be taken into account in the assessments of species under Descriptor 1. ***Units of measurement for the criteria***: - D1C2: abundance (number of individuals or biomass in tonnes (t)) per species.	

1.2.3.3 Definitions of reference points and thresholds in the context of regional discussions (i.e. OSPAR, HELCOM, HD) and national implementation

19. The following tables (Table 4, 5 and 6) summarise relevant information on definitions of criteria reference points and thresholds in the context of regional discussions (i.e. OSPAR and HELCOM), the HD and national implementation. In particular, they provide an overview of different approaches taken in different contexts. The national prospective is presented for some of the EU Mediterranean countries and represents examples of decisions taken by those countries only.

Table 4 - Definitions of criteria reference points and thresholds in the context of regional discussions (i.e. OSPAR, HELCOM, HD)

Criterion	Reference/baseline values	Thresholds
HELCOM C2.1 Population trends and abundance of seals (haul-out areas)	**Limit Reference Level** (LRL): at least 10,000 individuals.	GES is achieved for each species, when: i) the abundance of seals in each management unit is has attained a LRL of at least 10,000 individuals to ensure long-term viability; and ii) the species-specific growth rate is achieved indicating that abundance is not affected by severe anthropogenic pressures (HELCOM, 2018b). The growth rate aspect of the threshold value is assessed separately for populations at and below the **Target Reference Level** (TRL; which is population close to carrying capacity) (HELCOM, 2018b): - For populations at TRL, good status is defined as 'No decline in population size or pup production exceeding 10% occurred over a period up to 10 years'. - For populations below TRL, good status is defined as 3% below the maximum rate of increase for seal species, i.e. 7% annual rate of increase for grey seals and ringed seals and 9% for harbour seals. For good status, 80 % statistical support for a value at or above the threshold is needed.
HELCOM C4.1 Distribution of Baltic seals		GES is achieved when the threshold values for all considered parameters are achieved (HELCOM, 2018g): 1) the distributions of seals are close to pristine conditions (e.g. 100 years ago); 2) or where appropriate when all currently available haul-out sites are occupied (modern baseline); and 3) when no decrease in area of occupation occurs.

OSPAR C2.2 Harbour Seal and Grey Seal Abundance	**Rolling baseline** (current six-year assessment population size vs previous six-year assessment) and an historical fixed baseline. **Historical baseline** in 1992 or the closest value => year of HD entry into force.	***Assessment Value 1***: No decline in seal abundance of > 1% per year in the previous six-year period (a decline of approximately 6% over six years). ***Assessment Value 2***: No decline in seal abundance of >25% since the fixed baseline in 1992 (or closest value). The 25% chosen for the second assessment value currently approximates to 1% a year since 1992. Seal long-term trend in abundance (*Δbaseline*) calculated via generalised linear models (GLMs) or generalised additive models (GAMs). $\Delta abundance=(B-A/A)\times 100$; where A is the count fitted by the model in the baseline year and B is the count fitted by the model in the most recent survey year (OSPAR, 2018b). 80% confidence intervals.
HD Distributional Range and pattern of seals	**Favourable Reference Range** (ETC/BD, 2011): Range within which all significant ecological variations of the habitat/species are included for a given biogeographical region and which is sufficiently large to allow the long-term survival of the habitat/species.	**Favourable reference value**: at least the range (in size and configuration) when the Directive came into force (1992). If range insufficient to support a favourable status: larger (in such a case information on historic distribution may be found useful when defining the favourable reference range). **Changes in distributional pattern** are percentage change in occupancy between two periods for a given spatial unit: $\Delta \boldsymbol{distribution} = ((\boldsymbol{B}/\boldsymbol{N}) - (\boldsymbol{A}/\boldsymbol{N})) \times \mathbf{100}$; where A is the number of spatial units (e.g., sub-areas, grid cells) in an assessment unit (AU) occupied by seals during reference period A; B is the number of units occupied in a subsequent period B, and N is the total number of spatial units within the AU. For the present assessment, period A is 2003–2008 and period B is 2009–2014. The **Index of shift in occupancy** describes the overall shift in the seasonal distribution of seals between sub-areas or grid cells over time: $Shift = 2(A\&B)/(A+B)$; where A is the number of spatial units (e.g., sub-areas, grid cells) occupied by seals during reference period A; B is the number of units occupied in a subsequent period; A&B is the number of identical units occupied in both periods. For the present assessment, period A is 2003–2008 and period B is 2009–2014. The shift index value is between 0 and 1: a value of 0 indicates that there has been a complete shift in the spatial units occupied; a value of 1 indicates there has been no shift.
Criterion	**Reference/baseline values**	**Thresholds**
OSPAR Grey Seal Pup Production	**Baselines** (OSPAR, 2018d): A fixed-baseline year (1992) is used. A short-term rate-based assessment value was also adopted that uses a **rolling baseline** (Method 1; OSPAR, 2012).	Use of the two types of baseline and associated assessment values seeks to provide an indicator that would warn against both a slow, but long-term steady decline (the problem of 'shifting baselines' associated with only having a rolling baseline) and against a recovery followed by a subsequent decline (potentially missed with a fixed baseline set below reference conditions) (OSPAR, 2018d). **Indicator assessment** values were set as a **percentage deviation** from the **baseline value** (Method 3; OSPAR, 2012). Associated with these baselines, two **assessment values** were used to assess grey seal pup production in each AU: • ***Assessment value 1***: **No decline** in grey **seal pup production of >1% per year in the previous six-year period** (a decline of approximately 6% over six years). • ***Assessment value 2***: **No decline** in grey seal pup production of **>25% since the fixed baseline in 1992** (or closest year). The percentage change in pup numbers since the baseline year (Equation 2; $\Delta abundance$) and 80% confidence intervals is calculated from fitted values. Although no formal hypothesis testing was conducted, 80% confidence intervals were calculated to reflect the choice to set the significance level, α, equal to 0.20 or 20%. Calculation of **long-term trend in abundance**: $\Delta abundance=(B-A/A)\times 100$

OSPAR Abundance and Distribution of Coastal Bottlenose Dolphins		**Declining**: a decreasing trend of ≥5% over ten years (significance level p<0.05). Increasing is defined as an increasing trend of ≥5% over ten years (significance level p<0.05). **Stable**: population changes of <5% over ten years. 5% is derived from IUCN criterion to detect a 30% decline over three generations for a species (**Vulnerable**).
OSPAR Abundance and Distribution of Cetaceans	**Species Distribution**: • Density surface models if sufficient data are available from large-scale purpose-designed surveys. • Maps of observed sightings provide information on distribution as alternative.	**Declining**: decreasing trend of ≥5% over ten years (significance level p<0.05). **Increasing**: increasing trend of ≥5% over ten years (significance level p<0.05). **Stable**: population changes of <5% over ten years. **Power Analysis**: on at least three data points. Data have 80% power (the conventional acceptable level) to detect an annual rate of change, at a significance level (p value) of 0.05, of 1.5% for harbour porpoise, 2.5% for white-beaked dolphin, and 0.5% for minke whale. The power to detect trends could be improved by increasing the frequency of the large-scale surveys.
HELCOM Reproductive status of seals		Good status is achieved when the annual reproductive rate (i.e. the proportion of females pregnant/showing postpartum pregnancy signs per year) is at least 90% for harbour seals of five years and older, and grey and ringed seals of six years and older (HELCOM 2018f). A reproductive rate of **90%** is defined as the threshold for each of these parameters as this is **indicative of increasing populations**.

Source: Palialexis et al. 2019.

Table 5 - OSPAR Intermediate Assessment (2017) on cetaceans

Assessment scale	*Monitoring methods*	*Thresholds*	*Pressures/thresholds*
NE Atlantic (encompassing the North Sea/OSPAR Area II and Celtic Seas/OSPAR Area III)	Regular surveillance of abundance and distribution.	• ‘increasing’ means an increasing trend of ≥5% over 10 years (significance levels, p value, of 0.05) • ‘stable’ means population changes of < 5% over 10 years, and • ‘decline’ means a decreasing trend of ≥5% over 10 years (significance levels, p value, of 0.05).	• The main human induced cause of mortality is bycatch. • Bycatch of harbour porpoise: data from the ICES assessments of bycatch in the North Sea and Celtic Seas *vs.* best population estimate for the areas using two thresholds: 1% and 1.7%. (ASCOBANS agreed on 1 % bycatch mortality and 1.7 % total anthropogenic mortality).

Source: ICES WKDIVAGG REPORT 2018, ICES CM 2018/ACOM:47, Report of the Workshop on MSFD biodiversity of species D1 aggregation.

Table 6 - Extract from Table 3. Cetacean indicators currently employed by Contracting Parties in the OSPAR region as of August 2019. *In ACCOBAMS-MOP7/2019/Inf 47. 2019. REPORT FROM THE JOINT ACCOBAMS/ASCOBANS WORKING GROUP ON THE MARINE STRATEGY FRAMEWORK DIRECTIVE (MSFD)*.

France[1]			
MSFD Criteria	**Proposed Indicators**	**Species**	**Assessment value/threshold value/target**
D1C1	*OSPAR Common Indicator M6:* Incidental mortality rate (bycatch observer data)	Harbour porpoise	This common indicator currently does not have an assessment value. It will be decided upon by OSPAR in 2019/2020.
	National Indicator: Bycatch mortality rate (strandings data)	Common dolphin Harbour porpoise	
D1C2	*OSPAR Common Indicator M4:* Abundance of Cetaceans	Harbour porpoise Bottlenose dolphin White-beaked dolphin Minke whale	No assessment value has been applied in this assessment. For a trends’ assessment: a significant decline means a decreasing trend of ≥5%

			over 10 years (significance level p<0.05); a significant increase means an increasing trend of ≥5% over 10 years (significance level p<0.05); stable means population changes of <5% over 10 years.
	National Indicator: Trend in the relative abundance of Cetaceans	Common dolphin Striped dolphin Bottlenose dolphin Pilot whale Risso’s dolphin Minke whale	
D1C3	*National indicator:* Recurrence of unusual mortality events	Common dolphin Harbour porpoise Striped dolphin	
D1C4	*National indicator:* Trends in occupancy of cetaceans	Common dolphin Striped dolphin Bottlenose dolphin Pilot whale Risso’s dolphin Minke whale Fin whale	

Spain[6]

MSFD Criteria	Proposed Indicators	Species	Assessment value/threshold value/target
MT-tam D1.2.1	*National indicator:* Population size (Abundance, no. Individuals)	Harbour porpoise Common dolphin Bottlenose dolphin Atlantic fin whale	Maintain or restore the natural balance of the populations of key species for the ecosystem.
MT-dist D1.1.1 D1.1.2	*National indicator:* Range and pattern of distribution of the populations	Harbour porpoise Common dolphin Bottlenose dolphin Atlantic fin whale	The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions.
MT-dem D1.3.1	*National indicator*: Demographic characteristics of the population (mortality rate) (Parameters required for analysis- population size, mortality caused by these pressures. Others (birth rate, survival / mortality rate, etc.))	All species of cetaceans	Reduce the main causes of mortality and decrease of populations of groups of non-commercial species in the top of the food chain (marine mammals, reptiles, birds, marine, pelagic and demersal elasmobranchs), such as accidental catches, boat collisions, ingestion of marine litter, introduced land predators, pollution, destruction of habitats and overfishing.

20. France has more recently agreed to the following descriptions in relation to criterion D1C1 (Spitz et al. 2018). For each species they use two approaches (as in previous tables):

1. Estimation of the number of individuals who died by accidental capture using a drift model applied to stranded individuals.
2. Estimation of the annual incidental capture rate (total number of individuals incidentally captured divided by total abundance of the species) through a Bycatch Risk Assessment (see below).

21. Threshold reference values are set as follow:

- By-catch mortality rate less than 1.7% of the abundance with a probability> 80% ; and
- 80% confidence interval of the mean by-catch mortality rate less than 1.7%.

1.2.3.3.1 Criterion D1C1 on bycatch and available methods to estimate maximum bycatch thresholds for bycaught cetacean species

22. The MSFD Criterion D1C1, assessing that ‘*the mortality rate per species from incidental by-catch is below levels which threaten the species, such that its long-term viability is ensured*’, is well developed, at least

for cetacean species. For these species, a widely recommended framework exists, and it is well defined also for data-poor situations (e.g., FAO 2018 and STEFC 2019). This approach covers monitoring, assessment and mitigation aspects and it is based on direct data (independent observer data), not on interviews or self-assessment (indirect data). The latter **will never be able to assess the actual impact** of fishery-induced mortality at a population level.

23. In data poor context, a basic **Bycatch Risk Assessment (BRA)** can be applied to evaluate the impact of bycatch on relevant species. This is an approach proposed by the International Council for the Exploitation of the Sea (ICES)'s Working Group on Bycatch of Protected Species (WGBYC) and developed during the Workshop on Bycatch of Cetaceans and other Protected Species (WKRev812; ICES 2013). The essential idea of a BRA is to use an estimate of total fishing effort for the fisheries of concern in a specific region, in combination with some estimate of likely or possible bycatch rates that apply for the species of concern. This allows to evaluate whether the estimated total bycatch in that given region might be a conservation issue by threatening the survival of a given population, generating subsequent actions. The BRA is a better approach compared to that of applying discretionary flat percentages of "sustainable mortality" to the whole population of a given species (e.g., Rule of Thumb of 1% or the ASCOBANS 1.7 % when extended to all cetacean species; see Table 7) or establish a generic percentual decrease of total bycatch mortality in a fleet without taking into consideration the actual effect of such percentual decrease at population level.

Table 7 - Methods to assess the impact of fisheries on species of conservation concern (STECF 2019)

Method	Algorithm/concept	Key/Notes/Reference paper
ASCOBANS "rule of thumb"	To reduce bycatches to less than 1 % of the best available population estimate.	ASCOBANS 2000
ASCOBANS 1.7 %	1.7 % of best population estimate for harbour porpoises.	This was based on a simple deterministic population dynamics model with assumed maximum net productivity rate of 4 %, which found that 1.7 % total annual removal would allow a population to achieve 80 % of its carrying capacity over a very long time horizon (over un "infinite" period of time or until stabilisation). Extended to all species as total human-induced mortality.

24. When more data are available, particularly from observer programmes, more quantitatively accurate and conservative methods (i.e. in terms of total number of animal taken relative to the total population) can be applied to assess the impact of fisheries on species of conservation concern. These methods allow to incorporate into the assessment quantitative measures of conservation objectives. The most used and robust methods are the Potential Biological Removal (PBR), the Catch Limit Algorithm (CLA) and/or Removal Limit Algorithm (RLA) (STECF 2019). Specifics on these are given in Table 8.

Table 8 - Methods to assess the impact of fisheries on species of conservation concern (STECF 2019)

Method	Algorithm/concept	Key/Notes/Reference paper
U.S. Potential Biological Removal (PBR)	$Removal \quad limit = N_{min} \times \frac{1}{2} R_{max} \times F_R$	**N_{min}**=20th percentile of a log-normal distribution surrounding the abundance estimate (N) equivalent to the lower limit of a 60 % 2-tailed confidence interval). **R_{max}**=maximum population growth rate, **F_R**=tuning factor related to conservation objectives (assumed value for cetaceans of 0.04). U.S. **target** in cetacean PBRs is 50 % of carrying capacity within a 100-year period. Wade et al. 1998
Catch Limit Algorithm (CLA)	$CLA = \alpha \times R_{max} \times (D_T - \beta) \times N_T$	**D_T** =current population status **N_T** = current population size

Removal Limit Algorithm (RLA)		**α** and **β** = tuning factors related to conservation objectives. **IWC CLA conservation objective** = 72 % K within a 100-year period. **North Sea harbour porpoise RLA conservation objective** = 80% K within a 100-year period. **CLA:** Cooke 1999 **RLA:** Hammond *et al.* 2019

25. This general approach (i.e. carry out a BRA for data-poorer situations and use more accurate algorithms for data from fishery observer programmes) is similar to that discussed in other regional contexts (e.g., OSPAR, ASCOBANS) in the context of the MSFD implementation strategy.

In addition, the OSPAR Marine Mammal Expert Group (OMMEG) is currently discussing a new update for indicator M6 (Marine Mammal Bycatch).

2. RELEVANT ASPECTS OF THE ECAP/IMAP DISCUSSION

26. The overall discussion on the EcAp/IMAP process happens in the context of the UNEP/MAP Programme of Work (PoW) and is coordinated by the regional Activity Centres, mainly SPA/RAC for the biodiversity cluster, MEDPOL for pollution and marine litter cluster, and PAP/RAC for coast and hydrography. Documents prepared by experts are discussed by relevant Correspondence Groups on Monitoring CORMONs and subsequently submitted to the relevant Focal Points meetings, the EcAp Coordination Group (CG), the MAP Focal meeting and then the BC COP.

2.1 IMAP Common Indicators

27. Specific guidelines on Common Indicators, including their development, are contained in BC decisions regarding different taxa. For example, Decision IG.22/7 specifically stated that: "*it is an absolute necessity for UNEP/MAP to strengthen its cooperation with the relevant regional bodies, especially in relation to:*

- *EO1 […] with […] the Secretariat of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS), noting that the ACCOBAMS Survey Initiative […] will provide important inputs (in terms of monitoring methodologies, capacity building and reliable data on abundance and distribution of cetaceans).*
- *EO11, with ACCOBAMS, noting that further development of the candidate common indicators will need to be carried out in a close cooperation between UNEP/MAP and ACCOBAMS in light of pilot monitoring activities, additional expert knowledge, and scientific developments, during the initial phase of IMAP, and considering that ACCOBAMS is undertaking an identification of noise hot spots in the Mediterranean*".

28. Table 9 offers a comparison between MSFD criteria and EcAp/IMAP Common Indicators.

Table 9 - Comparison between MSFD Criteria and EcAp/IMAP Common Indicators for marine mammals

MSFD Criteria	EcAp/IMAP Common Indicators (CI) and Candidate Common Indicators (CCI)
D1C1 - PRIMARY: The **mortality rate per species from incidental by-catch** is below levels which threaten the species, such that its long- term viability is ensured.	**CI12 - Bycatch of vulnerable and non-target species (EO1 and EO3)** • No definitions of targets/of methods.
D1C2 - PRIMARY: • The **population abundance** of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured.	**CI4 - Population abundance of selected species** • Population size of selected species is maintained: o Cetaceans: The species population has abundance levels allowing to qualify to Least Concern Category of IUCN. o Monk seal: Number of individuals by colony allows to achieve and maintain a favourable conservation status.

D1C3 - **SECONDARY** for marine mammals:
• The **population demographic characteristics** (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures.
	CI5 - Population demographic characteristics
	• Population condition of selected species is maintained:
	  ○ Cetaceans:
	    ▪ *State* - Decreasing trends in human induced mortality
	    ▪ *Pressure* - Appropriate measure implemented to mitigate incidental catch, prey depletion and other human induced mortality.
	  ○ Monk seal:
	    ▪ *Pressure* - Appropriate measures implemented to mitigate direct killing and incidental catches and to preclude habitat destruction.

D1C4 - **PRIMARY for** species covered by Annexes II *[i.e.* ***bottlenose dolphins***, ***harbour porpoise***, ***monk seal]***, IV or V to Directive 92/43/EEC and **secondary for other species**:
• The **species distributional range and**, where relevant, **pattern** is in line with pre- vailing physiographic, geographic and climatic conditions.
	CI3 - Species distributional range
	• Species distribution is maintained:
	  ○ No definition for cetaceans.
	  ○ The Monk Seal is present along recorded Mediterranean coasts with suitable habitats for the species

D1C5 - **PRIMARY for** species covered by Annexes II *[i.e.* ***bottlenose dolphins***, ***harbour porpoise***, ***monk seal]***, IV and V to Directive 92/43/EEC and **secondary for other species**: • The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species.	Partially related to CI5

D10C3 - **SECONDARY**:
• The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned. Member States shall establish threshold values for these levels through regional or subregional cooperation.
	CCI24 - Trends in the amount of litter ingested by or entangling marine organisms, especially mammals, marine birds and turtles.
	• Decreasing trend in the cases of entanglement or/and a decreasing trend in the stomach content of the sentinel species.
	Threshold and reference values
	• Baseline Values for Ingested Marine Litter (gr)[1]:
	  ○ *Minimum value*: 0 gr
	  ○ *Maximum value*: 14 gr
	  ○ *Mean value*: 1.37 gr
	  ○ *Proposed Baseline*: 1-3 gr
	• Environmental Targets for Ingested Marine Litter (gr):
	  ○ *Types of Target*: % decrease in quantity of ingested weight (gr)
	  ○ *Minimum*: -
	  ○ *Maximum*: -
	  ○ *Reduction Targets*: Statistically Significant

D10C4 - **SECONDARY**: • The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects. Member States shall establish threshold values for the adverse effects of litter, through regional or subregional cooperation.	
D11C1 - PRIMARY: • The spatial distribution, temporal extent, and levels of anthropogenic impulsive sound sources do not exceed levels that adversely affect populations of marine animals. Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities.	**CCI26: Proportion of days and geographical distribution where loud, low, and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animals**

[1] Appendix 1 to Annex to Decision IG.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria.

D11C2 - PRIMARY: • The spatial distribution, temporal extent and levels of anthropogenic continuous low-frequency sound do not exceed levels that adversely affect populations of marine animals. Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or subregional specificities.	**CCI27: Levels of continuous low frequency sounds with the use of models as appropriate**

29. From Table 9, it is apparent that there is not always an equivalence between MSFD criteria and EcAp/IMAP Common Indicators. Moreover, some agreed definition for EcAp/IMAP Common Indicators somehow overlap topics that should be separated to allow a correct assessment (e.g., CI5 and CI12).

30. See also document UNEP/MED WG.482/25 (2020) that contains a comparative analysis of IMAP Indicators with those in the Commission Decision (EU) 2017/848.

31. Decision IG.22/7 also pointed out the necessity to set up a structured cooperation with GFCM, to develop EO3 (fisheries), that includes CI 12 (Bycatch of vulnerable and non-target species), which is common to EO1 and EO3 and fundamental for marine mammals. However, it is more relevant to EO1 as it constitutes a direct pressure on CI3, CI4 and CI5. The cooperation between BC and GFCM will help developing also elements of EO4 (food webs).

32. In addition, Decision IG.22/7 states that '*compared to Descriptor 11 related indicators (MSFD), candidate indicators 26 and 27 are more closely related to the acoustic biology of key marine mammal species of the Mediterranean which are known to be sensitive to noise, i.e. the fin whale, the sperm whale and the Cuvier's beaked whale*'. The discussion on the development of these CCIs is happening in the context of the collaboration between UNEP/MAP-SPA/RAC and ACCOBAMS, and thanks to the financial and organisational support from EU funded projects (i.e. QuietMed; see Table 9). Therefore, these are not considered in this document, except in relation to monitoring activities under CI3 (Species distributional range), particularly for *Ziphius* (a species for which impulsive noise of certain types represents a deadly threat).

33. The discussion on Candidate Common Indicator 24 (Trends in the amount of litter ingested by or entangling marine organisms, especially mammals, marine birds and turtles) already happened in the context of the work coordinated by UNEP/MAP-MED POL. In Decision IG.22/7, Contracting Parties agreed definitions and targets for marine litter ingested by marine mammals. Therefore, these are not considered in this document (see Table 9).

2.2 IMAP species of interest

34. IMAP fixes a reference list of species and habitats to be monitored. All cetacean species occurring in the Mediterranean Sea are considered in the IMAP. Particular attention is given to the eight resident cetacean species, divided into three different functional groups:

- Baleen whales: fin whale (*Balaenoptera physalus*)
- Deep-diving cetaceans: sperm whale (*Physeter macrocephalus*), Cuvier's beaked whale (*Ziphius cavirostris*), long-finned pilot whale (*Globicephala melas*) and Risso's dolphin (*Grampus griseus*).
- Other toothed species: short-beaked common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*), common bottlenose dolphin (*Tursiops truncatus*).

35. IMAP recommends monitoring and assessing common indicators for this selection of representative species for cetacean. However, four other rare species of cetaceans occur also in the Mediterranean Sea: harbour porpoise (*Phocoena phocoena*), rough-toothed dolphin (*Steno bredanensis*), false killer whale (*Pseudorca crassidens*) and killer whale (*Orcinus orca*).

2.3 IMAP assessment, monitoring scales and geographic reporting scales

36. On assessment, monitoring scales and geographic reporting scales, Annex to Decision IG.22/7 states the following:

'*A scale of reporting units' needs to be defined during the initial phase of IMAP taking into account both ecological considerations and management purposes, following a nested approach.*

The nested approach aims to accommodate the needs of the above is to take into account 4 main reporting scales:

(1) *Whole region (i.e. Mediterranean Sea);*
(2) *Mediterranean sub-regions, as presented in the Initial Assessment of the Mediterranean Sea, UNEP(DEPI)/MED IG.20/Inf.8;*
(3) *Coastal waters and other marine waters;*
(4) *Subdivisions of coastal waters provided by Contracting Parties'*.

37. For marine mammals, this nesting approach it is not necessary or, in some case, might even be not applicable, as for most CIs the monitoring and assessment must happen at regional level and a lower-level monitoring would not help assessing the GES. The only exceptions are the CI5 and CI12 which could be also assessed at lower scales (e.g., GFCM GSAs or new subdivisions given by the aggregation of some GSAs, in relation to each species' population structure).

3. PROPOSED REVISIONS AND/OR UPDATES TO AGREED OFFICIAL EcAp/IMAP DOCUMENTS

38. The reading of all relevant EcAp/IMAP materials on marine mammals has generated few proposals not only on EcAp/IMAP elements that need to be completed or created (e.g., assessment scales, reference values and thresholds, which were the main objective of this report), but also on necessary updates of some agreed aspects of EcAp/IMAP processes, which are no longer in line with the current situations (particularly because of new species' knowledge and progress made in discussions about those two processes). In the following paragraphs these are briefly presented.

39. The EcAp/IMAP framework, as well as the MSFD, is an adaptive process that should be re-evaluated regularly every six-year and retuned if necessary.

40. In the following sections we propose a set of revisions in documents attached to EcAp/IMAP decisions. For example, Appendix 1 to Annex to Decision IG.22/7 on IMAP, assigns a lower priority to *Ziphius*, *Stenella*, *Globicephala* and *Grampus* compared to the other species, based on some unclear/inexistent evidence on threats and population status. Based on robust knowledge on threats on some of these species, we propose that *Ziphius* becomes a priority species. This request is based on known and measured threats (underwater mid-frequency sounds, e.g., Frantzis *et al*. 1998) and the relatively limited availability of preferred habitat within the Mediterranean Sea (Cañadas *et al*. 2018).

3.1 Revisions to Appendix 1 of Annex to Decision Ig.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and related Assessment Criteria

41. Proposed revisions to Appendix 1 of Annex to Decision Ig.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria are shown in Annex 1 to this report.

3.2 Proposed updates of definitions for some Common Indicator

42. In Decision IG.21/3, Common Indicator 5 (demography) GES definition includes a reference to human-induced mortality, for both cetaceans and the monk seal and to habitat destruction for the monk seal. However, human-induced mortality, when it is relative to accidental capture in fishing gear, should be addressed for coherence in separate Common Indicator, such as, for example Common Indicator 12 (Bycatch of vulnerable and non-target species (EO1 and EO3). This is consistent with the MSFD primary criterion D1C1.

43. Moreover, the text of the CI5's definition refers to the assessment of the measures taken to reduce the different pressures (i.e. appropriate measures taken to reduce direct killing/by-catch/habitat destruction) rather than the assessment of the different parameters that should describe population demographic characteristics,

as the title of the indicator would suggest. The text of the CI5 title should, therefore, be reformulated so that it either refers to an indicator of measures to contrast the main pressures or the definition of the indicator should be modified so that it coherently reflects the assessment of specific demographic parameters (i.e. the mortality rate due to direct killing is such that it does not negatively influence the viability of the species, or the pupping rate/reproductive rate is within the range of increasing population levels etc). See Summary Tables for proposed text (see pages 32-38).

44. **Summary Tables** (see pages 32-38) also offer how to tackle the full development of Common Indicator 12 for marine mammal species, in line with what has been proposed by experts of several regional organisations, including FAO. So far, little progress has been made on the development of monitoring CI12 (GFCM 2019) and no progress on the methodological development of assessment methods and targets. However, given the good progress made within the FAO and EU context (FAO 2018, STEFC 2019; see section 1.2.3.3.1), we believe that the proposed solutions can be agreed by Barcelona Convention's Parties, at least for marine mammal species.

3.3 Streamlining definitions of Monk seal conservation status in SAP BIO

45. Barcelona Convention Decision IG.24/7 - *on Strategies and Action Plans under the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean, including the SAP BIO, the Strategy on Monk Seal, and the Action Plans concerning Marine Turtles, Cartilaginous Fishes and Marine Vegetation; Classification of Benthic Marine Habitat Types for the Mediterranean Region, and Reference List of Marine and Coastal Habitat Types in the Mediterranean* – contains several recommendations on monitoring different species, including the Monk Seal. The same applies to other agreed Regional Action Plans (RAP), including the one on Cetacean species (UNEP/MAP 2017). In this RAP, there is a proposed definition of "favourable conservation status"[2] that does not seem to be fully in line with the GES target as defined in the Decision IG.22/7 and should be reconsidered. In **Summary Tables** (see pages 32-38) take these recommendations into consideration, as much as possible. However, everything has been retuned in relation to the relevant agreed GES definitions.

Recommendation for future work: Within the ongoing process launched by SPA/RAC to elaborate the post 2020 SAP BIO, it would be beneficial to ensure the consistency of EcAp/IMAP GES definitions, targets and IMAP monitoring and assessment scales with SAP BIO (Decision IG.24/7) or at least, to ensure complementarity. In fact, any environmental management framework must be necessarily adaptive given the expected endless improvement on knowledge regarding habitats, species and threats, and constantly shifting baselines.

3.4 Monitoring and assessment methods and scales for cetacean species

46. It is fundamental to keep in mind that appropriate geographic scales must be consistent with the ecology of different marine mammal species and the geographic extent of their major threats/pressures, which need to be assessed. Therefore, ASI-like basin-wide data collection projects on distribution and abundance are the only means that will allow to populate the CI 3 and 4 and to provide key information for CI 12. This makes these means the highest priority for IMAP.

47. It is also very important that the Mediterranean basin-wide data collection is designed taking into consideration, as much as possible, all existing relevant sub-strata, including the EcAp/IMAP sub-regions, GFCM Geographical Sub Areas, National sub-division (if any) and other relevant descriptors sub-divisions (if any) related to pressures on these species.

48. Systematic surveys carried out at sub-regional level or smaller scale (e.g., national level), can only complement but not substitute data obtained through basin-wide surveys. Also, given the nature of these species (wide-ranging marine mammals), any sub-regional monitoring effort must be synchronised and designed to appropriately complement existing knowledge and fill gaps between ASI or similar campaigns.

[2] '*The conservation status will be taken as «favourable» when: i) population dynamic data indicate that cetaceans in the Mediterranean Sea Area are maintaining themselves on a long- term basis as a viable component of the ecosystem; ii) the range of cetaceans in the Mediterranean Sea Area is neither currently being reduced, nor is likely to be reduced on a long-term basis; iii) there is, and will be in the foreseeable future, sufficient habitats in the Mediterranean Sea Area to maintain cetaceans on a long-term basis'*.

49. In addition, it is important to focus Contracting Parties' resources on data collection that allow them to assess the status of these species at the required geographical scale. Thus, the proposed order of priority for monitoring scales of species and pressures is given in relation to species assessment scales. In this sense, the endorsed key message in the Annex I of Decision IG.23/6 ('more effort should be devoted in poorly monitored areas') it may become detrimental unless understood as complementary national data collection, to fill sub-regional gaps, only.

50. Sub-stratification within the Mediterranean region is a key aspect that must be considered at various levels:

1. during the design of monitoring surveys;
2. during the data analysis;
3. during the species' and overall GES assessments.

51. Conclusions on the best solutions are guided by considerations on the following aspects:

1. species' ecology;
2. existing geographical management units of human pressures (e.g., GFCM Sub-Areas);
3. administrative constraints on logistics (this becomes preponderant for the fieldwork phase);
4. administrative requirements for reporting under various international policies (e.g., MSFD, HD, EcAp, IMAP, etc.).

52. In regard to administrative constraints on logistics, during the early phases of the design of monitoring surveys, support from Contracting Parties is critical to identify the limitations due to air traffic regulation and to facilitate the delivery of appropriate permissions for aerial and ship surveys and allow the coverage of ecologically and administratively appropriate regions.

53. In regard to existing geographical management units of human pressures and to Contracting Parties' needs to report under various international policies (e.g., EcAp, IMAP, Habitat Directive and MSFD), consideration of different strata can be done as post-stratification while analysing data and carrying out assessments. However, all the relevant sub-divisions need to be considered, at least theoretically, during design to inform the best options, for example, on the most appropriate coverage.

Recommendations for future work: Concerning Common Indicator 3 (species distributional range), a better definition of specific High Priority (HP) and Low Priority (LP) sub-regional units, to be monitored in relation to important habitats for certain species (e.g., fin whales feeding grounds, *Ziphius* preferred habitats, sperm whales breeding grounds), needs to be refined based on ASI data, latest IUCN species Red List assessments, etc., prior the next assessment (2023).

Recommendation for future work: Concerning Common Indicator 12 (bycatch) for cetaceans and other protected species, since it is a shared indicator that requires the combination of data under EO1 and EO3, this should not be developed and regularly re-evaluated in isolation by the GFCM (as per approach suggested in Decision XXX), but it should be retuned through a specific work involving experts that developed CI3, CI4 and CI5 descriptions for the species of concern, ensuring the full cooperation with other relevant agreements (i.e. ACCOBAMS, Pelagos Agreement) and integration with other policies relevant at regional level (e.g., the MSFD D1C1). The assessment of CI12 should also be made by the same pool of experts.

54. Box 1 summarises details of the potential minimum requirements for a cetacean monitoring framework on Common Indicators 3, 4, 5 and 12 to enable Contracting Parties to meet their commitments in the EcAp framework. Full details are given in the **Summary Tables** (see pages 32-38).

Box 1 – Summary of monitoring framework for EcAp/IMAP Common Indicators for cetaceans		
CI3 – Distributional range CI4 - Abundance	**Regional monitoring**	**Sub-regional monitoring**
Frequency of data collection	• At least every 6 years (as per reporting cycle).	• Optimal: annually. • Minimum: biennially (3 comparable datasets/estimates). • Seasonal: fin whale, pilot whale*(?)*

Monitoring method	• Basin-wide line transect distance sampling surveys (see ASI standard protocols): shipboard and aerial (both visual and acoustic).	• Line-transect distance sampling methods: shipboard or aerial. • Mark-recapture Photo-ID (on selected species). • Passive acoustic monitoring (PAM) for selected species. • Multidisciplinary surveys.
Authority responsible for monitoring	• ACCOBAMS, UNEP/MAP/ SPA/RAC, EU, CPs periodic concerted action.	• Each CP: national monitoring schemes. • CPs of sub-regions when cooperation needed.
Frequency of Common Indicators update	*6 years (as per reporting cycle).*	
Frequency of assessment update	*6 years (as per reporting cycle).*	
Minimal amount of monitoring locations	• Mediterranean region (all four sub-regions must be covered with equal effort).	• Monitoring must cover representative parts of in sub-regions waters (at least three locations per sub-region to be identified through sub-regional workshops). • Photo-ID for relevant putative local populations or management units (e.g., bottlenose dolphins, common dolphins, fin whales, Cuvier's beaked whales; Risso's dolphins; sperm whales). • PAM stations dependent in potential corridors and important habitats for deep diving species.
CI5 - Demography	**Regional monitoring**	**Sub-regional monitoring**
Frequency of data collection	• Not applicable.	• Systematic.
Monitoring method	• Not applicable.	• Photo-id. • Strandings.
Authority responsible for monitoring	• None.	• Each CP: national monitoring schemes. • CPs of sub-regions when cooperation needed (matching photo-id catalogues).
Frequency of Common Indicators update	*6 years (as per reporting cycle).*	
Frequency of assessment update	*6 years (as per reporting cycle).*	
Minimal amount of monitoring locations	• Not applicable.	• Demographic parameters should be obtained from long-term studies in more than two locations per sub-region per species. • Strandings: whenever they occur on *Stenella* (pelagic delphinids) and *Tursiops* (coastal delphinids) or any other most frequent stranded species.
CI12 - Bycatch	**Regional monitoring**	**Sub-regional monitoring**
Frequency of data collection	• At least once per high priority fishing métiers within a reporting period.	• At least one year per high priority fishing métiers/gears to obtain bycatch rates, within each reporting cycle. • GFCM provides data on fishing effort for priority fishing gears and per fleet segment during a reference year, for each GSA and produce a risk analysis on the Mediterranean region, based on available bycatch rates per species.
Monitoring method	• Fishing effort per GSA per métier/gear.	• Annually: bycatch (onboard observations, at port questionnaires and strandings; FAO 2019 protocol may be used). • CPs monitor their fleets (at least one métier/gear per sub-region per year, rotating, starting from the most impacting ones). • National stranding networks collect data on fishery-induced mortality in marine mammal tissues. They provide biennial reports on these matters.
Authority responsible for monitoring	• GFCM, Contracting Parties (relevant authorities)	• Each CP: national monitoring schemes to provide bycatch rates and annual fishing effort.

Frequency of Common Indicators update	*6 years (as per reporting cycle)*
Frequency of assessment update	*6 years (as per reporting cycle)*

3.5 Monitoring and assessment methods and scales for the Mediterranean Monk seal

55. Box 3 describes the minimum requirements for a monitoring framework on monk seals for CIs 3, 4 and 5, organised mostly according to Group A and Group B countries (*sensu* revised Mediterranean monk seal conservation Strategy 2020-2026), as defined in Decision 24/7 (i.e. Group A countries are those that '*host monk seal resident breeding populations and the majority of the species population*'; Group B countries '*are important, because current monk seal sighting records suggest the potential for the species' survival and expansion in areas beyond Group A country borders*' and which '*may contain* […] *critical coastal habitat, which is likely to be re-colonised*''.

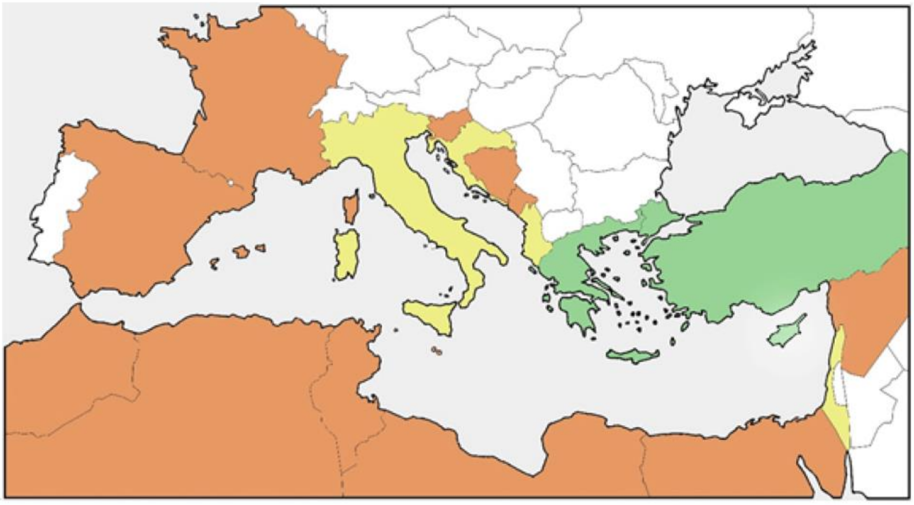


Figure 3: Monk seal conservation status by country (updated at 31.04.2019). *Key: Green: "Group A" countries (where monk seal breeding has been reported after year 2010). Yellow: "Group B" countries (where no monk seal breeding is reported, but where repeated sightings of monk seals (>3) were reported since 2010). Tan: "Group C" countries (where no monk seal breeding is reported, and where very rare or no sightings of monk seals (≤3) were reported since 2010), source: Decision.IG24/7.*

Box 2 – Summary of monitoring framework for EcAp/ IMAP Common Indicators 3 and 4 for the monk seal		
	Group A countries	**Group B and C countries**
Frequency of data collection	• Biennial (minimum requirement) • Annual (optimal)	• Continuous.
Monitoring method	• Pup counts based on cave inspections allow interpolation of population estimate (=> CI4) through conversion formula and allow pupping rate estimate (=> CI5) (minimum requirement). • Population estimate based on mark-recapture of photo-identified individuals based on camera trap monitoring (optimal) => CI4&5 • Opportunistic sightings and cave monitoring => CI3	• Recording opportunistic sightings (minimum requirement) => CI3 • Counts of photo-identified individuals based on camera trap monitoring in caves (optimal) => CI4 and CI5
Authority responsible for monitoring	• Each CP: national monitoring schemes	• Each CP: national monitoring schemes
Frequency of Common Indicators update	6 years (as per reporting cycle)	

Frequency of assessment update	6 years (as per reporting cycle)	
Minimal amount of monitoring locations	• All known locations in each Group A country covered at least once per reporting period.	• selected locations identified in Decision IG24/7 or in areas with high reported sighting frequency and habitat suitability

56. However, it is important to note that the country category subdivisions in the Strategy were revised in 2019, based on the availability of knowledge on monk seal presence in Mediterranean countries, with the objective of defining priority actions to be carried out in 2020-2026 in light of the regional Action Plan non-implementation. According to the strategy, Group C countries are "*also important because, although they are characterized by rare monk seal occurrence, they contain historical monk seal critical habitat.* […] *In the absence of sighting data collection mechanisms, some countries, known to host seals and suitable environmental conditions in the recent past, may currently qualify as Group C*". Some level of monitoring should therefore be carried out also in Group C countries, which hosted seals and suitable environmental conditions in the recent past. In fact, some of the priority actions foreseen for some Group C countries are defined with the intent of soliciting data collection frameworks designed at assessing monk seal presence in specific sectors of coastline (the ones with historical and currently more pristine suitable geomorphological habitat and seal presence).

3.6 Recommended monitoring, assessment, and reporting scales

57. Box 3 presents and additional summary of the proposed approach for marine mammal species in terms of monitoring methods and scales (MS), assessments scales (AS) and reporting scales (MRU) for considered Common Indicators and Candidate Common Indicators.

58. For mapping purposes, it is recommended to adopt the ETC/BD 10x10km for visualisation, ETRS 89 LAEA grid and the 50x50km for wide-ranging, relatively low-density species.

Box 3 - Proposed for marine mammal species primary monitoring methods and assessment & monitoring scales

Taxa	Common Indicators	Region	Sub-region	Sub-division (e.g., GFCM GSA)	National jurisdiction
Cetaceans	CI 3 Species distributional range	• **MS, AS, MRU** • **Distance sampling** for all species ○ **Acoustic and visual methods** for *Ziphius & Physeter*			• **MS** • **Acoustic and visual methods in** important habitats for *Ziphius, Physeter & Balaenoptera*
	CI 4 Population abundance	• **MS, AS, MRU** • **Distance sampling** for all species ○ **Acoustic and visual methods** for *Ziphius & Physeter*		• **MS** • **Distance sampling** for all species	
	CI 5 Population demography		• **MS, AS, MRU** • **Photo-id:** *Tursiops, Balaenoptera* • **Strandings**: *Stenella, Tursiops.*		• **MS** • **Photo-id:** *Tursiops, Balaenoptera* • **Strandings**: *Stenella, Tursiops.*
	CI 12 By-catch	• **MS, AS, MRU** • **Bycatch Risk Analysis** for all species		• **MS** • **On-board observers** for all species	

	CCI 26 Impulsive noise				• **MS** • **Acoustic buoys**: in *Ziphius* important habitats
Monk Seal	CI 3 Species distributional range	• **AS, MRU**			• **MS** • **Cave monitoring** in Country Group A • **Registry** of **opportunistic sighting** in Country Group B and C
	CI 4 Population abundance				• **MS** • **Pup counts in caves** in Country Group A and/or mark –recapture based on **Photo-id** through **caves' monitoring**
	CI 5 Population demography				

Key: MS=Monitoring Scale, AS=Assessment Scale, MRU=Marine Reporting Units.

3.7 Proposed reference values and thresholds for marine mammal species

3.7.1 The IUCN Least Concern guiding principle for cetacean species, reference values and thresholds

59. The development of thresholds for the Common Indicator 4 (Species abundance) of cetacean species followed the guiding principle contained in a decision of the Parties (Decision IG.21/3) to use the IUCN "*Least Concern*" (LC) concept. Hence, all proposals are consistent with the MSFD process, but not necessarily identical.

60. Box 4 summaries proposed assessment reference values, thresholds, and assessment units for the Common Indicator 4 (Species abundance) of cetacean species. Summaries of our proposals on potential reference values and thresholds for these species on Common Indicators (3, 5 and 12) are contained in "*STEP 3*" (light red section) of the **<u>Summary Tables</u>** (see pages 32-38).

Box 4 - Proposed assessment reference values, thresholds, and assessment units for the Common Indicator 4 (Species abundance) related to the 8 species commonly encountered in the Mediterranean

Note: this table needs to be updated with the outcome of the ongoing IUCN Red List Assessment on Mediterranean cetaceans

Species	**Proposed assessment units/MRUs**	**Reference value**	**Proposed 'state' assessment definition**	**If 'Least Concern'**
Striped dolphin (*Stenella coeruleoalba*) • Regularly present in all sub-regions • IUCN Mediterranean listing: VU • Generation length=22.5 (3-gen period=67.5 years)	Regional	ASI 2018 DS design-based estimate. *Corrected and uncorrected for availability bias.* Every time that historical abundance values are revised, a new assessment of the species is necessary.	Maintain total abundance at or above reference levels.	*Stable or no decrease of ≥20% over 3 generations (1.8% within a reporting period).*
Common dolphin (*Delphinus delphis*) • Regularly present in all sub-regions • IUCN Mediterranean listing: EN • Generation length=14.8 (3-gen period=44.4 years)	Regional		Maintain total abundance at or above reference levels.	*No decrease of ≥20% over 3 generations (2.7% within a reporting period).*

Coastal bottlenose dolphins (*Tursiops truncatus*)
• Regularly present in all sub-regions
  ○ Preferred habitat <100 m
  ○ Common over the continental shelf (<200m)
  ○ Present offshore
• IUCN Mediterranean listing: LC
• Generation length=21.1 (3-gen period=63.3 years)
	Regional		Not applicable	*No decrease of ≥20% over 3 generations (1.9% within a reporting period).*

• Threats *to assess:* ○ bycatch ○ *food chain* pollution *(PCBs, heavy metals, etc.)*				
Risso's dolphin (*Grampus griseus*) • Regularly present in all sub-regions • IUCN Mediterranean listing: DD • Generation length=19.6 (3-gen period=58.8 years)	Regional		Maintain total abundance at or above reference levels.	*No decrease of ≥20% over 3 generations (2.0% within a reporting period).*
Long finned pilot whale (*Globicephala melas*) • Regularly present in the Western Mediterranean • IUCN Mediterranean listing: EN • Generation length=24 (3-gen period=72 years)	Regional		Maintain total abundance at or above reference levels.	*No decrease of ≥20% over 3 generations (1.7% within a reporting period).*
Cuvier's beaked whale (*Ziphius cavirostris*) • Regularly present in all sub-regions ○ Deep-*waters'* canyons, slope. • IUCN Mediterranean listing: VU • Generation length= Unknown • Threats *to assess:* ○ bycatch ○ *mid-frequency impulsive noise in* important *habitats*	Regional	ASI 2018 DS design-based estimate. *Corrected and uncorrected for availability bias.* Every time that historical abundance values are revised, a new assessment of the species is necessary.	Maintain total abundance at or above reference levels.	*No decrease of ≥ 1.5% within a reporting period.*
Sperm whale (*Physeter macrocephalus*) • Regularly present in all sub-regions, but the Adriatic. • IUCN Mediterranean listing: EN • Generation length=31.9 (3-gen period=95.7 years)	Regional		Maintain total abundance at or above reference levels.	*No decrease of ≥20% over 3 generations (1.3% within a reporting period).*
Fin whale (*Balaenoptera physalus*) • Regularly present in all sub-regions • IUCN Mediterranean listing: EN • Generation length=25.9 (3-gen period=77.7 years)	Regional		Maintain total abundance at or above reference levels.	*No decrease of ≥20% over 3 generations (1.5% within a reporting period).*

Source: estimated generation lengths are from Taylor et al. 2007.

61. In terms of existing GES definitions for cetacean species CI4 (*Abundance*), it is important to notice that IUCN categories do not evaluate the current status of a species in relation to a "pristine" condition, nor the MSFD or HD. There is a general agreement on the fact that it is impossible to establish what "natural levels" means in quantitative terms, because of a combination of lack of historical data and series and demographic and ecological complexity of many species, including marine mammals. This explains the reason why we do not use the terminology "baseline values", which could be misleading, but rather "reference values". Initial reference values for cetacean species can be based on the results of the data analyses from the 2018 ASI project; although some subregions (i.e. Adriatic) can have abundance values collected earlier on at the correct scale and through "primary methods" (see **Summary Tables**, pages 32-38), which can allow moving the first reference value at an earlier date with respect back in the years (i.e. 2010; Fortuna et al. 2018).

62. The transposition of the quantitative meaning of IUCN Criterion A to define the condition of "Least Concern" over a "3-generation time" window was made in relation to the EcAp/IMAP reporting period (6-year). In simple words, this means that a decrease of less than 20% over a "3-generation" period is acceptable. Anything between 20% and 29% would qualify a species for the category "Near Threatened". Potential "acceptable" decreases vary among species because generation-time varies, sometimes considerably.

63. The IUCN definition of "generation length" is "*the average age of parents of the current cohort (i.e. newborn individuals in the population). Generation length therefore reflects the turnover rate of breeding*

individuals in a population. Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual, except in taxa that breed only once. Where generation length varies under threat, the more natural, i.e. pre-disturbance, generation length should be used" (Taylor *et al*. 2007). The Generation length include the Inter-breeding interval (IBI) parameter.

64. Proposed thresholds consider what to do in case of LC species and what for all other species that are listed into threaten categories (i.e. Critically Endangered, Endangered and Vulnerable). In terms of monitoring routine, the Category "Near threaten" should be considered a "buffer" zone in which countries should engage in *ad hoc* monitoring cycles, possibly focusing on parameters that can help to best understand the real situation for a given species.

Recommendation for future work: The appropriate level of significance for thresholds and reference values needs to be discussed and agreed before the next assessment (2023).

Recommendation for future work: Some additional work needs to be done before the next assessment on the evaluation of the potential impact of constantly changing baselines and on allowing the use of constantly decreasing trends within a specific time-window for CI3, CI4 and CI5. See, for example, the solutions adopted by OSPAR on Grey Seal Pup Production.

65. For Common Indicator 5 (demographic parameters), reference and threshold values will need to be defined, as soon as sufficient information will become available on demographic characteristics and will be sufficiently robust to provide average values for sub-regional reference populations. In fact, in order to develop appropriate reference values for those species for which is possible (i.e. those for which data on mark-recapture, gender and reproductive history can be acquired), long-term datasets are necessary (usually of a few decades). In addition, given the high variability within species, this indicator might be particularly challenging for cetacean species.

3.7.2 Proposed reference values and thresholds for the Monk seal

66. Summaries of our proposals on Potential reference values and thresholds for the Monk seal for all Common Indicators (3, 4, 5 and 12) are contained in "*STEP 3*" (light red section) of the **Summary Tables** (see pages 32-38).

67. Unfortunately, there is no reference map for the species range at Mediterranean level, with sufficient detail that allows to measure shifts in range across 6-year reporting periods. At present the only available data is contained in the IUCN 2015 red listing and the 2019 monk seal strategy subdivision of monk seal areas hosting resident (and therefore known reproductive nuclei) seals, as opposed to areas with monk seal sightings but no formal map exists.

Recommendation for future work: Concerning CI 3, the existing range maps constructed for Habitats Directive reporting, which should be the same as those for MSFD, should be merged into one, with the addition of other data from non-EU and EU countries (e.g., citizen-science, IMAP monitoring, field-work and strandings, etc.). This should be the current baseline against which to measure changes. This work should be finalised before the next reporting period (2023).

68. Similar issues apply to the estimated abundance: at present the IUCN estimate, while based on the best available evidence, is still far from describing the actual population estimate that should be based on homogeneous methodologies. In fact, methods used in the region to estimate abundance are extremely different (e.g., Greek population is estimated through pup counts converted into number of total individuals based on a multiplier obtained from various monk seal populations; whereas the south-eastern Turkish coast population is estimated using mark-recapture methods).

Recommendation for future work: In regard to CI 4, Mediterranean experts need to cooperate to establish a standard method to estimate abundance that takes into account individual displacement across whole range, which will allow to inform and compare temporal and sub-regional trends, before 2023 assessment. This initiative should be organised in the context of the IMAP revision process.

69. The monitoring and assessment of this endangered species (Karamanlidis and Dendrinos 2015) would highly benefit from concerted programmes carefully analysing trends in distributional range, total abundance and reproductive rates.

70. In regard to demographic parameters, pup production (pup counts) is an important parameter to be used to assess the Mediterranean population. Considering the difficulty in doing wide ranging monitoring it could be reasonable to elect "index areas" (e.g., Levantine basin, Ionian islands, North Aegean, etc.) in which to do a more in depth analysis to identify other parameters. These could be: (a) the annual birth rate in "index areas" (reproductive females/number of pups); (b) age class structure (long term); (c) age at maturity, etc.

Recommendation for future work: In regard to CI 5, Mediterranean experts need to cooperate to elaborate a more structured approach on how to explore and identify the best demographic parameters for the medium-long term monitoring, before 2023 assessment. This initiative should be organised in the context of the IMAP revision process.

3.8 New IMAP Candidate Common Indicators (CCI) relevant to marine mammals

71. In terms of assessing the impact of a polluted ecosystem at population level (EO9), the creation of a Candidate Common Indicator that represents a proxy for "population health condition of cetacean species" is proposed. This CCI would assess the level of pollutants' concentration in tissues of free-ranging and stranded specimens, in particular, of compounds such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), hexachlorobenzene (HCB) and dichlorodiphenyltrichloroethane and its main metabolites (DDTs), heavy metals and new emerging pollutants. This new CCI could be monitored at sub-regional level and it would necessitate concerted/coordinated programmes. It would be analysed in blubber, liver, kidney and skin samples (ideally bone, spleen and lung should also be considered) from stranded animals and on free-ranging specimens (through blubber-skin biopsies sampling conducted within national jurisdictions and by researchers with contrasted expertise on remote biopsy sampling). These data should be considered at sub-regional level for the assessment.

72. The definitions of the Candidate Common Indicator could be similar to those of Criterion D8C2 (Species and habitats which are at risk from contaminants) of the MSFD, as in the table below:

Criteria elements	Criteria	Methodological standards
Species and habitats which are at risk from contaminants. Member States shall establish **that list of species**, and **relevant tissues to be assessed**, and habitats, through regional or subregional cooperation.	**D8C2** — Secondary: The **health of species** and the condition of habitats (such as their species composition and relative abundance at locations of chronic pollution) are **not adversely affected due to contaminants including cumulative and synergetic effects**. Member States shall establish those adverse effects and their threshold values through regional or subregional cooperation.	*Use of criteria:* The extent to which good environmental status has been *achieved* shall be expressed for each area assessed as follows: […] for each species assessed under criterion D8C2, an estimate of the abundance of its population in the assessment area that is adversely affected; […]. The use of criterion D8C2 in the overall assessment of good environmental status for Descriptor 8 shall be agreed at regional or subregional level. The *outcomes* of the assessment of criterion D8C2 shall contribute to assessments under Descriptors 1 and 6, where appropriate.

4. SUGGESTIONS POTENTIALLY RELEVANT TO THE DISCUSSION ON DECISIONS REGARDING AGREED GES AND OF THE ONGOING OVERALL INTEGRATION PROCESS

73. While considering current ongoing process at the European level on the MSFD and regionally on EcAp and IMAP, the authors identified few topics that might be of interest for future consideration. These are:

1) The following species have a limited geographical distribution in the Mediterranean. Some consideration should be given on whether to consider them at some stage, in relation to their importance within a sub-region prospective.

Species with limited sub-regional geographical distribution			
Species	**Present**	**Reference value**	**Additional information**
Harbour porpoise (*Phocoena phocoena relicta*)	Eastern Mediterranean: North Aegean Sea	Not Available	• *Phocoena phocoena* is a Priority species under the EU HD. This sub-species is endemic of the Black Sea. • Generation length=11.9 (for *Phocoena phocoena*)
Killer whale (*Orcinus orca*)	Gibraltar Strait (Western Mediterranean)	Check the ongoing IUCN Assessment	• Generation length=25.7
Rough-toothed dolphin (*Steno bredanensis*)	Eastern Mediterranean	Check the ongoing IUCN Assessment	• Generation length= Not available
False Killer Whale (*Pseudorca crassidens*)	Eastern Mediterranean (in proximity of Suez Canal)	Not Available	• Species frequently encountered in the Suez Canal adjacent area. Recent observations and strandings (2019-2020) were reported in Tunisia and Libya.

2) Common Indicators could be prioritised. For example, in order to assess the status of a given cetacean species it is sufficient to collect regularly information on abundance (CI4) and human-induced mortality (e.g., CI12). This is true also in the context of IUCN Red listing, under Criterion A.

74. In addition to these considerations, knowing that the discussion on the overall integration of GES of all Common Indicators (topic outside the scope of this report) is ongoing, it is important to highlight that this process should duly consider issues related to transboundary species and pressures and their connectivity, since GES achievement by one Contracting Party may be dependent on actions taken by other Contracting Parties within the region or any sub-regions, given various interactions, among these elements especially regarding anthropogenic pressures that may have transboundary effects.

75. To achieve the ultimate objective (i.e.: assess the overall Mediterranean GES), a strategy on how to integrate pressures, impacts and state elements and their interrelation to the extent possible among different relevant Ecological Objectives (EO) needs to be defined (2018 UNEP/MED WG.450/3; 2019 UNEP/MED WG.467/7; 2020 UNEP/MED WG.482/Inf.13).

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<u>SUMMARY TABLES</u> - IMAP COMMON INDICATORS (CI), GES OBJECTIVES AND TARGETS RELATED TO MARINE MAMMALS

Agreed EcAp Common Indicators, Ecological Objectives, GES definitions and GES target						STEP 1 Refining scales of <u>monitoring</u>, by revising the existing IMAP/EcAp proposals and identifying adequate scales for the most relevant species in the Mediterranean context.		STEP 2 Developing scales of assessment (if different from those of monitoring) and assessment criteria		STEP 3 Develop threshold and reference values	
Common Indicator	**Ecological Objective**	**Operational Objective**	**GES definition**	**GES target**	***Comments, suggestions***	***Existing context*** Species/functional group	***Proposed changes*** Key: WM=Western Mediterranean; I&CM=Ionian and Central Mediterranean; A=Adriatic; A&LS=Aegean and Levantine seas.	***Existing context***	***Proposed changes***	***Existing context***	***Proposals***
CI3: Species distributional range[3]	Eo1 - Biological diversity is maintained or enhanced. The quality and occurrence of coastal[4] and marine habitats and the distribution and abundance of coastal and marine species[5] are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	1.1 Species distribution is maintained	None in Decision IG.21/3. ***2017 Proposal***: The species are present in all their **natural** distributional range.	***State***: none in Decision IG.21/3. ***2017 Proposal***[6]: The distribution of marine mammals remains stable or expanding and the species that experienced reduced distribution in the past are in favourable status of conservation and can recolonise areas with suitable habitats. ***Pressure/Response***[7]: Human activities having the potential to exclude marine mammals from their natural habitat within their range area or to damage their habitat are regulated and controlled. Conservation measures implemented for the zones of importance for cetaceans. Fisheries management measures that strongly mitigate the risk of incidental taking of monk seals and cetaceans during fishing operations are implemented.		Fin whale / Mysticetes	<u>**Primary monitoring**</u> • *Geographic scale*: Regional. • *Method*: standard & synchronised between all countries (i.e. ASI-like). • *Frequency*: at least once per reporting period. <u>**Secondary monitoring**</u> • *Geographic scale*: Sub-Regional / National. ○ **High Priority sub-regions** (HP): in WM and I&CM key habitats for this species (i.e. feeding, corridor). ○ **Low priority sub-regions** (LP) in A and A&LS. • **Method**: ○ in **HP**: systematic regular monitoring (including photo-id). ○ in **LP** complement systematic monitoring with other adequate and standard method (UNEP MAP 2019). • **Frequency**: ○ in **HP** sub-regions the minimum requirement is: at least three times (better annually in selected places); ○ in **LP** at least one time over the reporting period.	New proposal in UNEP/MED WG.450/3: • Regional: large cetaceans	• Primary assessment/MRU: Regional. • Frequency: once every reporting period.	None	**Reference values distributional range**: • <u>*Mediterranean cetaceans* (**all species**)</u>: map to be created based on Mannocci et al. 2018, Canadas et al. 2018 (*Ziphius*) • <u>*Adriatic cetaceans*</u>: Fortuna et al. 2018 (*Tusiops*, *Stenella*) • <u>*Monk seals*</u>: map to be created based all existing data. **Thresholds for distributional range**: • The extent of the distribution of each species remains stable or expanding compared to a **reference map** (see above). In particular, the Extent of occurrence (EOO) shows: 1) no decline (in all sub-regions where the species was regularly found since last assessment, 2) no decline of number of locations or local putative populations for the species within its distributional range. Given the difficulty to assess the distribution of cetacean species at a finer scale, both reference values and thresholds for this CI should be revised at each assessment cycle.
						Sperm whale / Odontocete (deep feeder)	<u>**Primary monitoring**</u> • **Geographic scale**: Regional. • **Method**: As in previous cell. • **Frequency**: As in previous cell. <u>**Secondary monitoring**</u> • **Geographic scale**: Sub-Regional / National. ○ **High Priority** (HP) in WM, I&CM and A&LS key habitats for this species (i.e. breeding, corridor). ○ **Low priority** (LP) in A • **Method**: As in “Fin whale” cell. • **Frequency**: As in “Fin whale” cell.			None	
						Cuvier’s beaked whale (deep feeder)	<u>**Primary monitoring**</u> • **Geographic scale**: Regional. • **Method**: As in “Fin whale” cell. • **Frequency**: As in “Fin whale” cell. <u>**Secondary monitoring**</u> **Geographic scale**: Sub-Regional / National. ○ **High Priority** (HP) in WM, I&CM and A&LS key habitats for this species (i.e. feeding). ○ **Low priority** (LP) in A • **Method**: As in “Fin whale” cell. • **Frequency**: As in “Fin whale” cell.			None	

[3] https://www.medqsr.org/common-indicator-3-species-distributional-range-marine-mammals
[4] By coastal it is understood both the emerged and submerged areas of the coastal zone as considered in the SPA/BD Protocol as well as in the definition of coastal zone in accordance with Article 2e and the geographical coverage of Article 3 of the ICZM Protocol.
[5] On the basis of Annex II and III of the SPA and Biodiversity Protocol of the Barcelona Convention.
[6] UNEP(DEPI)/MED WG.444/6/Rev.1. IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries). 6th Meeting of the Ecosystem Approach Coordination Group, Athens, Greece, 11 September 2017.
[7] Decision IG.21/3 on the Ecosystems Approach including adopting definitions of Good Environmental Status (GES) and targets.

SUMMARY TABLES - IMAP COMMON INDICATORS (CI), GES OBJECTIVES AND TARGETS RELATED TO MARINE MAMMALS

Agreed EcAp Common Indicators, Ecological Objectives, GES definitions and GES target						STEP 1 Refining scales of monitoring, by revising the existing IMAP/EcAp proposals and identifying adequate scales for the most relevant species in the Mediterranean context.		STEP 2 Developing scales of assessment and assessment criteria		STEP 3 Develop threshold and reference values	
Common Indicator	**Ecological Objective**	**Operational Objective**	**GES definition**	**GES target**	***Comments, suggestions***	***Existing context*** Species/functional group	***Proposed changes*** Key: WM=Western Mediterranean; I&CM=Ionian and Central Mediterranean; A=Adriatic; A&LS=Aegean and Levantine seas.	***Existing context***	***Proposed changes***	***Existing context***	***Proposals***
CI3: Species distributional range[8] *continue*	Eo1 - Biological diversity is maintained or enhanced. The quality and occurrence of coastal[9] and marine habitats and the distribution and abundance of coastal and marine species[10] are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	1.1 Species distribution is maintained	None in Decision IG.21/3. ***2017 Proposal***: The species are present in all their **natural** distributional range.	***State***: none in Decision IG.21/3. ***2017 Proposal***[11]: The distribution of marine mammals remains stable or expanding and the species that experienced reduced distribution in the past are in favourable status of conservation and can recolonise areas with suitable habitats. ***Pressure/Response***[12]: Human activities having the potential to exclude marine mammals from their natural habitat within their range area or to damage their habitat are regulated and controlled. Conservation measures implemented for the zones of importance for cetaceans. Fisheries management measures that strongly mitigate the risk of incidental taking of monk seals and cetaceans during fishing operations are implemented.		Long finned pilot whale (epipelagic feeder)	**Primary monitoring** • **Geographic scale**: Regional. • **Method**: standard & synchronised between all countries (i.e. ASI-like). • **Frequency**: at least once per reporting period. **Secondary monitoring** • **Geographic scale**: Sub-Regional / National. ○ **High Priority sub-regions** (HP) in WM key habitats for this species (i.e. feeding, corridor). ○ **Low priority** (LP) in I&CM. • **Method**: ○ in **HP**: systematic regular monitoring; ○ in **LP** complement systematic monitoring with other adequate and standard method (UNEP MAP 2019). • **Frequency**: ○ in **HP** sub-regions the minimum requirement is biannual; ○ in **LP** at least one time over the reporting period.	New proposal in UNEP/MED WG.450/3: • Sub-regional: small cetaceans	• **Primary assessment/MRU**: Regional. • **Frequency**: once every reporting period.	None	*See previous page.*
						Risso's dolphin (epipelagic feeder)	**Primary monitoring** • **Geographic scale**: Regional. • **Method**: As in previous cell. • **Frequency**: As in previous cell. **Secondary monitoring** • **Geographic scale**: Sub-Regional / National. ○ **High Priority sub-regions** (HP) in WM & A key habitats for this species (i.e. feeding, corridor). ○ **Low priority** (LP) in I&CM and A&LS. • **Method**: As in "Fin whale" cell. • **Frequency**: As in "Fin whale" cell.			None	
						Bottlenose dolphin (epipelagic feeder)	**Primary monitoring** • **Geographic scale**: Regional. • **Method**: As in previous cell. • **Frequency**: As in previous cell. **Secondary monitoring** • **Geographic scale**: Sub-Regional / National. ○ **High Priority sub-regions** (HP) in key habitats for this species in all sub-regions (i.e. feeding, corridor). ○ **Low priority** (LP) in offshore areas. • **Method**: As in "Fin whale" cell. • **Frequency**: As in "Fin whale" cell.			None	
						Common dolphin (epipelagic feeder)	**Primary monitoring** • **Geographic scale**: Regional. • **Method**: As in previous cell. • **Frequency**: As in previous cell. **Secondary monitoring** • **Geographic scale**: Sub-Regional / National. ○ **High Priority sub-regions** (HP) in WM, A&LS key habitats for this species (i.e. feeding, corridor). ○ **Low priority** (LP) in A, I&CM. • **Method**: As in "Fin whale" cell. • **Frequency**: As in "Fin whale" cell.			None	
						Striped dolphin (epipelagic feeder)	**Primary monitoring** • **Geographic scale**: Regional. • **Method**: As in "Fin whale" cell (except for photo-id).			None	

[8] https://www.medqsr.org/common-indicator-3-species-distributional-range-marine-mammals
[9] By coastal it is understood both the emerged and submerged areas of the coastal zone as considered in the SPA/BD Protocol as well as in the definition of coastal zone in accordance with Article 2e and the geographical coverage of Article 3 of the ICZM Protocol.
[10] On the basis of Annex II and III of the SPA and Biodiversity Protocol of the Barcelona Convention.
[11] UNEP(DEPI)/MED WG.444/6/Rev.1. IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries). 6th Meeting of the Ecosystem Approach Coordination Group, Athens, Greece, 11 September 2017.
[12] Decision IG.21/3 on the Ecosystems Approach including adopting definitions of Good Environmental Status (GES) and targets.

							• **Frequency**: As in "Fin whale" cell.				

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Agreed EcAp Common Indicators, Ecological Objectives, GES definitions and GES target						**STEP 1** **Refining scales of <u>monitoring</u>, by revising the existing IMAP/EcAp proposals and identifying adequate scales for the most relevant species in the Mediterranean context.**		**STEP 2** **Developing scales of assessment and assessment criteria**		**STEP 3** **Develop threshold and reference values**	
Common Indicator	**Ecological Objective**	**Operational Objective**	**GES definition**	**GES target**	***Comments, suggestions***	***Existing context*** Species/functional group	***Proposed changes*** Key: WM=Western Mediterranean; I&CM=Ionian and Central Mediterranean; A=Adriatic; A&LS=Aegean and Levantine seas.	***Existing context***	***Proposed changes***	***Existing context***	***Proposals***
CI3: Species distributional range *continue*	EO1 - Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	1.1 Species distribution is maintained	The **Monk Seal** is present along recorded Mediterranean coasts with suitable habitats for the species[6].	***State***[7]: The distribution of Monk Seal remains stable or expanding and the species is recolonizing areas with suitable habitats. ***Pressure***[7]: Human activities having the potential to exclude marine mammals from their natural habitat within their range area or to damage their habitat are regulated and controlled. Fisheries management measures that strongly mitigate the risk of incidental taking of monk seals and cetaceans during fishing operations are implemented.		Monk Seal	**<u>Primary monitoring</u>** • **Geographic scale**: Sub-regional ○ In Group A countries: ○ Specifically, monitor populations in sites consistent with the Regional Strategy for the conservation of Monk seal in the Mediterranean (RSMS). ○ In Group B and C countries: area with suitable habitat and/ historical presence. • **Method**: ○ In Group A countries: ▪ Registry on opportunistic sightings / citizen science ▪ Photo traps in selected caves ○ In Group B & C countries: ▪ Registry on opportunistic sightings (minimum requirement) ▪ Photo traps in selected caves of selected locations identified by the revised RSMS. • **Frequency**: Annual (minimum requirement) or all known locations in each Group A country covered at least three times (biannually) per reporting period.	None	• **Primary assessment/MRU**: Regional. • **Frequency**: once every reporting period.	None	**Reference values distributional range**: • *<u>Monk seals</u>*: map to be created based all existing data.

SUMMARY TABLES - IMAP COMMON INDICATORS (CI), GES OBJECTIVES AND TARGETS RELATED TO MARINE MAMMALS

Agreed EcAp Common Indicators, Ecological Objectives, GES definitions and GES target						STEP 1 Refining scales of monitoring, by revising the existing IMAP/EcAp proposals and identifying adequate scales for the most relevant species in the Mediterranean context.		STEP 2 Developing scales of assessment and assessment criteria		STEP 3 Develop threshold and reference values	
Common Indicator	**Ecological Objective**	**Operational Objective**	**GES definition**	**GES target**	***Comments, suggestions***	***Existing context*** Species/functional group	***Proposed changes*** Key: WM=Western Mediterranean; I&CM=Ionian and Central Mediterranean; A=Adriatic; A&LS=Aegean and Levantine seas.	***Existing context***	***Proposals***	***Existing context***	***Proposals***
CI4: Population abundance of selected species[13]	EO1- Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	1.2 Population size of selected species is maintained	The species population has abundance levels allowing to qualify to Least Concern Category of IUCN.	***State***[6]: Populations recover towards natural levels. ***2017 Proposal***: No human-induced mortality is causing a decrease in breeding population size or density. Populations recover towards natural levels.		Fin whale	**Primary monitoring** • *Geographic scale*: Regional. • *Method*: standard & synchronised between all countries (i.e. ASI-like). • *Frequency*: at least once per reporting period. **Secondary monitoring** • *Geographic scale*: Sub-Regional / National. ○ *High Priority sub-regions* (HP): in WM and I&. ○ *Low priority* (LP):in A and A&LS. • **Method**: ○ in HP: systematic regular monitoring (including photo-id); ○ in LP complement systematic monitoring with other adequate and standard method (UNEP MAP 2019). • **Frequency**: ○ in HP sub-regions the minimum requirement is biennial. ○ in LP at least one time over the reporting period.	IMAP Monitoring Protocols 2019	• **Assessment / MRU**: Regional. • **Frequency**: once every reporting period.	None.	• Check IUCN Mediterranean Red Listing and if EN, CR, VU then maintain total abundance at or above reference levels. • When listed as LC, no decrease of ≥20% over 3 generations (1.5% within a 6-year reporting period). • Regional reference value: ASI 2018 DS design-based estimate (see Box 4 for details).
						Sperm whale	**Primary monitoring**: As in "Fin whale" cell. **Secondary monitoring**: • *Geographic scale*: Sub-Regional / National. ○ HP: in WM, I&CM and A&LS. ○ LP: in A. • *Method*: As in "Fin whale" cell. • *Frequency*: As in "Fin whale" cell.	None.		None.	• Check IUCN Mediterranean Red Listing and if EN, CR, VU then maintain total abundance at or above reference levels. • When listed as LC, no decrease of ≥20% over 3 generations (1.3% within a 6-year reporting period). • Regional reference value: ASI 2018 DS design-based estimate (see Box 4 for details).
						Cuvier's beaked whale	**Primary monitoring**: As in "Fin whale" cell. **Secondary monitoring** • *Geographic scale*: Sub-Regional / National. ○ HP in WM, I&CM and A&. ○ LP in A. • *Method*: As in "Fin whale" cell. • *Frequency*: As in "Fin whale" cell.	None.		None.	• Check IUCN Mediterranean Red Listing and if EN, CR, VU then maintain total abundance at or above reference levels. • When listed as LC, no decrease of ≥ 1.5% within a 6-year reporting period. • Regional reference value: Canadas *et al.* 2018 & ASI 2018 DS design-based estimate (see Box 4 for details).
						Long finned pilot whale	**Primary monitoring**: As in "Fin whale" cell. **Secondary monitoring** • *Geographic scale*: Sub-Regional / National. ○ **High Priority sub-regions** (HP) in WM. ○ **Low priority** (LP) in I&CM. • **Method**: As in "Fin whale" cell. ○ **Frequency**: As in "Fin whale" cell.	None.		None.	• Check IUCN Mediterranean Red Listing and if EN, CR, VU then maintain total abundance at or above reference levels. • When listed as LC, no decrease of ≥20% over 3 generations (1.7% within a reporting period). • Regional reference value: ASI 2018 DS design-based estimate (see Box 4 for details).
						Risso's dolphin	**Primary monitoring**: As in "Fin whale" cell. **Secondary monitoring** • **Geographic scale**: Sub-Regional / National. ○ **High Priority sub-regions** (HP) in WM & A. ○ **Low priority** (LP) in I&CM and A&LS. • **Method**: As in "Fin whale" cell. • **Frequency**: As in "Fin whale" cell.	None.		None.	• Check IUCN Mediterranean Red Listing and if EN, CR, VU then maintain total abundance at or above reference levels. • When listed as LC, no decrease of ≥20% over 3 generations (2.0% within a reporting period). • Regional reference value: ASI 2018 DS design-based estimate (see Box 4 for details).

[13] https://www.medqsr.org/common-indicator-4-population-abundance-selected-species-marine-mammals

SUMMARY TABLES - IMAP COMMON INDICATORS (CI), GES OBJECTIVES AND TARGETS RELATED TO MARINE MAMMALS

Agreed EcAp Common Indicators, Ecological Objectives, GES definitions and GES target						**STEP 1** **Refining scales of monitoring, by revising the existing IMAP/EcAp proposals and identifying adequate scales for the most relevant species in the Mediterranean context.**		**STEP 2** **Developing scales of assessment and assessment criteria**		**STEP 3** **Develop threshold and reference values**	
Common Indicator	**Ecological Objective**	**Operational Objective**	**GES definition**	**GES target**	***Comments, suggestions***	***Existing context*** Species/functional group	***Proposed changes*** Key: WM=Western Mediterranean; I&CM=Ionian and Central Mediterranean; A=Adriatic; A&LS=Aegean and Levantine seas.	***Existing context***	***Proposals***	***Existing context***	***Proposals***
CI4: Population abundance of selected species[14] *continue*	EO1- Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	1.2 Population size of selected species is maintained	The species population has abundance levels allowing to qualify to Least Concern Category of IUCN.	***State***[6]: Populations recover towards natural levels. ***2017 Proposal***: No human-induced mortality is causing a decrease in breeding population size or density. Populations recover towards natural levels.		Bottlenose dolphin	**Primary monitoring**: As in "Fin whale" cell. **Secondary monitoring** • **Geographic scale**: Sub-Regional / National. ○ **High Priority sub-regions** (HP). ○ **Low priority** (LP) in offshore areas. • **Method**: As in "Fin whale" cell. • **Frequency**: As in "Fin whale" cell.	None.		None.	• Check IUCN Mediterranean Red Listing and if EN, CR, VU then maintain total abundance at or above reference levels. • No decrease of ≥20% over 3 generations (1.9% within a reporting period). • Regional reference value: ASI 2018 DS design-based estimate (see Box 4 for details). ○ Adriatic: Reference value (2010: Fortuna et al. 2018)
						Common dolphin	**Primary monitoring**: As in "Fin whale" cell. **Secondary monitoring** • **Geographic scale**: Sub-Regional / National. ○ **High Priority sub-regions** (HP) in WM, A&LS key habitats for this species (i.e. feeding, corridor). ○ **Low priority** (LP) in A, I&CM. • **Method**: As in "Fin whale" cell. • **Frequency**: As in "Fin whale" cell.	None.		None.	• Check IUCN Mediterranean Red Listing and if EN, CR, VU then maintain total abundance at or above reference levels. • When listed as LC, no decrease of ≥20% over 3 generations (2.7% within a reporting period). • Regional reference value: ASI 2018 DS design-based estimate (see Box 4 for details).
						Striped dolphin	**Primary monitoring**: As in "Fin whale" cell.	None.		None.	• Check IUCN status and if EN, CR, VU then > only. • Maintain total abundance at or above reference levels. • When listed as LC, no decrease of ≥20% over 3 generations (1.8% within a reporting period). • Regional reference value: ASI 2018 DS design-based estimate (see Box 4 for details).
			Number of individuals by colony allows to achieve and maintain a favourable conservation status.	***State***[7]: Continual recovery of population density.		Monk Seal	**Primary monitoring (pending definition of a single standardised method to avoid double counting and allow inter-regional comparison)** • **Geographic scale**: Sub-regional • **Method**: ○ Group A countries: ▪ Individuals counts based on cave monitoring (minimum requirement) and/or mark-recapture based on photo-identified seals data in sites consistent with the revised Monk seal strategy. ○ Group B & C countries: ▪ Photo-identification of individuals based on images obtained from non-invasive monitoring of resting caves. Caves in sites that require monitoring should be decided based on evidence of recurrent sightings recorded through the results of the opportunistic sighting registry ○ **Frequency**: Annual.	None.	• **Assessment/ MRU**: Regional	None.	• Increase on total population of 1% over six-year reporting period AND increase in number of pups compared to the last assessment. • Provisional reference value: to be estimated.

[14] https://www.medqsr.org/common-indicator-4-population-abundance-selected-species-marine-mammals

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Common Indicator	**Ecological Objective**	**Operational Objective**	**GES definition**	**GES target**	***Comments, suggestions***	***Existing context*** Species/functional group	***Proposed changes*** Key: WM=Western Mediterranean; I&CM=Ionian and Central Mediterranean; A=Adriatic; A&LS=Aegean and Levantine seas.	***Existing context***	***Proposals***	***Existing context***	***Proposals***
CI5: Population demographic characteristics[15]	EO1 - Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	1.3 Population condition of selected species is maintained	***State[7]***: Decreasing trends in human induced mortality. ***Pressure[7]***: Appropriate measure implemented to mitigate incidental catch, prey depletion and other human induced mortality.	Species populations are in good condition: Low human induced mortality, balanced sex ratio and no decline in calf production[7]. ***2017 Proposal***: preliminary assessment of incidental catch, prey depletion and other human induced mortality followed by implementation of appropriate measures to mitigate these threats.	Move GES definitions for state and pressure to CI12 and reformulate GES definitions for CI5	Cetaceans (*Stenella*, *Tursiops* and *Balaenoptera* as proxy for functional groups)	**Primary monitoring** • **Geographic scale**: Sub-regional / National. • **Species**: focus on *Stenella*, *Tursiops* and *Balaenoptera*. **Parameters**: ○ adult survival probability, juvenile survival probability; fecundity/breeding productivity/rate; age class distribution; sex ratio; population growth rate. • **Method**: ○ **Stranding network** collecting standard measures and biological material (e.g., teeth and reproductive organs) ○ **Photo-ID network** collecting standard pictures (list of parameters including calf) • **Frequency**: continuous for strandings, regularly and frequent for photo-ID. **Secondary monitoring** • **Geographic scale**: Sub-Regional. • **Method**: one dedicated concerted and cooperative campaign collecting biopsies (for sex ratio, and hormones rates). • **Frequency**: at least once per reporting period.		• **Assessment/ MRU**: Sub-regional & all "local populations" (long-term studies). • **Frequency**: once per reporting period.		It is not possible to develop reference and threshold values at this point.
			Pressure[7]: Appropriate measures implemented to mitigate direct killing and incidental catches and to preclude habitat destruction and disturbance.	Species populations are in good condition: Low human induced mortality, appropriate pupping seasonality, high annual pup production, balanced reproductive rate and sex ratio[6]. ***2017 Proposal***: decreasing trends in human induced mortality (e.g., direct killings, pupping/resting habitat /disturbance/occupation)	Move GES definitions for state and pressure to CI12 and reformulate GES definitions for CI5. Add "Habitat disturbance" to the definition of Pressure in GES.	Monk seal	**Primary monitoring** • **Geographic scale**: Sub-regional in countries Group A. • **Method**: Pup counts in critical/selected breeding caves (minimum requirement). • **Frequency**: annual.		• **Assessment/MRU**: Sub-regional & all "colonies". • **Frequency**: once per reporting period.		**Reference values demography**: • *Total annual national pup counts*: to be estimated. • *Annual birth rate*: define index areas and produce estimates. **Threshold values**: • Increase from last assessment.

[15] https://www.medqsr.org/common-indicator-5-population-demographic-characteristics-marine-mammals

SUMMARY TABLES - IMAP COMMON INDICATORS (CI), GES OBJECTIVES AND TARGETS RELATED TO MARINE MAMMALS

Agreed EcAp Common Indicators, Ecological Objectives, GES definitions and GES target						STEP 1 Refining scales of monitoring, by revising the existing IMAP/EcAp proposals and identifying adequate scales for the most relevant species in the Mediterranean context.		STEP 2 Developing scales of assessment and assessment criteria		STEP 3 Develop threshold and reference values	
Common Indicator	**Ecological Objective**	**Operational Objective**	**GES definition**	**GES target**	***Comments, suggestions***	***Existing context*** Species/functional group	***Proposed changes*** Key: WM=Western Mediterranean; I&CM=Ionian and Central Mediterranean; A=Adriatic; A&LS=Aegean and Levantine seas.	***Existing context***	***Proposals***	***Existing context***	***Proposals***
CI12: Bycatch of vulnerable and non-target species (EO1 and EO3)	EO3-EO1 - Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock	***2017 Proposal***: Incidental catch of vulnerable species (i.e. sharks, marine mammals, seabirds and turtles) are minimized.		***2017 Proposal***: The abundance / trends of populations of seabirds, marine mammals, sea turtles and sharks key species (selected according to their actual and total dependence on the marine environment, and to their ecological representativeness) is stable or not reducing in a statistically significant way taking into account the natural variability compared to the current situation.	***Cetaceans*** ***State***[7]: **No unsustainable impact at population level**. Decreasing trends in human induced mortality. ***Pressure***[7]: Appropriate measure implemented to mitigate incidental catch, prey depletion and other human induced mortality.	Marine mammals	• In each GFCM GSA, at least one year of cetacean bycatch rate monitoring per each high priority fishing métiers (to be defined), within each reporting cycle. • GFCM provides data on fishing effort during reference year for priority fishing métiers, for each GSA. • **Annually**: bycatch (onboard observations, questionnaires and strandings) and systemic pollution (strandings) • CPs monitor their fleets (**at least one métier per sub-region per year, rotating**). • National stranding network collect data on fishery-induced mortality and level of pollutants in marine mammal tissues. They provide biennial reports on these matters. • Each CP: national monitoring schemes to provide bycatch rates and annual fishing effort.		• **Assessment/MRU**: Regional & Sub-regional (or aggregated GFCM GSAs). • **Frequency**: annual or biennial.		• **Regional**: BRA on each species for the potentially most dangerous fishing gears. ○ Threshold of the total estimated bycatch per all fishing gears: **1% of the total population**. This triggers in-depth monitoring programmes. • **Sub-regional**: ***thresholds*** calculated with CLA or RLA on each species, based on actual observations on bycatch rates, total fishing effort, biological parameters and conservation objectives (CLA = 72% K; RLA = 80% K).
					Monk seal ***Pressure***[7]: Appropriate measures implemented to mitigate direct killing and incidental catches and to preclude habitat destruction.						

ANNEX 1 - PROPOSED REVISIONS TO APPENDIX 1 OF ANNEX TO DECISION IG.22/7 ON INTEGRATED MONITORING AND ASSESSMENT PROGRAMME OF THE MEDITERRANEAN SEA AND COAST AND RELATED ASSESSMENT CRITERIA

Proposed revisions to Appendix 1 of Annex to Decision Ig.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria are all in red. Added text is in **bold**, proposed deletions are ~~strikethrough~~.

Revisions are proposed for the next three tables.

Proposed revisions to Annex to Decision IG.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria

Species class	**Species functional groups**	
	~~CEEC~~**/OSPAR**	~~FR experts proposal~~ **EcAp/IMAP** ~~(subdivision of toothed whales)~~
Marine mammals	Baleen whales	~~baleines à fanons (Mysticètes)~~ **Baleen whales (Mysticetes)**
	Toothed wales	~~Odontocètes épipélagiques stricts (alimentation entre 0 à -200 m)~~ **Strictly epipelagic Odontocetes (feeding between 0 and -200m)**
		~~Odontocètes épi- et méso-bathy-pélagiques (alimentation de 0 à >-200 m)~~ **Epi-, mesopelagic Odontocetes (feeding > -200m)**
	Seals	~~Phoques (pinnipèdes)~~ **Seals (pinnipeds)**

<u>Proposed revisions</u> to Appendix 1 to Annex to Decision IG.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria

Corrections in red, **added text** in **bold**, proposed deletions are ~~strikethrough~~ and ~~red~~.

Minimum list			Texel-Faial Criteria								Typology/listed	
A	B	C	D	E	F	G	H	I	J	K	L	M
Predominant habitat or "Functional" group of species	**Specific habitat type or species to be monitored**	**ADDITIONAL INFORMATION (to be further discussed): specific representatives species or habitats (Invertebrates associated with habitats)**	**(sub)regional importance**	**Rarity**	**Key functional role**	**Declining or threatened**	**Sensitivity / Vulnerability (exposure to pressures): cf. column N to V**	**feasibility (for monitoring): cf. column W to AG**	**Priority (estimated from column D to I)**	**Assessment monitoring scale**	**EUNIS 2015**	**Habitats Directive**
Mammals - baleen whales	*Balaenoptera physalus* (Linnaeus, 1758)		subregional			**T**		**yes**	**1**	~~subregional~~ **regional**		
Mammals - toothed whales (deep feeder)	*Physeter macrocephalus* (Linnaeus, 1758)		subregional			**T**	**High**	**yes**	**1**	subregional		
Mammals - toothed whales (deep feeder)	*Ziphius cavirostris* (Cuvier G., 1832)		subregional			**T**	**High**	**yes**	~~2~~ **1**	subregional		
Mammals - toothed whales (epipelagic feeder)	*Delphinus delphis* ~~(~~Linnaeus, 1758~~)~~		subregional					**yes**	**1**	subregional		
Mammals - toothed whales (epipelagic feeder)	*Tursiops truncatus* (Montagu, 1821)		~~regional~~ **subregional**				**Moderate**	**yes**	**1**	~~regional~~ **subregional**		priority species
Mammals - toothed whales (epipelagic feeder)	*Stenella coeruleoalba* (Meyen, 1833)		regional					**yes**	**2**	regional		
Mammals - toothed whales (epipelagic feeder)	*Globicephala melas* (Trail**l**, 1809)		subregional					**yes**	**2**	subregional		
Mammals - toothed whales (epipelagic feeder)	*Grampus griseus* (Cuvier G., 1812)		subregional				**Moderate**	**yes**	**2**	subregional		
Mammals - seals	*Monachus monachus* (Hermann, 1779)		subregional			T	**High**		**1**	subregional		priority species

<u>Proposed revisions</u> to Appendix 1 to Annex to Decision IG.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria *[continuing from previous table]*
Corrections in red, **added text** in **bold**, proposed deletions are ~~strikethrough~~ and ~~red~~.

Minimum list		Main pressures (binary=occuring or not: to be prioritized (ranked) for each specific representatives species or									Feasibility										
		N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
Predominant habitat or "Functional" group of species	**Specific habitat type or species to be monitored**	**Physical loss of habitat (construction ports, marinas)**	**Physical damage to habitat**	**Nutrient enrichment**	**Contaminants**	**Removal by fishing (target, non-target)**	**Hydrological changes (thermal, salinity regime)**	**Other disturbances to species (e.g. litter, visual disturbance)**	**UW noise**	**NIS**	**Vessel**	**Lab facilities, equipment, consumables**	**Taxonomic expertise (technicians, scientists)**	**Monitoring techniques developed**	**Aerial**	**Land-based**	**In-water**	**Indicators established**	**Existing observatory stations / long term monitoring programmes**	**Satellite / Remote Sensing / aerial platforms**	**Oceanographic platforms**
Mammals - seals	*Monachus monachus* (Hermann, 1779)										Yes	Yes	~~Moderate~~	**Non invasive monitoring of selected resting/breeding caves to allow photoidentification for mark-recapture and pup counts**				Yes	Yes	~~Teledection Tracking~~	
Mammals – baleen whales	*Balaenoptera physalus* (Linnaeus 1758)										Yes	Yes	Moderate	Shipboard, acoustic or aerial ~~strip~~ **line** transects	**Yes, line transect**	**Only used in the Strait of Gibraltar**		Yes	Yes	~~Teledection Tracking~~ **Yes**	
Mammals - toothed whales (deep feeder)	*Physeter macrocephalus* (Linnaeus, 1758)					***					Yes	Yes	Moderate	Shipboard surveys; Acoustic surveys; Aerial surveys (but not optimum due to long dives, **photo-ID**			**Yes, acoustic**	Yes	Yes	~~Teledection Tracking~~ **Yes**	
Mammals - toothed whales (deep feeder)	*Ziphius cavirostris* (Cuvier G., 1832)										Yes	Yes	Moderate	Shipboard surveys, Acoustic surveys (but not easy to detect), Aerial surveys (but not optimum due to long dives)			***Fix acoustic***	Yes	Yes	~~Teledection Tracking~~ **Yes**	
Mammals - toothed whales (epipelagic feeder)	*Delphinus delphis* ~~(~~Linnaeus, 1758~~)~~										Yes	Yes	Moderate	Shipboard or aerial ~~strip~~ **line** transects	**Yes, line transect**			Yes	Yes	~~Teledection Tracking~~ **No**	
Mammals - toothed whales (epipelagic feeder)	*Tursiops truncatus* (Montagu, 1821)										Yes	Yes	Moderate	Shipboard, acoustic or aerial ~~strip~~ **line** transects, **photo-ID**	**Yes, line transect**			Yes	Yes	~~Teledection Tracking~~ **No**	
Mammals - toothed whales (epipelagic feeder)	*Stenella coeruleoalba* (Meyen, 1833)										Yes	Yes	Moderate	Shipboard or aerial ~~strip~~ **line** transects	**Yes, line transect**			Yes	Yes	~~Teledection Tracking~~ **No**	
Mammals - toothed whales (epipelagic feeder)	*Globicephala melas* (Trail**l**, 1809)										Yes	Yes	Moderate	Shipboard, acoustic or aerial ~~strip~~ **line** transects	**Yes, line transect**			Yes	Yes	~~Teledection Tracking~~ **No**	
Mammals - toothed whales (epipelagic feeder)	*Grampus griseus* (Cuvier G., 1812)										Yes	Yes	Moderate	Shipboard, acoustic or aerial ~~strip~~ **line** transects, **photo-ID**	**Yes, line transect**			Yes	Yes	~~Teledection Tracking~~ **No**	

Notes on proposed revisions: ***Marine mammals are dramatically impacted by IUU driftnets. In case of Sperm whales, even few animals per year taken at regional level are to be considered a serious threat.

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**UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN**

21 June 2021
Original: English

Fifteenth Meeting of SPA/BD Focal Points

Videoconference, 23-25 June 2021

Agenda Item 7: Status of implementation of the Ecosystem Approach (EcAp) Roadmap

7.1. Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP- Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Appendix C Rev.1: Monitoring and Assessment Scales, Assessment Criteria, Thresholds and Baseline Values for the IMAP Common Indicators 3, 4 and 5 related to Marine Turtles

UNEP/MAP
SPA/RAC-Tunis, 2021

In charge of the study at SPA/RAC

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Report prepared by:

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Acknowledgment

This report was prepared with the participation and voluntary contribution of the Biodiversity Online Working Group (OWG) on Marine Turtles namely: Ferdinand Bego, Draško Holcer, Srđana Rožić, Martina Marić, Mohamed Said Abdelwarith, Françoise Claro, Fanny Girard, Marianna Giannoulaki, Giancarlo Lauriano, Giulia Mo, Angela Paglialonga, Ali Baddredine, Sladjana Gvozdenovic, Tina Centrih Genov, José Carlos Báez, Yakup Kaska and Oguz Turkozan

Executive Summary

Two necessarily overlapping sympatric assessment systems have been established covering marine habitats and species within the Mediterranean. On one hand, you have 2 European Union (EU) Directives the EU Marine Strategy Framework Directive (MSFD- Directive 2008/56/EC) and the EU Habitats directive (92/43/EC) both of which apply only to EU Member States (MSs) and the second is the Ecosystem Approach (EcAp) & Integrated Monitoring and Assessment Programme (IMAP) process of the Barcelona Convention (UNEP/MAP 2016; UNEP(DEPI)/MED IG.22/Inf.7) that apply to all Contracting Parties (CPs) of the Mediterranean, noting that all are parties to this Regional Sea Convention, this means *all* the 21 riparian countries that border the Mediterranean Sea and including the European Union.

In terms of certain marine species and in this case, sea turtles, both systems intend to report on their conservation status and that of populations with reference to Good Environmental Status (GES), which is determined through elaboration of certain criteria/indicators. Predefined scales of monitoring and assessment are required for these criteria/indicators and findings need to be compared to either baseline or threshold values (whichever is most appropriate) to confirm GES is met, and/or to determine if trends are improving or worsening.

Elaboration of three specific EcAp/IMAP Common Indicators (CI) for marine turtles in the Mediterranean are the subject of this report namely:

CI 3 – Species distribution range

> Existing GES definition: “The species continues to occur in all its natural range in the Mediterranean, including nesting, mating, feeding and wintering and developmental (where different to those of adults) sites”

CI 4 – Population abundance

> Existing GES definition: “The population size allows to achieve and maintain a favourable conservation status taking into account all life stages of the population”

CI 5 – Population demographic characteristics

> Existing GES definition: “Low mortality induced by incidental catch and favourable sex ratio and no decline in hatching rate”

This report presents information, perspectives and recommendations on 1) revising the existing scales of monitoring, 2) establishing suitable scales of assessment and appropriate assessment criteria, and 3) establishing appropriate baseline and threshold values on which to base GES.

In order to stimulate progress towards realisation of workable regional assessments for sea turtles, proposals contained herein provide a pragmatic approach to establishing baselines and thresholds using conceptually simple methods for determination and assessment of populations in terms of GES. Given time and increased capacity, following the acceptance of the initial scales and thresholds/baselines determined by the current process, it is foreseen that some adjustment may be required, especially for the threshold and baseline components, to reflect more robust scientific determination of GES, however no adjustment would be expected for the remainder of the current and subsequent IMAP six-year assessment periods.

The following tables provide summaries of the existing status of the elaboration of the three subject CIs together with proposed updates and clarifications that are made within the main body of this report.

Agreed EcAp Common Indicators, Ecological Objectives, GES definitions and GES target					STEP 1 Refining scales of monitoring, by revising the existing IMAP/EcAp proposals and identifying adequate scales for the most relevant species in the Mediterranean context.		STEP 2 Developing scales of assessment		STEP 3 Developing assessment criteria		STEP 4 Develop threshold and baseline values	
Common Indicator	**Operational Objective**	**GES definition**	**GES target**	**Comments, suggestions**	**Existing context**	**Proposed changes**	**Existing context**	**Proposals**	**Existing context**	**Proposals**	**Existing context**	**Proposals**
CI3: Species distributional range [1]	Species distribution is maintained	The species continues to occur in all its natural range in the Mediterranean, including nesting, mating, feeding and wintering and developmental (where different to those of adults) sites	State • Turtles continue to nest in all known nesting sites • Turtle distribution is not significantly affected by human activities Pressure/Response • Protection of known nesting, mating, foraging, wintering and developmental turtle sites. • Human activities having the potential to exclude marine turtles from their range area are regulated and controlled. • The potential impact of climate change is assessed		Species distribution ranges can be gauged at local (i.e., within a small area like a national park) or regional (i.e., across the entire Mediterranean basin) scales using a variety of approaches. Long-term monitoring of these areas provides information on the temporal evolution in species distributions.	Revise mapping requirements to two maps; one for nesting areas and one for marine areas. Nesting areas monitoring • Geographic scale: ○ (sub-)National. Up to 7 established sites or 75% of national nesting activity (index areas) • Method: ○ standard nesting beach surveys. • Frequency: ○ Minimum = June/July annually for index areas. ○ six-yearly national scale. Nearshore monitoring • Geographic scale: ○ (sub-)National. Up to 4 sites. • Method: ○ systematic regular monitoring index areas. ○ bycatch/stranding data. • Frequency: ○ biannual monitoring index areas. ○ year-round bycatch/stranding recording. ○ six-yearly national scale. Offshore monitoring • Geographic scale: ○ (sub-)National/regional. • Method: ○ Aerial surveys ○ Boat surveys ○ Bycatch recording. ○ Opportunistic boat surveying. • Frequency: ○ Yearly for aerial and boat surveys ○ Year-round for bycatch records ○ *Ad hoc* boat surveying. ○ six-yearly national scale.	The European (ETRS) 10x10km grid is used for mapping the distribution and range…, Three different maps (grids) are produced yearly for each species accounting for breeding sites, wintering sites and feeding/developmental sites. Number of 10x10 km cells (presence/absence) occupied for breeding or wintering or feeding/developmental areas along the Mediterranean (or subregional) coast and in all pelagic marine areas.	Nesting areas National and Subdivisional level GES assessments based on maintenance of distribution of all nesting sites. Marine areas Subregional GES assessments.	Turtles continue to nest in all known nesting sites. Turtle distribution is not significantly affected by human activities.	Nesting areas Turtles remain present in all parts of annually monitored nesting sites and at all established sites during periodic surveys. Marine areas Turtles remain present in all annually monitored, CP defined, hotspot areas and no evidence of definitive absences in any other area withing the RMU distribution.	None	Nesting areas Baselines centred on 1992 to be used for established nesting sites. More recent data to be modelled to 1992 era levels for these sites. New and emerging sites to use maximum existing 6-year average as baseline. Marine areas All areas assumed to have turtle presence (in line with updated IUCN-MTSG RMU boundaries) unless proven otherwise.

[1] https://www.medqsr.org/common-indicator-3-species-distributional-range-marine-turtles

Agreed EcAp Common Indicators, Ecological Objectives, GES definitions and GES target					**STEP 1** **Refining scales of monitoring, by revising the existing IMAP/EcAp proposals and identifying adequate scales for the most relevant species in the Mediterranean context.**		**STEP 2** **Developing scales of assessment**		**STEP 3** **Developing assessment criteria**		**STEP 4** **Develop threshold and baseline values**	
Common Indicator	**Operational Objective**	**GES definition**	**GES target**	**Comments, suggestions**	**Existing context**	**Proposed changes**	**Existing context**	**Proposals**	**Existing context**	**Proposals**	**Existing context**	**Proposals**
CI4: Population abundance of selected species [2]	Population size of selected species is maintained	The population size allows to achieve and maintain a favourable conservation status taking into account all life stages of the population	State • No human induced decrease in population abundance • Population recovers towards natural levels where depleted		For counts carried out on an annual basis, a number of sites should be selected that represent a sufficiently large proportion of the subregional or national population, with criteria being delineated by expert groups. The "Demography Working Group[3]" suggests that comprehensive surveys should be carried out every 5 years, with the aim of covering all breeding, foraging, wintering and developmental sites. However, here, it is recommended that the whole coastal and marine area is covered on a national or subregional scale to take into account changes in population distribution (and hence counts) in relation to climate change.	Nesting areas monitoring • Geographic scale: ○ (sub-)National. Up to 7 sites or 75% of national nesting activity (index areas) • Method: ○ standard nest count surveys. • Frequency: ○ Minimum = June/July annually for index areas. ○ six-yearly national scale. Nearshore monitoring • Geographic scale: ○ (sub-)National. Up to 4 sites. • Method: ○ systematic regular monitoring index areas. ○ bycatch/stranding data. • Frequency: ○ biannual monitoring index areas. ○ year-round bycatch/stranding recording. ○ six-yearly national scale. Offshore monitoring • Geographic scale: ○ (sub-)National. • Method: ○ Aerial surveys ○ Boat surveys using standardised protocols • Frequency: ○ Yearly organised aerial/boat surveys ○ six-yearly national scale.	For counts carried out on an annual basis, a number of sites should be selected that represent a sufficiently large proportion of the subregional or national population, with criteria being delineated by expert groups. The "Demography Working Group" suggests that comprehensive surveys should be carried out every 5 years, with the aim of covering all breeding, foraging, wintering and developmental sites. However, here, it is recommended that the whole coastal and marine area is covered on a national or subregional scale to take into account changes in population distribution (and hence counts) in relation to climate change.	Nesting areas National and Subdivisional level GES assessments based on maintenance of nesting abundance at all sites. Marine areas Subregional GES assessments based on relevant population segments present in each area.	Nesting areas The average breeding population size during at least a decade is suggested as the base level (based on International Union for Conservation of Nature Red List minimal criteria for sea turtles) Marine areas for non-breeding animals at wintering / foraging / developmental sites, number of individuals (n) with appropriate modelling to extrapolate population numbers	Nesting areas Rolling average of previous six years' data to count in the annual assessment. To coincide with the six-yearly regionwide GES assessments. Marine areas Rolling average of previous six years' data to count in the annual assessment. To coincide with the six-yearly regionwide GES assessments. Observations on numbers of turtles in different life-stages and sex ratios to be considered for indications of perturbations in population structure (see CI 5)	None.	Nesting areas Baselines centred on 1992 to be used for established nesting sites. More recent data to be modelled to 1992 era levels for these sites. New and emerging sites to use maximum existing 6-year average as baseline. Marine areas GES baseline taken as annual abundance derived from existing modelled abundances[4] or first year of monitoring which should begin ASAP across the Mediterranean. Where historic (post 1992) data showing larger populations exist, they can be used to amend the baseline of specific countries. For both areas a decrease in population abundance of 10% over a six-year reporting period should trigger increased conservation actions to prevent further decreases and populations falling out of GES

[2] https://www.medqsr.org/common-indicator-4-population-abundance-selected-species-marine-reptiles

[3] Cardona L, *et al.* (2015) Demography of marine turtles nesting in the Mediterranean Sea: a gap analysis and research priorities. Demography Working Group of the 5th Mediterranean Conference on Sea Turtles. 37pp. Bern Convention, T-PVS/Inf (2015) 15

[4] Sparks LM & DiMatteo AD (2020) Loggerhead sea turtle density in the Mediterranean Sea. NUWC-NPT Tech Rep 12360. 77pp.

Agreed EcAp Common Indicators, Ecological Objectives, GES definitions and GES target					STEP 1 Refining scales of monitoring, by revising the existing IMAP/EcAp proposals and identifying adequate scales for the most relevant species in the Mediterranean context.		STEP 2 Developing scales of assessment		STEP 3 Developing assessment criteria		STEP 4 Develop threshold and baseline values	
Common Indicator	**Operational Objective**	**GES definition**	**GES target**	**Comments, suggestions**	**Existing context**	**Proposed changes**	**Existing context**	**Proposals**	**Existing context**	**Proposals**	**Existing context**	**Proposals**
CI5: Population demographic characteristic [5]	Population condition of selected species is maintained	Low mortality induced by incidental catch. Favourable sex ratio and no decline in hatching rates.	Response • Measures to mitigate incidental captures in turtles implemented	Reformulate GES definitions for CI5 based on factors that can be influenced by intervention but gather data on wider demographic parameters.	A number of sites should be selected that represent a ***sufficiently large proportion of the subregional or national population for demographic data to be collected (reflecting the breeding, wintering, foraging and developmental populations that are representative of the region).*** If possible, populations should be selected where animals have been tracked with a sufficient number of units (i.e., >50 individuals), from which the connectivity among these different habitat types can be established.	Nesting areas monitoring • Geographic scale: ○ (sub-)National. Up to 7 established sites or 75% of national nesting levels • Methods: ○ Standard: hatchling emergence success (HES) and nest temperature data. ○ Additional: Sex ratio adults • Frequency: ○ Annually, Minimum: August/September for index area HES and May-September for temperature data. April-May for adult sex ratios. ○ six-yearly national scale. Nearshore monitoring • Geographic scale: ○ (sub-)National. Up to 4 index hotspot sites. • Method: ○ systematic regular monitoring index areas. ○ bycatch/stranding data. • Frequency: ○ biannual monitoring index areas. ○ year-round bycatch/stranding recording. ○ six-yearly national scale. Offshore monitoring • Geographic scale: ○ (sub-)National. • Method: ○ Bycatch recording. ○ Opportunistic boat surveying. • Frequency: ○ Year-round bycatch records ○ *Ad hoc* boat surveying. ○ six-yearly national scale.	The selected breeding sites should aim to be genetically diverse, so as this diversity can be detected at foraging/ wintering/ developmental grounds where different populations diverge. This will facilitate the selection of marine areas for protection that support the highest genetic diversity (i.e., the greatest accumulation of different breeding populations), as well as those that support single breeding populations, which may be of equal importance. Opportunistic data should be collected from all possible sources, wherever possible, and compiled into a single database, which might be used to provide an overview of the entire area. Knowledge about the sex, health and genetic structure of the different populations/subpopulations will be obtained, by understanding recruitment and mortality within different parts of a population and across populations. This information is important to understand whether there are sex-specific mortality risks at different age/size classes, which is important towards aiding population recovery. Also, knowledge on the physical health and genetic health of populations will be obtained, which will indicate the capacity for resilience to human activities, including climate change.	Nesting areas National and Subdivisional level GES assessments. Marine areas Subregional GES assessments.	At present, specific demographic parameters are not regularly assessed to a similar level of female/nest counts, due to the data intensive nature of this component. Many programs assess clutch success (i.e., the number of eggs that hatch from a clutch); however, this represents a small component. Research on offspring sex ratios, juvenile sex ratios, adult (operational) sex ratios is intermittent and based on different fieldwork approaches/methods and analytical techniques depending on the objective (usually, aiming towards a journal publication). Most studies that do exist are focused on the breeding areas; thus, greater focus is required at foraging, wintering and developmental areas, with in-water limitations needing to be accounted for in analyses. Therefore, set analyses need to be established that are applicable within and/or across the different habitat types to allow comparison at the Mediterranean level.	Nesting areas Maintenance of suitable hatchling sex ratios and high hatchling emergence success. Marine areas Quantification of bycatch and calculation of bycatch mortality rates. Observations on numbers of turtles in different life-stages and sex ratios to be considered for indications of perturbations in population structure.	No threshold and baseline values have been consistently defined and applied to date.	Nesting Areas 'Good' HES values can be taken from published literature and taken as thresholds with a buffer zone for improved conservation measures. Nest temperature records to be monitored with estimations of over 95% female production as an upper threshold. Marine areas Human-induced mortality as a component of longevity and survivorship is the one factor that can be measured and affected by conservation actions and hence can be considered as an actionable indicator for GES. Numbers of deaths should be used as the indicator with a stable or declining trend in numbers indicating GES.

[5] https://www.medqsr.org/common-indicator-5-population-demographic-characteristics-marine-reptiles

Preamble

Briefly, the Terms of Reference for the consultant undertaking the current contracted activity covered the following four topics:

1 *Revise the existing scale of monitoring* and further work on developing adequate scales of monitoring for the Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria (IMAP) Common Indicators (CIs) 3 (Distribution), 4 (Abundance) and 5 (Demography) related to marine turtles;

2 *Establish scales of assessment* and

3 *Establish assessment criteria* for the IMAP CIs 3, 4 and 5 related to marine turtles;

4 *Establish baseline and threshold values* for Ecological Objective 1 related to marine turtles;

Three Deliverables were initially anticipated to be submitted.

D1 Document detailing the consultant's workplan and timetable (completed; August 2020) and;

D2 Document covering topics 1 to 3 above;

D3 Document covering topic 4 above.

However, it was agreed between SPA/RAC and the consultant that D2 and D3 can be combined into a single deliverable document. This report represents that document of the two combined deliverables.

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I. Introduction

1. Two necessarily overlapping sympatric assessment systems have been established covering marine habitats and species within the Mediterranean. On one hand, you have 2 European Union (EU) Directives the EU Marine Strategy Framework Directive (MSFD- Directive 2008/56/EC) and the EU Habitats directive (92/43/EC) both of which apply only to EU Member States (MSs) and the second is the Ecosystem Approach (EcAp) & Integrated Monitoring and Assessment Programme (IMAP) process of the Barcelona Convention (UNEP/MAP 2016; UNEP(DEPI)/MED IG.22/Inf.7) that apply to all Contracting Parties (CPs) of the Mediterranean, noting that all are parties to this Regional Sea Convention, this means *all* the 21 riparian countries that border the Mediterranean Sea and including the European Union.

2. In terms of certain marine species and in this case, sea turtles, both systems intend to report on their conservation status and that of populations with reference to Good Environmental Status (GES), which is determined through elaboration of certain criteria/indicators. Predefined scales of monitoring and assessment are required for these criteria/indicators and findings need to be compared to either baseline or threshold values (whichever is most appropriate) to confirm GES is met, and/or to determine if trends are improving or worsening. EcAp Common Indicators (CI) and their corresponding MSFD Criteria are presented in Table 1.1 below. Both, especially the EcAp definitions, are presented as very simplistic overviews of the Theme, whereas data recording to meet the requirements of each are varied and complex.

Table 1.1 EcAp/IMAP Common Indicators subject to this assessment and their MSFD equivalents.

Theme	**Barcelona Convention EcAp /IMAP** Ecological Objective 1 Common Indicator # UNEP(DEPI)/MED WG.444/6/Rev.1 (marine turtle specific excerpts)	**EU MSFD** Descriptor 1 Criterion # Commission Decision (EU) 2017/848 of 17/05/17
Distribution	**CI 3** Turtle distribution is not significantly affected by human activities *and* turtles continue to nest in all known nesting sites	**D1C4** The species *distributional range* and where relevant, pattern, is in line with prevailing physiographic geographic and climatic conditions
Abundance	**CI 4** No human induced decrease in population abundance	**D1C2** The *population abundance* of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured
Demography	**CI 5** Low mortality induced by incidental catch. Favourable sex ratio and no decline in hatching rate	**D1C3** The population *demographic characteristics* (e.g., body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures.

3. Guidance for Common Indicators, including specific sections for marine turtles, has been published (UNEP(DEPI)/MEDWG.444/6/Rev.1) and links the EcAp /IMAP process with that of the MSFD. It is clear from the document that there is a need for a coherent regionwide set of assessment standards that apply to all CPs, as each CP currently has defined their own disjointed targets.

4. GES can be assessed in several ways that may combine both baseline and trend-based approaches. A solely baseline approach based on a predetermined threshold value does not permit normalisation of an expanding/improving situation within the indicator, leading to indicators in decline remaining in GES.

5. Conversely a solely trend-based approach does not permit any decrease in an indicator, no matter how much it exceeds the initial level when GES status may have been indicated. Combined baseline and trend-based approaches includes thresholds that evolve in response to improving conditions, hence recognising the new state as GES, and permit small-scale variation in conditions to not immediately throw an improved indicator out of GES (Figure 1.1).

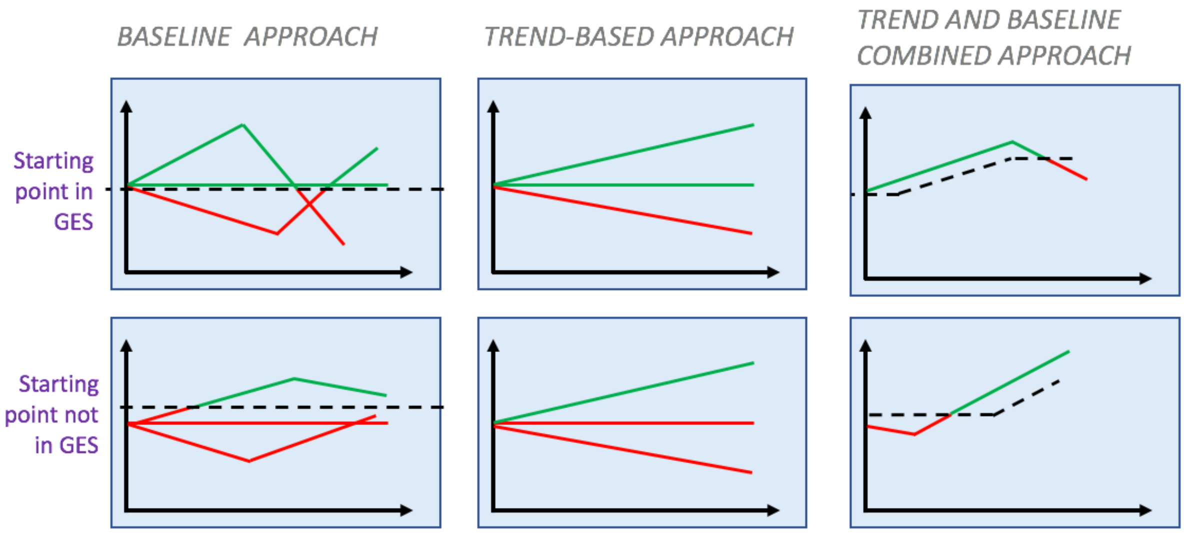

Figure 1.1. Approaches to determination of GES. Green line - GES met. Red line - GES not met. Dashed line - threshold values.

6. The setting of threshold values for an indicator is a complex and imprecise process, that requires detailed understanding of historic or past reference values and their interplay with contemporaneous pressures. An idealised situation equates to reference values being known from a period with no anthropogenic pressures acting upon indicator. Given it is unlikely that data are available from this pristine situation, alternative methods of determining acceptable thresholds are used. These alternative methods have been discussed at length within the EU MSFD context (Palialexis et al. 2019) and yet no single method has been adopted as standard either across the European member states or in any particular EU region or subregion. This is partly to do with lack of compatible monitoring regimes and hence absence of suitable data and partly to do with the differing levels of feasibility of each method.

7. Additionally, though there are likely precise theoretical threshold values that may be adopted, in practice these values can neither be definitively stated nor can data acquired be sufficiently robust to precisely determine which side of a single point threshold the indicator sits. Instead of the hard threshold it is more practical to have a threshold value range that covers the uncertainty of GES assignment. Thus, an indicator falling in this buffer zone will trigger additional measures to improve clarity in the assignment and precautionary-principal conservation measures (Figure 1.2).

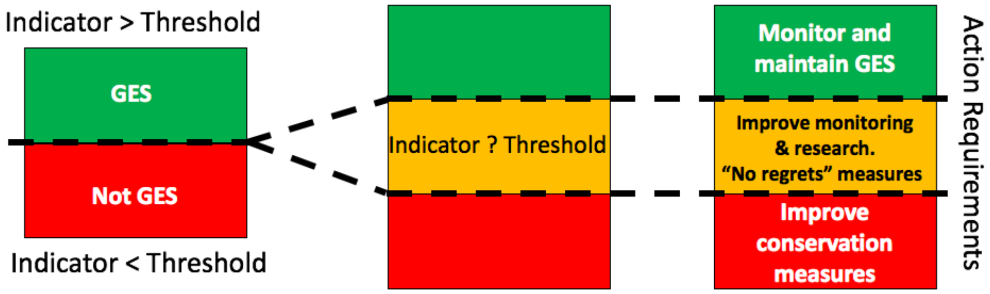

Figure 1.2. Threshold level setting incorporating uncertainty.

8. In order to stimulate progress towards realisation of workable regional assessments for sea turtles, proposals contained herein provide a pragmatic approach to establishing baselines and thresholds using conceptually simple methods for determination and assessment of populations in terms of GES. Given time and increased capacity, following the acceptance of the initial scales and thresholds/baselines determined by the current process, it is foreseen that some adjustment may be required, especially for the threshold and baseline components, to reflect more robust scientific determination of GES, however no adjustment would be expected for the remainder of the current and subsequent IMAP six-year assessment periods.

9. Unlike the situation for sea birds and marine mammals, there are a very limited number of marine turtle species that need to be assessed in the EcAp process. Of the seven species of marine turtle that inhabit the world's oceans only two have established resident breeding populations in the Mediterranean and require assessment. These are the loggerhead turtle (*Caretta caretta*; IUCN (regionally) Least Concern) and green turtle (*Chelonia mydas*; IUCN (globally) Endangered). Loggerheads in the Mediterranean are from two-possibly three globally defined Regional Management Units (RMUs) defined in Wallace et al. 2010. These are the most populous 'endemic' Mediterranean RMU supplemented with fewer turtles that have migrated into the area from the North West Atlantic and possibly the North East Atlantic Ocean RMUs. Loggerhead presence is so widespread across the Mediterranean, shown through tracking, at-sea surveys and stranding records, that they have been chosen to be used by the EU as a bio-indicator species for monitoring marine litter distribution and abundance[6]. Green turtles in the Mediterranean contrast with loggerhead turtles in that they are almost exclusively from the 'endemic' Mediterranean RMU and the vast majority of them remain in the eastern Mediterranean (Figure 1.3). With regard to breeding sites, loggerhead turtle nesting areas are currently concentrated along the shores of the eastern Mediterranean, though new and increased nesting is occurring in the western Mediterranean. Green turtles breed almost exclusively in the north eastern part of the eastern Mediterranean, except for one nest recorded in Tunisia and two recorded on the Island of Crete in Greece (Figure 1.4).

10. It is clear from the differing distributions of the two marine turtle species that each CP will have a distinct subset of the population segments to monitor and assess, with both requiring their own independent assessments of GES that will inform a taxon-wide GES status.

[6] https://indicit-europa.eu/

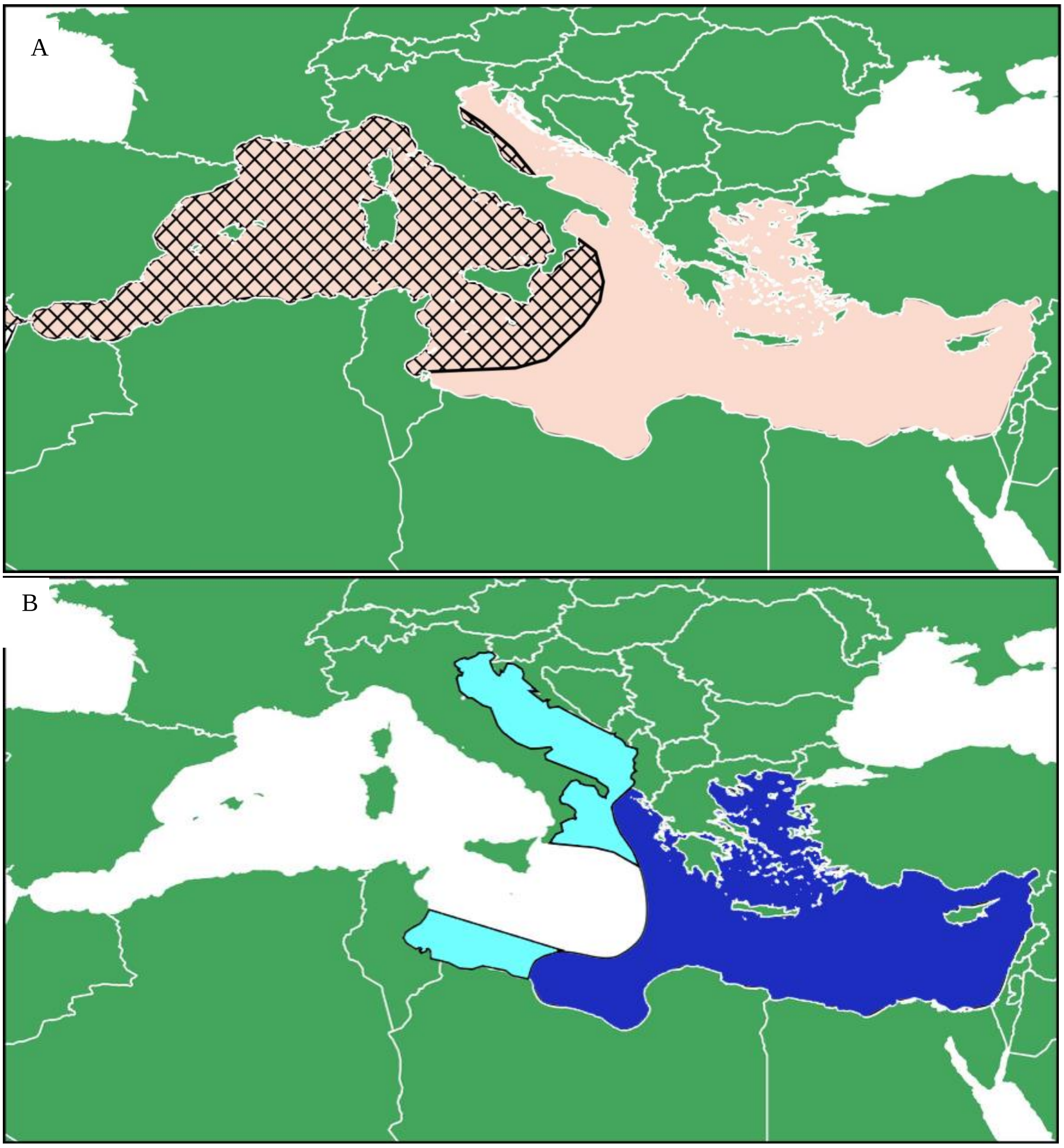

Figure 1.3. Marine turtle RMU limits in the Mediterranean. (A) Loggerhead distribution in the Mediterranean. Beige = Mediterranean RMU, crosshatch = Atlantic RMU. From RMU distribution presented in Wallace et al. (2010). (B) Green turtle distribution in the Mediterranean. Dark blue = established RMU distribution (Wallace et al. 2010). Pale blue (lower polygon) = extension of the distribution confirmed by sat tracking (Stokes et al. 2015) and a single nesting event in Tunisia. Pale blue (upper polygon) = recent records of green turtle captures (Piroli et al. 2020, Bentivegna et al. 2011, Lazar et al. 2004)

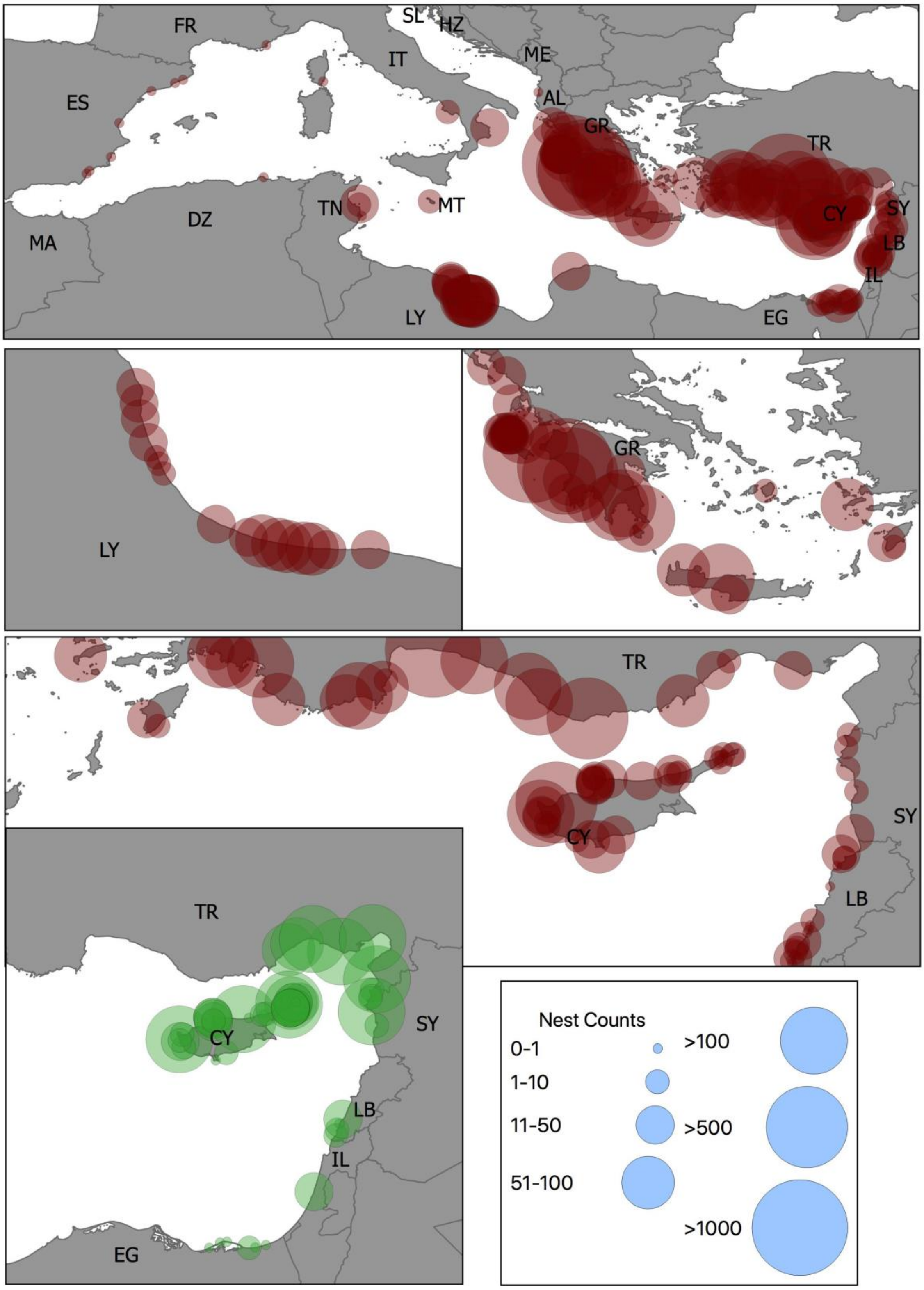

Figure 1.4. Overview of marine turtle nesting across the Mediterranean region. Note that nesting site information from Italy, Israel and Egypt are only available at sub-national levels and are summed and *presented at generalised locations*. Additionally, not all nesting beaches in Libya are represented due to lack of precise beach coordinates. Red circles – Loggerhead nesting sites. Green circles – Green turtle nesting sites. (Reproduced from SPA/RAC-UNEP/MAP 2020)

II. Scales of monitoring

11. Sea turtles occupy three main marine zones and one terrestrial zone during their life cycle. The breeding adults of both sexes congregate **nearshore at *breeding areas*** at predictable periods of time before migrating away to their 'foraging grounds'[7]. Clutches of eggs incubate on **sandy beach *breeding areas*** which are selected by the adult females. The hatchling and early-years turtles move to **deeper epipelagic *offshore habitats*** (>5km[8] from shore) for a number of years before they leave this developmental habitat and, frequently, undergo an ontogenetic shift to **neritic and often *nearshore habitats*** (<5km from shore).
There is a strong need for representation in monitoring data from across the region and from a suitable number of representative sites per habitat type per Contracting Party. Each requirement is elaborated in turn below.

Breeding areas
12. Assessment of nesting levels and distribution around the Mediterranean has progressed well in recent years, at a time when the range of loggerhead nesting areas is expanding. Accordingly, most Contracting Parties can be assigned to one of four categories relating to nesting activity that is independent for both endemic sea turtle species. Nesting prevalence ranges from established and high level to no or only sporadic nesting. The four categories of prevalence are presented in Table 2.1 together with the associated Contracting Parties.

Table 2.1. Classification of nesting status of countries per sea turtle species in 2020

Loggerhead turtles (*Caretta caretta*)	Green turtles (*Chelonia mydas*)
Category 1 - Established: common / dense	
Greece, Turkey, Cyprus, Israel, Libya,	Turkey, Cyprus, Syria
Category 2 - Established: limited / sparse	
Italy, Syria, Lebanon, Egypt, Tunisia	Lebanon, Israel, Egypt
Category 3 - New: emerging / low level	
Spain	NA
Category 4 - Absent: No / sporadic* nesting	
France*, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania*, Malta*, Algeria*, Morocco	Spain, France, Italy, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania, Greece*, Libya, Malta, Tunisia*, Algeria, Morocco

Spatial Scope
13. Countries in which nesting is now well established and plentiful (Category 1 countries) are subject to annual minimum monitoring to record 75% of the nation's nesting per species, or top 7 nesting areas, whichever is achieved first. In the case of extensive single nesting beaches, core areas of approximately 10km may be defined and used as index of nesting at that key site. Countries with established but low-level nesting (Category 2 countries) should identify a minimum of up to 4 index sites recording or recording 50% of the nation's nests (per species), whichever comes first, to monitor annually. Countries with new and emerging nesting (Category 3) should continue dedicated coast monitoring and citizen science monitoring projects to record any nesting across the country. Countries with no sites where regular nesting occurs should incorporate any observations, or lack thereof, from other coastal based actions (e.g., summer beach stranding monitoring), including citizen science reports, as negative results for nesting.

[7] The term 'foraging grounds' is used to cover the location(s) inhabited by sea turtles away from their nesting areas, which is where they reside for the majority of the time.
[8] 5km range distance is indicated as this is the range that can be monitored by drone from the shore and hence separates the marine habitat into two areas of differing simplicity of access for assessment. The offshore zone may still contain demersal/benthic turtle habitats as well as epipelagic ones.

14. All countries should undertake periodic broadscale coastal assessments for nesting to facilitate adaptive monitoring practices that meet the conservation needs of the species at country level. If new nesting areas arise that warrant monitoring, as they contain nationally important nesting levels, the new location should be added to monitoring effort undertaken at all the original index beaches, as long-term datasets provide a better understanding of variation and trends in turtle nesting habits.

Temporal Scope

15. Loggerhead turtles migrate to their breeding areas a month or more prior to the onset of nesting. Male loggerheads depart the nesting areas early in the nesting season when females are no longer receptive (Schofield et al. 2017, 2020), and it is assumed to be the same for green turtles. Female turtles depart the breeding areas after depositing their quota of eggs - normally in one to five clutches. The nesting season in the Mediterranean generally lasts from late May to early August with peak nesting occurring in June and July. Consequently, monitoring in breeding habitats should take place during April/May for at-sea turtle surveys and from late May to August for nest count surveys. Nest monitoring should continue until the end of September to record the fate of the majority of incubating nests and assess annual hatchling production. The broadscale coastal assessments for nesting should be carried out or reviewed every six years to facilitate adaptive monitoring practices that meet the conservation needs of the species at country level.

Data analysis and outputs

16. Monitoring at the index nesting beaches should ideally be undertaken such that nest counts are accurate to within 10% of the actual number of nests and no worse than 20% modelled accuracy. See SWOT (2011) for monitoring methods that can achieve the required level of accuracy of nest monitoring. At sea surveys should be repeated three times over a period of a week in the pre-nesting period to be able to generate confidence limits to numbers of turtles that are present. Ideally the at-sea surveys should produce data in which male and female turtles can be distinguished. See Schofield et al. (2017) for example methodology. Data should be compiled into annual GIS map summaries that facilitate determination of trends in distribution and abundance of nests, for CI 3 and CI 4 respectively, and sex ratios of adults for CI 5.

Nearshore demersal/benthic foraging habitats

17. Data on nearshore habitats used by sea turtles, away from their seasonal use before and during the breeding season, is patchy and based mainly on data from stranding records with very few coastal hotspots recognised in the literature. Examples of known nearshore turtle hotspots are Amvrakikos Gulf, Greece (Rees et al. 2013, 2017), Drini Bay, Albania (White et al. 2013, Piroli et al. 2020), Fethiye Bay (Turkozan & Durmus 2000; Baskale et al. 2018), Iskenderun Bay (Oruç 2001; Turkozan et al. 2013) and Lake Bardawil, Egypt (Rabia & Attum 2020) in which many turtles are located in waters less than 3m deep and some form of capture-mark-recapture study have taken place.

Spatial Scope

18. Given turtles are present in waters of all countries bordering the Mediterranean, each country should establish, as a minimum, a national stranding network to report and record the majority of turtles that strand along the vast majority of the country's shoreline, as indicate in the updated Mediterranean Action Plan for marine turtles conservation (UNEP/MED IG.24/22 2019). It should be noted that debilitated and dead turtles may drift considerable distances before they strand, and interpretation of their origins needs to be accepted with caution (Santos et al. 2018). This network need not conduct systematic surveys in people-frequented areas, but seasonal surveys remote areas would improve coverage at a national level. Additionally, effort-adjusted turtle bycatch rates should be reported per fishery as well as its fishing effort at several key areas around the country to help quantify presence of turtles at sea and also evaluate the threat that these fisheries present. The General Fisheries Commission for the Mediterranean (GFCM) are encouraging the documenting

of marine turtle and other bycatch in regional fisheries (FAO 2020) and successful implementation of this initiative will contribute greatly to our understanding of the threats that sea turtles are facing.

19. Various datasets such as stranding records, fisheries records, results from local stakeholder questionnaires and tracking data should be used to identify nearshore marine hotspots around the country, with each Contracting Party determining its own criteria to identify hotspots. Up to 4 of these nearshore hotspots (per species) per country should be included in an in-water monitoring program and, if logistically feasible, at least one of these hotspots should also be the location of a capture-mark-recapture study to acquire data relevant to CI 5.

20. All countries are to undertake more broadscale review of turtle presence in neritic waters every six years to facilitate adaptive monitoring practices that meet the conservation needs of the species at country level. If new, important, foraging areas arise, or are discovered, that warrant monitoring, the new location should be added to monitoring effort undertaken at all the original hotspots, as long-term datasets provide a better understanding of variation and trends in turtle numbers.

Temporal Scope

21. Stranding networks and fishery bycatch record taking should operate year-round whilst the in-water hotspot monitoring programme surveys should be carried out in winter and summer with a set of repeated surveys in each season to provide confidence intervals on the number of turtles that are present.

Data analysis and outputs

22. Year-round, national data should be normalised for observer effort, and summarised by month or quarterly to identify seasonal trends and annually to generate year-on-year comparative data. Data should be mapped to the specified grid system in GIS software to standardize presentation in space and over time. The bi-annual hotspot monitoring data should be internally assessed separately to identify trends and combined into an annual summary that is mapped as for year-round data.

Offshore habitats

23. Offshore habitats are the most spatially extensive and logistically challenging to monitor zone in which turtles reside, and the difficulty to monitor turtles there is further exacerbated through the generally lower densities of turtles that are present. However, these habitats are where the majority of turtles reside given a population structure that includes multi-decadal lifespans and a far greater number of juveniles than adults. Given the widespread distribution of loggerhead turtles that entirely overlaps that of green turtles in the Mediterranean, all Contracting Parties should adopt measures to monitor the presence of sea turtles in oceanic habitats.

Spatial Scope

24. One way of monitoring offshore turtle presence *and* quantify threat levels to turtles is to employ national fisheries bycatch reporting mechanisms (see FAO 2020 and FAO, 2019) that incorporate a *sufficient proportion of vessels per area and per fishing gear*. However robust scientific data should be recorded from aerial and boat surveys. To extend coverage and establish regular distance surveys, these dedicated aerial and boat surveys can be supplemented with sightings utilising ferries or tourist boats as survey vessels (e.g., Zampollo et al. 2018, Casale et al. 2020). Effort should be made to identify turtles by species where possible, however outside of breeding migrations it can be assumed that any turtle over 40cm in length observed in offshore habitats will be a loggerhead as almost all green turtles have switched to benthic nearshore foraging habitats by that size class.

Temporal Scope

25. At a minimum periodic basis, such as every six years to match the IMAP cycle, collaborative subregional aerial surveys (e.g., ACCOBAMS Survey Initiative[9]) can be organised to assess turtle and other marine megafauna presence at sea, thus supplying broadscale quantitative data that can contribute to CI 3 and especially CI 4. Until there are repeated validated data from aerial surveys to form a strong baseline these aerial surveys should be carried out more frequently than every six years. Bycatch records and transect survey data should be collected year-round to establish seasonality in turtle presence and abundance etc.

Data analysis and outputs

26. As for nearshore data, year-round, national data should be summarised by month or quarterly to identify seasonal trends and annually to generate year-on-year comparative data. Data should be mapped to the specified grid system in GIS software to standardize presentation in space and over time. This mapping of gridded data also applies to any periodic, national and sub-regional aerial surveys that are performed.

Know Gaps and Uncertainties

27. Gaps and uncertainties for successful assessment of GES occur in both data types held and acquired and in the process for determining GES itself. These were previously listed in UNEP(DEPI)/MED WG.444/6/Rev.1. Here below the list was revised, selecting, with minor revision, those items determined to be the most important for having sufficient data to use in GES assessments, with reference to a recent Gap analysis on the conservation of marine turtles in the Mediterranean (SPA/RAC-UNEP/MAP 2020). Those items that referred to the process of determining GES have been removed as they are being resolved with the acceptance, after review, of proposals presented in this document.

Population distribution data gaps

- Location of all important wintering/feeding and developmental sites of juvenile and adult turtles
- Connectivity among the various sites in the Mediterranean
- Identify possible baselines and index sites
- Generate or update databases and maps of known nesting, feeding, wintering habitats in each Contracting Party.

Population demographic data gaps

- Number of males and females frequenting all breeding/nesting sites each year (operational sex ratio), and the total number of individuals in the breeding populations
- Number of adults and juveniles frequenting wintering/feeding and developmental sites, along with how numbers vary across the season as individuals enter and leave different sites
- *Knowledge on recruitment levels at representative index breeding areas from each relevant contracting party*
- Knowledge on the sex ratios within different components (breeding, *recruiting*, *maturing*, wintering/feeding), overall and across populations.

Pressure data

- Analysis of pressure/impact relationships for these sites, *with special attention to fishing pressure and mortality rates*
- Criteria for a risk-based approach to monitoring and develop harmonized sampling instructions where appropriate.

Data acquisition

- Identify monitoring capacities and gaps in each Contracting Party
- Develop monitoring synergies in collaboration with GFCM for- EO3 (Harvest of commercially exploited fish and shellfish), to collect data on sea turtle by-catch

[9] https://accobams.org/main-activites/accobams-survey-initiative-2/asi-preliminary-results/

• Investigate monitoring synergies with other relevant EOs that will include coast-based fieldwork, in relation to monitoring of new/unknown sea turtle nesting beaches, and of beached/stranded animals, to obtain more widespread information.

III. Scales of Assessment

28. Each country should look at its own data to determine national GES assessments. The **Contracting Party assessment** would take into account data on the CI 3, CI 4 and CI 5 that are obtained through monitoring at selected index nesting and nearshore foraging areas and through national offshore monitoring. In this level of assessment, data will inform the respective country if and where additional conservation measures are required to move towards GES if it is not met, or flag locations where indicators are suggesting worsening situations, whilst GES based on threshold values is still achieved.

29. Each Contracting Party assessment should feed into a **subdivisional scale assessment** in terms of reproductive distribution for two reasons. 1) genetic analyses have indicated several sub-RMU population clades exist for both loggerheads and green turtles (Figure 3.1); and 2) loggerhead turtles are undergoing a range expansion throughout the Mediterranean, probably driven by climate change, which renders a universal threshold value obsolete. Possible emergent regular nesting sites need to be treated differently to long-established major and minor nesting sites (see Section 2). For turtles in their other habitats (nearshore and offshore foraging zones) Contracting Party assessments should feed into subregional assessments. Contracting party assignation to specific subdivisions and subregions is provided in Table 3.1 and Figure 3.2.

30. **Subregional assessment** level is the most suitable scale for turtles in marine habitats for a number of demographically defensible reasons. The western Mediterranean which is the only sub-region to have large numbers of Atlantic loggerheads residing and to a *very* small degree breeding there, with only low-level emergent nesting taking place. The Adriatic Sea has little to no nesting taking place, but a large number of turtles present at sea that are potentially facing high threats from intensive fishing that takes place in the sub-region. The remaining two areas (Central Mediterranean/Ionian and the Aegean/Levant) cover the main nesting sites for both endemic species of sea turtle and the vast majority of the spatial distribution of green turtles with only very low numbers of that species being found in the Adriatic Sea. The Central Mediterranean/Ionian region also hosts important demersal and epipelagic feeding grounds for loggerheads and the Levant contains important migratory corridors for both species.

31. Because of the borders established in the current subdivision / subregion structure, data from several countries, especially Italy, Greece, Turkey and Libya will need to contribute multiple transnational segments. It is possible therefore that a country may not be in GES at national level, but subdivision and subregion areas to which the Contracting Party can be in GES depending on the subnational part of the Contracting Party's assessment, i.e., non-achievement of GES by a Contracting Party does not automatically result in non-achievement of GES of all of the subdivisions and subregions in which that party is situated (Figure 3.3).
Due to the intensity of work required, it is likely that not all Contracting Parties will be able to determine values for all relevant components that combine to make up CI 5. In these cases, demographic values from proximate Contracting Parties, or from any regional Contracting Party where data are scarce, can be used in calculating related demographic values. For example, accurate clutch frequency data (CF; the average number of clutches of eggs laid by a turtle during a single nesting season) are hard to acquire as they necessitate intensive nocturnal fieldwork programs, smaller scale but expensive tracking projects or large scale, technically complex and expensive sampling and genetic studies. Thus, species-specific CF values can be adopted by Contracting Parties from one of the few locations that they have been established in the region (e.g., Broderick et al. 2002, Rees et al. 2020).

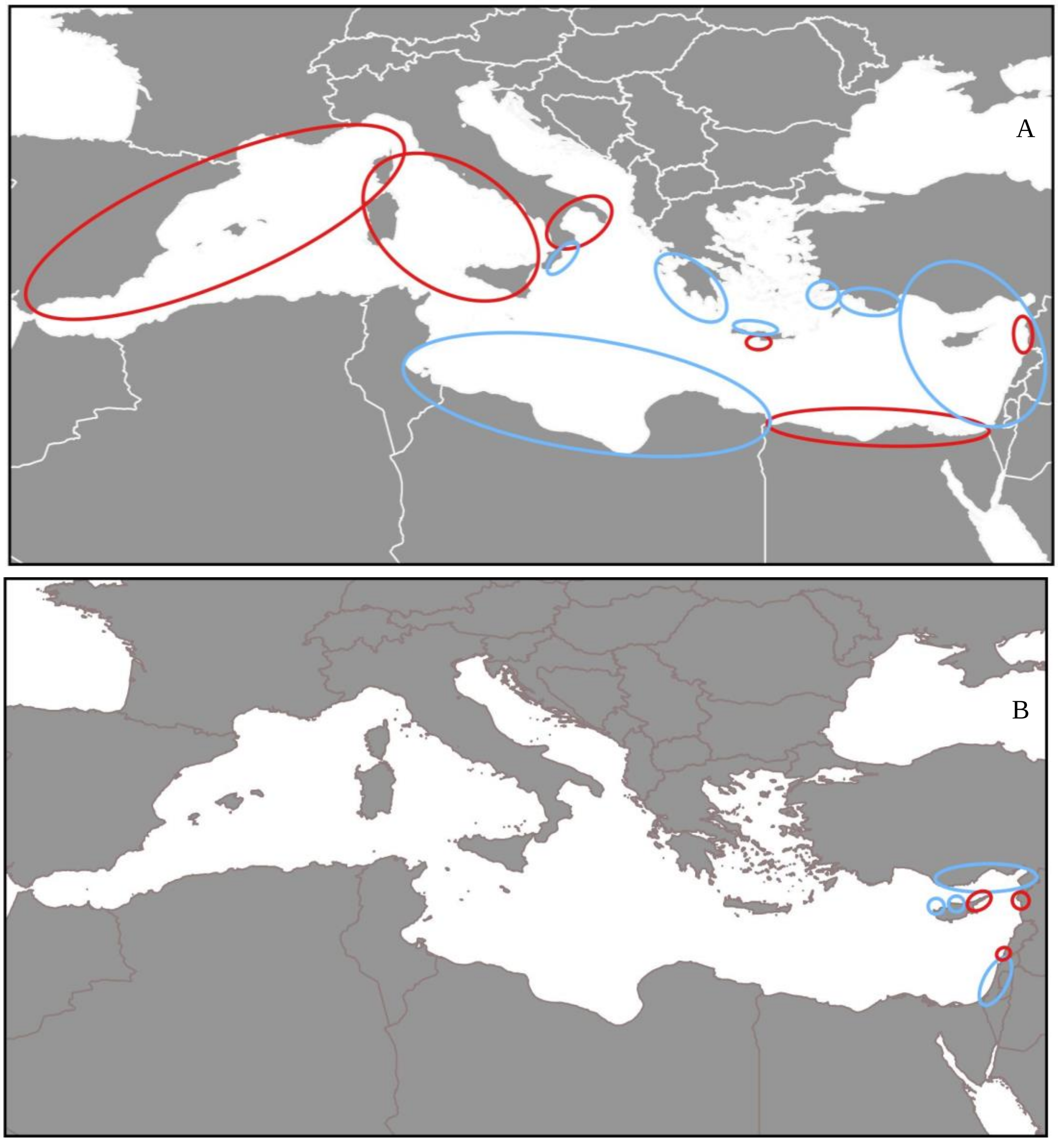

Figure 3.1. Genetic clusters for marine turtles breeding in the Mediterranean. (A) Loggerhead mtDNA genetic clusters (Based on Shamblin et al. 2014) (B) Green turtle mtDNA STR genetic clusters (Based on Tikochinski et al. 2018). Cluster colour codes: blue = defined, red = not processed / unsampled

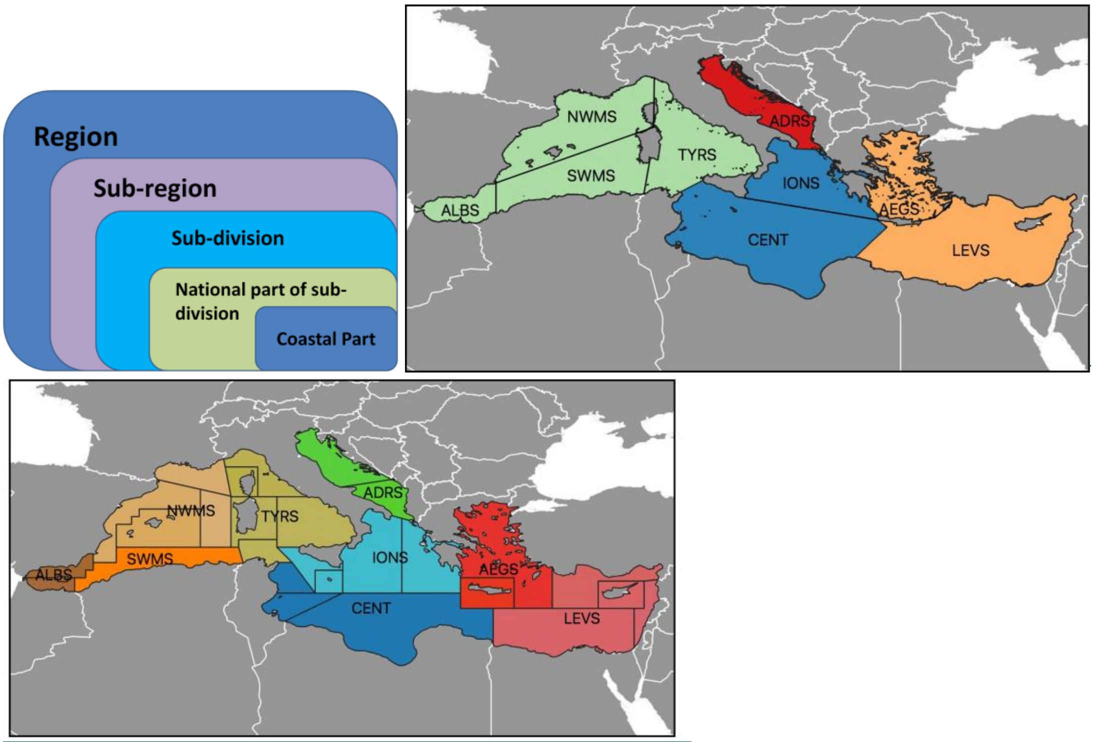

Figure 3.2. The established approximate four Sub-regions (coloured ~~areas~~ clades on map) and *draft suggested*, nested, nine Sub-division segments of the Mediterranean Sea, based on GFCM boundaries, for marine and nesting area assessment scales respectively. *(See also Table 3.1*)

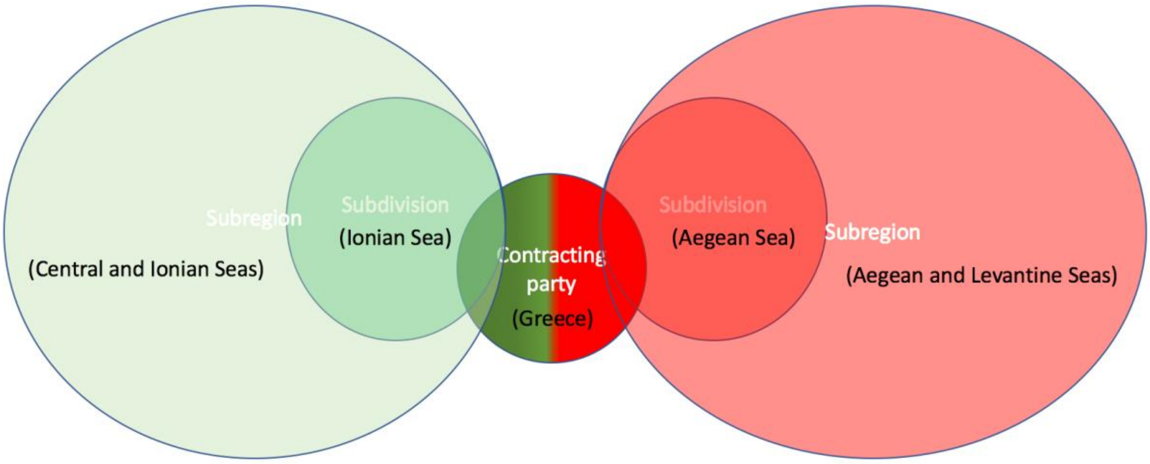

Figure 3.3. A Contracting Party that only partly achieves GES for any specific CI has a non-achieving status but may contribute both positively (GES achieved; green) and negatively (GES not achieved; red) to *draft subdivision* and subregion status based on the relevant prevailing condition at the sub-national level, with the example given of Greece.

Table 3.1. Suggested placement of Contracting Parties into four Subregional & 9 *draft* Subdivisional segmentation of the Mediterranean Sea for marine and nesting area assessment scales respectively. CPs in parenthesis contribute only a small portion of their coast towards the relevant *draft* sub-division. *(See also Figure 3.2*)

Sub-Region	Sub-Division	Contracting Party
	North Western (NWMS)	Spain, France~~, Italy~~

Western Mediterranean Sea	Alboran Sea (ALBS)	Spain, ~~(Algeria,)~~ Morocco
	Tyrrhenian Sea (TYRS)	Italy, Tunisia (France)
	South Western (SWMS)	~~(Spain),~~ Algeria~~, (Italy)~~
Adriatic Sea	Adriatic Sea (ADRS)	Italy, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania
Central and Ionian Seas	Central (CENT)	~~Italy,~~ Libya, ~~Malta,~~ Tunisia (Italy)
	Ionian Sea (IONS)	Italy, Greece, Malta
Aegean and Levantine Seas	Aegean Sea (AEGS)	Greece, Turkey
	Levantine (LEVS)	Turkey, Cyprus, Syria, Lebanon, Israel, Egypt~~, (Libya)~~

IV. Assessment Criteria

CI 3 Distribution

32. The distribution criterion is a Boolean characteristic assessed over a predefined spatial grid of occurrence. Turtles are either recorded as present or absent, for nesting on sandy beaches or foraging at in-water locations with a predefined 10km square grid. For the well-defined somewhat one-dimensional nesting beach turtle focal areas their predictable presence at certain times of the year makes the distribution assessment relatively straightforward compared to the expansive two-dimensional marine realm. Nevertheless, with temporally and spatially sufficient monitoring taking place, as defined above, assessment towards GES can be made across the Mediterranean region in all habitats. Table 4.1 lists the various factors that need to be considered to understand sea turtle distribution together with the broad-strokes methods used and what data is to be collected.

Table 4.1. Topics and data gathering requirements for CI 3: turtle distribution per species.

Terrestrial habitat (nesting beach)		
Necessary information	**Methods**	**Data collected**
Actual nesting activity distribution	Foot patrols UAV surveys Plane surveys (Genetics)	Extent of each nesting site. Nesting activity locations. (Haplotyping adults)
Potential nest site distribution (minor / emerging nesting beaches)	Foot patrols UAV surveys Plane surveys	Extent of each potential nesting site. Confirmation of nesting/no nesting every 6 years.
Marine habitat		
Necessary information	**Methods**	**Data collected**
Offshore foraging areas	Plane surveys Telemetry Bycatch Boat surveys UAV surveys (boat based) (Genetics)	Location of turtles Seasonality of presence (Mixed stock analysis)
Nearshore foraging areas	Boat surveys UAV surveys Plane surveys Telemetry Bycatch Strandings (Genetics)	Location of turtles Seasonality of presence (Mixed stock analysis)
Migratory pathways	Telemetry Bycatch	Location of turtles Seasonality of presence
Internesting areas	Telemetry UAV surveys Boat surveys	Location of turtles

Breeding area

33. Each stretch of coast should be classified as nesting beach or not, in 10km blocks following a presence/absence criterion based on both historic and most recent data on the knowledge of nesting locations. From the annual nest count surveys that cover a high proportion of a country's nesting, based on country category defined in Table 2.1, the spatial distribution of nesting can be determined per year. Every six years, this national situation should be revisited and at least a sample of previously known nesting areas and other potential nesting areas need to be re-assessed. GES should be declared when all monitored index sites are fully maintained as nesting sites and there is little or no degradation of other known sites, that may be monitored to a lesser degree and are not included as index sites.

Nearshore / Offshore habitats

34. Validation of the distribution of turtles in both nearshore and offshore habitats should come from changes in results from monitoring methods described in Section 2. The ubiquitous presence of loggerhead turtles across the entire Mediterranean Sea and current and anticipated patchiness of distribution data mean that their potential presence should be assumed unless persistent absence can be confirmed (e.g., through persistent lack of turtle bycatch records in a fishery and area which previously reported them, or where a monitored nearshore hotspot no longer has turtles). The predefined 10km grid squares should be used for monitored hotspot areas. Other locations should present amalgamated and interpolated distribution data that show a combination of assumed and confirmed at-sea presence. Similar assertions should be made for green turtles within their more restricted eastern Mediterranean range. Given the stipulated existence of monitoring at several key nearshore foraging sites and sufficient reporting of bycatch data per Contracting Party, GES can be argued from persistence of turtles recorded in all areas. Periodic subregional aerial or other survey data can be used to support these assumptions for both turtle species.

CI 4 Abundance

35. The measure of abundance per species of turtle per grid cell covers a scale that includes zeros but is quantified as some measure of density, such as numbers of nests or turtles per 10 km cell. The difficulty in acquiring robust monitoring data from marine habitats highlights the necessary investment of effort and resources required by Contracting Parties in order to properly assess this CI for turtles, and the benefit from maximising data acquisition for multiple taxa from single surveying efforts. Table 4.2 lists the various factors that need to be considered to understand sea turtle abundance together with the broad-strokes methods used and what data these methods collect.

Table 4.2. Topics and data gathering requirements for CI 4: turtle abundance.

Nesting beach		
Necessary information	**Methods**	**Data collected**
Actual nest site locations	Foot patrols UAV surveys Plane surveys	Number of nests/tracks per season per index beach.
Potential nest site locations (minor / emerging nesting beaches)	Foot patrols UAV surveys Plane surveys	Quantification of nesting / no nesting every 6 years.

Marine habitat		
Necessary information	**Methods**	**Data collected**
Offshore foraging areas	Plane surveys Boat surveys UAV surveys Telemetry (Genetics)	Number of turtles (seasonal considerations) Location of turtles (seasonal considerations) (Mixed stock analysis)
Nearshore foraging areas	Boat surveys UAV surveys Telemetry Stranding Plane surveys (Genetics)	Number of turtles (seasonal considerations) Location of turtles (seasonal considerations) (Mixed stock analysis)
Migratory pathways	Telemetry (Genetics)	Number of turtles (seasonal considerations) (Mixed stock analysis)
Internesting areas	Telemetry UAV surveys	Number of turtles (seasonal considerations) Density of turtles

Breeding area

36. As suggested above, abundance of turtles present at a breeding site, in its most basic form, can be inferred from the numbers of nests deposited on the monitored index nesting beaches and subsequently divided by the number of 10 km cells to provide a density value, when required. However, nest numbers do not provide an irrefutable direct indication of the number of adults breeding annually in a population. This is because adult female turtles deposit between one and five clutches in a given breeding season, and successive breeding seasons may be two or more years apart for the nesting turtles. Additionally, given the temperature-determined sex differentiation in sea turtles, sex ratios of populations may significantly differ from 1:1 and furthermore, male turtles are reported to return to breed more frequently than females, often annually. Given these facts, deriving adult population size (abundance) from a nest count from a single year is likely to produce widely erroneous results. Nevertheless, the use of nest count trend data is generally accepted as the most practical way of determining population abundance, e.g., it is this metric used in the IUCN MTSG to determine red list status of regional and global assessments. The underlying demographic factors (assessed in CI 5) need to be incorporated in any determination of adult turtle abundance associated with monitored nest numbers. Additionally, to avoid misinterpretation caused by interannual variation, a time series of at least six years of nest count data should be used.

Nearshore

37. Nearshore abundance data should be collected from the monitored index coastal hotspots (see Section 2) which will give a six-monthly assessment. The two seasonal surveys can be combined to give an annual assessment on abundance per location and the various coastal hotspots combined to give a national value (for monitored index hotspots). Bycatch and stranding records should be analysed annually to identify any locations with increasing rate occurrence (bycatch values adjusted for fishing effort) which may mean increasing populations, or for areas where regular turtle reports are reducing or no longer occurring which may indicate local reduction in population size. However, the main robust and defensible data to contribute to the abundance assessment should come from standardised repeated surveys in the hotspots. The nearshore zone is also utilised by both species of turtle as migratory thoroughfares at regular times of the year (pre- and post- breeding season) and this may affect abundance estimates determined during certain time periods, so monitoring and analysis need to account for this seasonality.

Offshore

38. This region is the one that is hardest or most expensive to survey and produce spatially explicit abundance values. That said, as indicated in Section 2, there are several ways to monitor the presence of- and derive abundance values for- sea turtles in the open seas. Abundance values from dedicated annual or periodic regional or subregional aerial surveys should be used for definitive assessments and to validate opportunistic survey results and can be used to cover gaps in data collection from contracting parties unable to generate their own national abundance data. Sighting data from ferry routes, or touristic boats can additionally contribute to the abundance estimates, if collected systematically over a long period (Zampollo et al. 2018, Casale et al. 2020). These data can be more accurately spatially grouped to provide quantitative turtle abundance estimates along the ferry route. Variability in these data can be investigated to determine what level of sightings are required to identify real increases and decreases in population abundance. The offshore zone is also utilised by both species of turtle as migratory thoroughfares at regular and predictable times of the year (pre- and post-breeding season) and this may affect abundance estimates determined during certain time periods, so monitoring and analysis need to account for this seasonality.

CI 5 Demography

39. Understanding the demography of sea turtle metapopulations helps to identify which pressures may most impact on population stability and which conservation measures are likely to have greatest effect in stabilising or recovering population levels. The basic principle being that the number of turtles recruiting to the population each year needs to be sufficient to sustain the level of reproductive adults in the population given the differing mortality rates affecting the population at each ontogenetic stage / age class. To adequately assess this basic principle requires data on numerous aspects of the sea turtles' life cycle including fecundity rates and their interplay with threats to the turtles' environment and the turtles themselves, for example through fisheries bycatch. Table 4.3 lists the various factors that need to be considered to understand sea turtle demography together with the broad-strokes methods used and what data these methods collect. Data on certain aspects of demography may take decades to acquire and not all Contracting Parties have the capacity to determine them unilaterally. This especially applies for topics such as age at sexual maturity, and longevity etc. In these cases, a Contracting Party can adopt values produced by other Contracting Parties or regional collaborations as proxies for their own populations. However, each nation is strongly encouraged to gather data relating to reproductive output and population recruitment through targeted monitoring of index nesting beaches.

Breeding area

40. The focus on data gathering at nesting sites is on individual and population level reproductive output, population recruitment, sex ratios of hatchlings and adults and adult longevity. Output, recruitment and hatchling sex ratios are relatively simple to determine and should be undertaken at the monitored index beaches that have been selected by each Contracting Party. The other data topics require intensive monitoring regimes to be carried over the well-defined summer breeding season and should carried out where possible.

Nearshore neritic

41. This zone is generally occupied by larger juvenile (>45cm CCL) through to adult loggerhead sea turtles and by small juvenile (>30cm CCL) through to adult green turtles – though green turtles may shift through a series of size-class specific habitats/locations. Data required from this habitat focus on size class distribution, growth rates, sex ratios, survivorship (which can include bycatch and mortality rates) and age at maturity. Several of these topics require intensive and specialised, invasive, research methods, such as determining age at maturity and sex ratio of juvenile turtles, and data from other Contracting Parties or collaborative efforts can be used for these topics, but each Contracting Party should acquire its own data where feasible in terms of expertise and resources.

Offshore oceanic

42. This zone is most commonly inhabited by hatchlings and early-years juvenile turtles, <30cm for both species, though loggerheads of larger size classes – including a large proportion of adults – may remain in the oceanic zone year-round. Data acquisition here broadly follows that for neritic stage turtles, such as size class distribution, growth rates, survivorship (which can include bycatch and mortality rates) and sex ratios with little or no opportunity for direct data on age and size at sexual maturity. Again, if necessary, collaborative data or data from other Contracting Parties can be used where an individual Contracting Party is unable to acquire its own data.

Table 4.3. Topics and data gathering requirements for CI 5: turtle demography. **factors that can be *improved* by direct conservation measures. *factors that can be *improved* by indirect conservation measures.

Breeding areas			
Necessary information	**Methods**	**Data collected**	**Refs.**
Clutch size	Nest excavation	Number of eggs per clutch	1, 12, 14
Incubation duration (ID)	Regular Foot patrols Temperature loggers	Laying/hatching dates Incubation temperature profile	12
**Hatchling emergence hatching success	Nest excavation	Percentage of eggs that produced a hatchling that escaped the nest (considering predation and inundation etc.)	1, 14
Internesting Interval	Telemetry Night patrols (Genetics)	Nesting events identified from movements Nesting events identified by observation of turtle (Nesting events confirmed by individual-specific DNA analysis)	9, 14
Remigration Interval	Telemetry Night patrols (Genetics)	Presence in nesting area confirmed through observation of individual or from tracking	13, 14
Clutch frequency	Telemetry Night patrols (Genetics)	Number of clutches per individual identified from movements Number of clutches per individual identified by observation of turtle (Number of clutches per individual confirmed by individual-specific DNA analysis)	2, 3, 14
**Sex ratio Hatchlings	Regular Foot patrols Temperature loggers (Biochemical analysis -hatchlings)	Derived from laying and hatching dates (ID) Derived from nest/beach temperatures (Assessed from blood sampling / hormone assay)	10, 14
(operational) Sex ratio adults	UAV survey Plane survey Boat survey (Genetics - hatchlings)	Proportion of sexes observed during the pre-nesting season gathering at sea near the nest site (Determined by identification of males from genetic characteristics and inferred from multi-paternity in clutches)	15, 16
Longevity	Foot patrols Capture-Mark-Recapture (CMR)	Reproductive longevity and output of females and repeat presence of males	17, 18

Marine habitat			
Necessary information	**Methods**	**Data collected**	**Refs.**
Oceanic foraging area: size classes / Sex ratio	Boat surveys UAV / Plane surveys Bycatch	Abundance and distribution data separated by size and sex (where sexing individuals is only possible for sub-adult and adult size classes from external morphology)	11, 14
Neritic foraging area: size classes / Sex ratio	Boat surveys UAV / Plane surveys Bycatch / Strandings	Abundance and distribution data separated by size and sex (where sexing individuals is only possible for sub-adult and adult size classes from external morphology)	4, 7, 11, 14
**Oceanic foraging area: threats and survivorship	Bycatch Telemetry CMR	Incidence of bycatch and resulting mortality rates Mortality rate of identifiable individuals	8, 14, 24
**Neritic foraging area: threats and survivorship	Bycatch / strandings CMR Telemetry	Incidence of bycatch and resulting mortality rates Mortality rate of identifiable individuals	8, 14, 24
*Oceanic foraging area: health index	Bycatch CMR	Size/weight Pollutants	20, 25
*Neritic foraging area: health index	CMR Bycatch / strandings	Size/weight Pollutants	19, 20, 21, 22, 23,
Growth rates	Bycatch Strandings CMR	Size at capture	6, 14
Age and size at sexual maturity	Bycatch/ Strandings , CMR	Age (skeletochronology) Maturity (necropsy/ laparoscopy) When mature (from CMR).	5, 8, 12, 14

V. Baseline and Threshold Values for IMAP/EcAp CIs

CI 3 Distribution

Breeding area

43. The most appropriate measure to establish distribution of nesting areas is through accepting a baseline reference year. Baseline spatial distribution to be used should be that recorded in 1992 with the year chosen to align with historic threshold data adopted at the onset of the EU Habitats directive, with this applying to all riparian countries of the Mediterranean, not only those in the EU. Where data are not available for this period the oldest records dated after 1990 can be used. All long-term studies have shown that nesting areas that were present in 1992 are still valid nesting areas today. Using the data from annual monitoring at index nesting sites covering the majority of nesting in each Contracting Party, reduction of the number of 10km blocks with nesting can be identified. This is to be supplemented every six-year cycle with more widespread national reassessments of nesting distribution for a more complete national and regional view.

44. Loggerhead turtles are currently undergoing a relatively rapid expansion of breeding site distribution with new regular nesting sites occurring in Italy and increased number of sporadic nesting in Spain, Albania and Malta. Many of these sites are already heavily developed and are not ideal nesting grounds for turtles, leading to successful establishment of breeding populations likely to be entirely conservation dependent. National programs currently underway to monitor nesting in these countries should be maintained. Green turtles are not yet demonstrated to be undergoing a range expansion in terms of nesting sites, with only three anomalous nesting events recorded as taking place since 2007, namely two nests at widely different locations on Crete, in Greece, and one nest in Tunisia. However, should range expansion been shown, baseline values can be treated in the same way as for loggerheads in emerging nesting sites.
National programs currently underway to monitor nesting in countries with emerging nesting populations should be maintained with the aim to confirm the establishment of these areas as regular nesting sites and implementation of necessary conservation measures.

45. GES can be accepted per Contracting Party for Category 1 and 2 countries (Table 2.1 and Breeding Areas; Fig 1.4), when annual monitoring confirms that nesting is taking place at all the selected index sites. Years without nesting at all established index sites are indicative that GES is not achieved and that reasons for the lack of nesting should be investigated and remedial action, to minimize threats, taken to facilitate return of nesting activity. For Category 3 countries, GES can be assumed if nesting is continuing at a national level for sporadic nesting, but GES is not achieved where no nesting is recorded over six years at a low-level but regular nesting site.

Nearshore

46. Because of the paucity of data and understood general low density of turtle presence in coastal waters, it can be assumed that turtles are still currently distributed in all their natural ranges across the Mediterranean Sea. For loggerheads, this means the entire coastal waters are accepted as part of their baseline distribution (Figure 1.3A). However, green turtle baseline distribution is restricted to the eastern Mediterranean, generally as depicted in the Mediterranean green turtle RMU in Wallace et al. (2010) article but with the south western extent of occurrence of the species reaching to the south of Tunisia as shown by satellite tracking adult turtles (Figure 1.3B).

47. GES status for this part of the Indicator can be lost if monitored nearshore hotspots are shown to no longer have turtles present at any time of the year or if bycatch and stranding (when a turtle washes ashore dead, injured or debilitated) data reveal no more turtles are being recorded in a certain region. The hotspot monitoring presence should be indicated in the relevant blocks of the regional 10km grid, but the stranding

and bycatch data should be applied at sub-national level as the amount of data collected and spatial accuracy of presence records are low.

Offshore

48. There is a greater paucity of data and lower density of turtles present in offshore neritic and oceanic habitats than in nearshore habitats, hence the accurate assessment of turtle distribution in terms of presence/absence is even more difficult to determine. Consequently, effort made to assess turtles in the offshore zone should focus on data collection towards CI 4 and CI 5 as presented in Sparks and DiMatteo (2020). The baseline distribution of loggerhead and green turtles should be accepted as depicted in Figure 1.3.

CI 4 Abundance

49. Determination of abundance baselines and thresholds is more involved than for CI 3 (distribution), with the main issues being: (a) how to set a baseline (e.g., based on a certain historic data or modelled values)?, (b) how to acquire sufficient suitable data that will be used in abundance assessments?, and based on the precautionary principle, (c) how much of a buffer of uncertainty should be assigned to ensure that increased conservation measures are put in place before populations collapse?

50. Setting these values and acquiring relevant requires differing methods and levels of effort and based on the turtle habitat under examination. Assessments based at the nesting areas are simplest as they are restricted spatially and temporally, nearshore habitats are next most accessible for monitoring and offshore oceanic habitats are the most difficult and expensive to assess though have been carried out with notable success of the ASI project of ACCOBAMS in 2018[10].

51. For both species of turtle breeding in the Mediterranean, prior to the potential of GES not being achieved, negative population trends should be used to raise concern and drive increased conservation actions, with a recommended trigger of a greater than estimated 10% decrease in population size over a six-year reporting period.

Breeding areas

52. Baseline values rather than thresholds are suggested to be used for loggerheads to aid determination of GES, with values derived from the average of five years of nest count data centred on 1992. The year is chosen to align with historic threshold data adopted with the establishment of the EU Habitats directive, and five years of data (1990-1994) to determine historical level are shown to be very similar to an average of all nesting data between 1984-1991 – the longest and hence most historic published time series of data from two of the most important loggerhead nesting areas in the Mediterranean (Margaritoulis and Rees 2001, Margaritoulis 2005). Adoption of this timeframe can be further validated with other long-term datasets for Mediterranean loggerhead nesting, if they exist. Where data are not available for this period the oldest records can be used and modelled against other contemporary datasets, as seasonal inter-seasonal variation in nest numbers shows rough correlation across the region, to establish baseline data for those sites extrapolated back to 1992, or a trend-based approach using rolling 6-year datasets and baseline value from start of monitoring dataset. Many loggerhead nesting sites across the eastern Mediterranean in the latter 2010s through to 2020 are showing increased numbers of nests (Pers. Obs.), which may suggest updating baseline values to more recent averages, however it is not known if these increases are part of a multidecadal cycle, as demonstrated for loggerheads in the NW Atlantic (Ceriani et al. 2019) which will include a forthcoming decline in nest numbers not resulting from any specific anthropogenic worsening of habitat conditions and/or effects of climate change and adaptations of turtles to such changes. Consequently, 1992 average or modelled baseline data for long-term datasets should currently be maintained (for at least one more six-year IMAP reporting

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[10] https://accobams.org/main-activites/accobams-survey-initiative-2/asi-preliminary-results/

cycle) until the increases in nest numbers is confirmed as a positive trend in population size. National programs currently underway to monitor nesting in countries with new and emerging nesting populations should be maintained and baseline values should be assumed as individual nests. Baselines in these areas should be revised upwards (using a trend-based approach) with every six-year cycle to ensure that spatially stable nest sites with increasing numbers of nest are represented in their best condition and a return to zero is not acceptable.

53. No such historic time-series nest count data exist for Mediterranean green turtles, with only one published dataset originating from late 1989 (Lara-Cyprus) and two from 1993 (Alagadi-Cyprus and Israel). Five- and ten-year rolling average values for these three locations indicate a general increase in nest numbers over time, indicating that adoption of the most historic five-years of data for a given nesting site is a suitable baseline value. It should be noted that these three sites have been subject to long-term nest management and protection measures and are therefore likely to be in better condition, with more positive nest trends, than other sites where conservation actions have not been, or have more recently been put in place. However, the lack of certainty over historic nesting levels at green turtle nesting sites suggests that adoption of the most historic 5 years' worth of data, with periodic trend-based increases, remains most valid.

54. No nesting areas are currently considered at carrying capacity, and hence have the potential to host increased numbers of nests over time. However, no nesting area is known to ever have been at theoretical carrying capacity so that threshold should not be taken into account for determining GES.

Nearshore neritic

55. Abundance estimates in nearshore habitats will mainly be generated through annual hotspot monitoring for both species. It is not anticipated that historic abundance values will be available or calculable, so data from the first monitoring year should be accepted as baseline. Monitoring through the year should be conducted so that the actual number of turtles present with an estimate of variance can be calculated. The sites can then be considered achieving GES if the annual estimate is above baseline minus 1 standard error and all sites need to be in this condition, so that GES at a large site cannot compensate for lack of GES at a lesser site. Lastly, periodic aerial surveys can be used to generate data at subregional scale timed to take place prior to the six-yearly assessment period. It is unlikely that the aerial surveys will cover the same locations as the nearshore hotspot monitoring so both datasets would need to be taken into account in the periodic assessment, together with stranding data if obtained in sufficient levels. Given that across the Mediterranean both species of sea turtle are tentatively regarded as displaying an upward trend in population size (based on increased nest numbers), current levels of turtle abundance in nearshore neritic waters are likely to represent a positive state for GES determination and future assessments that fluctuate above this baseline value should all be considered GES.

Offshore oceanic

56. Where historic records for offshore presence and abundances of sea turtles exist, these can be used as baselines. Such data is lacking and improbable to be accurately modelled for the majority of contracting parties and hence the first year's data collected should act as baseline. Due to the low densities and high motility of turtles in the oceanic realm abundance values should be determined at large subnational or national scales. Broad-scale abundance values derived from sightings data from non-dedicated observation platforms such as systematic observations from ferries/platforms can be used. Ideally this data should be robust enough to allow abundance values with estimates of variance to be calculated. Periodic sub-regional aerial surveys can provide a snapshot of abundance used to calibrate national findings. GES can be accepted unless measurable decreases in abundance below threshold (abundance baseline, minus one standard error) are detected at national level.

CI 5 Demographics

57. Demographic characteristics of populations need to be assessed for accurate modelling of population structure and anticipated resilience to anthropogenic and other stressors. For conservation purposes, these characteristics are better evaluated using threshold values rather than baselines. The values should be constant over time, irrespective of population size, and set at levels that are sufficiently conservative to ensure that positive outcomes result from summary assessments of complex data types.

58. Not all sought-after data are equal in terms of ease of attainment, both in terms of timescales and effort required for their determination. For example, estimations of *clutch size* and *hatchling emergence success* can be obtained from one week's fieldwork whereas determination of longevity or survival of breeding adults requires decades of intense nocturnal fieldwork over several months per year. Consequently, hard to acquire demographic values generated by monitoring and research efforts by one Contracting Party can be used by another Party until they have their own equivalent data. Indeed, in some cases, for example for small nesting populations, the effort required to determine certain values, such as *clutch frequency* and *remigration intervals*, far outweigh the utility of determining Contracting Party-specific data points and other subregional values can be adopted in the Party's national assessment.

59. Certain demographic metrics are useful for understanding population resilience but cannot be affected by conservation measures, e.g., *clutch size*, whereas other metrics can be used to understand population resilience and can be positively affected by conservation measures, e.g., *hatchling emergence success*. It is those metrics that can be manipulated that should be used as main criteria for determining GES relating to CI5.

60. A full list of metrics to understand sea turtle demography, which metrics can be improved through conservation measures and what data need collecting is presented in Table 4.3. Each metric is discussed in turn, below, with regard to established values and the need for Contracting Parties to determine local, up-to-date data values.

Metrics obtained from Breeding Areas

Clutch Size (CS)

61. This is a commonly collected metric obtained from post-hatch excavation of nests or from egg counts during relocation of clutches soon after egg-laying. CS is needed to be able to determine *Hatching Success* and *Hatchling Emergence Success* (see below) and is part of the data that contributes to understanding sea turtle fecundity. Typical CS for loggerheads ranges from 70 to 110 and for green turtles the range is 100 to 115 (Casale et al. 2018). It is not a measure that can be manipulated for conservation purposes, but it should be assessed by each individual Contracting Party.

Incubation Duration (ID)

62. Precise laying and hatching dates are required to calculate an accurate ID. IDs are negatively correlated with nest temperature and hence can be used to produce a rough estimate of the *Sex Ratio of Hatchlings* produced by the nest. This sex ratio feeds into demographic models that predict sex ratios at later life stages which in turn can affect population resilience. It is not a measure that should be directly manipulated, though if there is strong evidence that beach temperatures are frequently exceeding the thermal tolerance of embryos (see *Hatchling Emergence Success*) then management measures such as nest shading can be adopted to reduce the temperature to tolerable levels. ID should be assessed by each individual Contracting Party at each index nesting site.

Hatchling Emergence Success (HES)

63. This is a frequently collected metric and is a measure that combines both egg fertility and suitability of nest conditions that result in a certain percentage of eggs that will successfully develop to produce hatchlings that emerge from the nest. HES may be reduced if the nest is inundated by sea water, when sand infiltrates the air spaces between the eggs, if incubation temperatures lie outside the thermal tolerance range for embryo development, if the nests are plundered by predators or if nests are crushed or trampled by heavy machinery etc., or if the sand conditions are not conducive to successful incubation. Reported HES for loggerheads in the Mediterranean varies greatly and ranges from around 20 to 80% (Casale et al. 2018) and for green turtles it averages around 75% (Casale et al. 2018). The green turtle value (75%) can be accepted as a threshold level for this species in the region and 65% is a suitable target value for loggerhead turtles. This is a measure for which conservation actions can be carried out and as such it is a suitable candidate to have target thresholds assigned, however as HES is only determined at the end of a nest's incubation, conservation measures need to be put in place for the following seasons. For example, if many nests are inundated by storm waves, nest relocation measures can be adopted and if nests are being depredated then nest protection measures or predator management measures can be put in place. To balance out inter-nest variation, all nests should be treated as one single clutch. For example, if HES was averaged across the season per nest then a nest with 30 eggs of which 7 produced hatchlings that emerged (23%) and a nest of 140 eggs with 122 emerged hatchlings (87%) would give a HES of 55% (not meeting GES), whereas if all nests were treated as a single clutch 129 eggs from 170 eggs would be recorded as producing emerged hatchlings with a resulting HES of 76%, which reflects the actual beach-level HES, and GES is met. Obviously, the effect of HES from small clutches reduces as sample size increases, but it may skew results in small samples sizes and should be avoided through treating all nests as a single clutch. Additionally, to assess HES across the beach then stratified sampling of nests needs to be undertaken combining at least three different nest incubation conditions, namely, *in situ* / relocated nests, inundated / non-inundated nests and depredated / non-depredated nests. As not all eggs can be found for depredated nests, the CS for non-predated nests should be used for these nests to standardize their contribution to the final HES value. Exceeding threshold values for HES should be targeted per monitored nesting area per year. Absolute thresholds should be set at 10% lower than average trigger no GES, with a buffer extending from average to this -10% mark indicating additional conservation measures are indicated. This equates to non-achievement of GES threshold values of 55% for loggerheads and 65% for green turtles. HES should be assessed by each individual Contracting Party at each index nesting site.

Internesting Interval (II)

64. This is the elapsed time in days between clutch deposition and the next time the turtle emerges onto the beach to nest- whether successfully or not. Determining II requires intensive night work on a capture-mark-recapture project during the nesting season that needs to be carried out by trained personnel to avoid disturbance to the nesting turtles. II, used together with *Clutch Frequency* (see below) can indicate how long a turtle will be resident in the breeding area, post onset of nesting, however the daily trend in nest numbers is a better indicator of how many turtles may still be in the breeding area. Normal values are from 10 to 20 days (loggerheads; Margaritoulis et al. 2013, green turtles; Broderick et al. 2002). It negatively correlates with sea temperature (Hays et al. 2002) and is not a metric that can or needs to be affected by conservation measures. There is no requirement for a Contracting party to obtain data for II as part of a basic monitoring program.

Remigration Interval (RI)

65. The number of years between successive breeding seasons is known as the Remigration Interval. It ranges from one to five years or more but is commonly two or three years. RI is related to the conditions in foraging grounds experienced by the adult turtles that influence the rate at which the turtles can replenish body condition and build up enough reserves to see them through a breeding period season. Male turtles, requiring fewer biological resources pre breeding season, are thought to have shorter RIs than females, as has been

documented for loggerhead turtles breeding on Zakynthos Island, Greece (Schofield et al. 2020). Accurate determination of RI is important for population modelling (Casale & Ceriani 2020).

Clutch Frequency (CF)

66. This is the average number of clutches deposited by a turtle during a single breeding period. Each clutch is separated by an *Internesting Interval*, during which time the subsequent clutch is ovulated, fertilised and the shells formed on the eggs. CF output of individual females is derived from capture-mark-recapture data (Broderick et al. 2002), tracking studies (Rees et al. 2020) or genetic studies (Shamblin et al. 2017). Knowing CF contributes to the estimations of number of breeding females in a given season. There is limited data on clutch frequency for Mediterranean turtles. The only data for green turtles comes from Cyprus where CF of 2.9 – 3.1 has been estimated (Broderick et al. 2002). Similarly, a CF of 1.8 – 2.2 has been estimated loggerhead turtles nesting on Cyprus, but more recently a value of 3.8 ± 0.7(SD) was calculated from Greece. CF is not a metric that can be affected by conservation measures. Given the difficulty in obtaining accurate population level CF values, published data can be used across the Mediterranean for determining demographic metrics.

Sex Ratio of Hatchlings (SR-H)

67. Sex ratio of hatchlings is roughly obtained from interpreting IDs, nest or beach temperatures or, more accurately, from sampling hatchlings (e.g., Mrosovsky et al. 2002, Tezak et al. 2020). Methods involving hatchling sampling are invasive and is best only carried out on larger populations. Sex ratios feed into the demographic assessment of a population such as higher ratios of females facilitating faster population recoveries or extreme lack of males possibly leading to unsuccessful breeding seasons for individual females. Sex ratios published to date in the Mediterranean are typically female skewed for both loggerheads and green turtles (Casale et al. 2018). However different areas and times of the season may produce closer to 50% ratio or even be male biased (e.g., Katselidis et al. 2012). SR-H is not a metric that should be manipulated, except for the most extreme cases where and HES is consistently being compromised due to thermal extremes. Estimates for SR-H should be assessed by each individual Contracting Party at each index nesting site to understand that sufficient male turtles are still being produced under the influence of climate change. A female threshold of no more than 95% per country can be used, as research has indicated that only a low percentage of male hatchlings are required to maintain populations and there is equal concern over reduced *hatchling emergence success* (Hays et al. 2017) which is also to be monitored and can be mitigated against.

Sex Ratio of Breeding Adults (SR-BA)

68. SR-BA can be determined from surveys of the nearshore marine habitat for approximately one month prior to the onset of the nesting season until nesting begins, i.e., from mid-April to mid-to-late-May. The number of adult male and female turtles observed during the survey produce the season’s operational sex ratio (OSR), but this can be taken further to produce functional-OSR when timing of the surveys is taken into account (Schofield et al. 2017). OSR can also be determine through in-depth genetic studies of paternity in multiple nests from a population (Wright et al. 2012). SR-BA is used for demographic analyses and provide insights into any persistence and effects of skewed SR-H. OSR (male:female) for loggerheads is 1:2.7 at Zakynthos, Greece (Schofield et al. 2017) 3:1 for green turtles in Turkey (Turkozan et al. 2019) and 1.4:1 for green turtles in Cyprus (Wright et al. 2012). No other data exist for Mediterranean turtles. SR-BA is not a measure that can be manipulated for conservation purposes but should be assessed periodically by each individual Contracting Party.

Longevity

69. Longevity is best determined from intensive capture-mark-recapture projects, carried out at nesting areas. Understanding how long animals may live provides insight on lifetime reproductive output for adult female turtles that contribute towards population modelling. Current maximum reproductive longevity for

adult female loggerheads in Greece was recently published at 33 years (Margaritoulis et al. 2020). Longevity was analysed for loggerheads and green turtles in Cyprus (Omeyer et al. 2019) with loggerheads breeding up to 25 years and green turtles 24 years. No other data have been published for the Mediterranean. Biological longevity are not metrics that can be manipulated for conservation purposes, but reduction of threats, both marine and terrestrial will aid turtles' abilities to live to reach their natural lifespans and hence their reproductive potential. Due to the length of time required to measure these traits they need not be ascertained for all nesting populations, though they can be an aspirational goal for nascent turtle monitoring projects at index nesting areas per Contracting Party.

Metrics from other marine habitats

Size classes / sex ratios in offshore foraging areas

70. These data are gathered from dedicated surveys, surveys from regular boat traffic, such as ferries, aerial surveys and bycatch records (See Casale et al. 2006). They give an understanding of the population structure in the open seas including data on abundance, distribution and threats. Turtles found in the open seas may range from yearlings to adults for loggerheads and yearlings to around 30cm for green turtles. There will likely be bias in observations as bigger turtles will be easier to spot. In subadult and adult sizes that are observed close-up as with bycaught turtles, sex of individuals can be inferred from tail length. Size classes and sex ratios are not metrics that can be manipulated for conservation purposes, but they should be assessed by each individual Contracting Party for CI 3 & CI 4.

Size classes / sex ratios in nearshore foraging areas

71. Similar to the offshore zone, these data are gathered from dedicated surveys, surveys from regular boat traffic, such as ferries, aerial surveys and bycatch records (e.g., Casale et al. 2014), but additional data can be obtained from strandings (e.g., Maffucci et al. 2013). They give an understanding of the population structure in the nearshore seas including data on abundance, distribution and threats. Turtles found nearshore may generally range from 45cm-juveniles to adults for loggerheads and 30cm-juveniles to adults for green turtles. There will likely be bias in observations as bigger turtles will be easier to spot. In subadult and adult sizes, that are observed close-up as with bycaught turtles or low-flying drones, sex of individuals can be inferred from tail length. Size classes and sex ratios are not metrics that can be manipulated for conservation purposes, but they could be assessed by each individual Contracting Party for CI 4.

Threats and survivorship in offshore foraging areas

72. Data on these metrics are obtained from fisheries bycatch, telemetry and capture-mark-recapture (CMR) studies, with the latter utilising bycaught turtles. Threats are classified as catch per unit effort per fishery that also records direct mortality rates resulting from the bycatch event. Telemetry data can reveal probable mortality events as demonstrated by Snape et al. (2016), which is useful to assess post-bycaught indirect mortality, but sample sizes need to be large to derive population level inferences. Threats and survivorship are metrics that can be influenced for conservation purposes. Efforts to reduce levels of bycatch (through bycatch reduction devices or revised fishing practices) or improve the condition of bycaught turtles (through better handling and release protocols, e.g., Gerosa & Aureggi 2001, FAO & ACCOBAMS 2018) can create positive outcomes at population level. Threat levels and survivorship should be assessed by each Contracting Party and conservation measures put in place as a precautionary measure irrespective of trend in mortality. At national level, each Contracting Party should aim to acquire robust bycatch data that will hopefully show a reduction in mortality, over time, and at the very least to not let the trend in anthropogenic mortality worsen. A stable (from first year of data collection) or negative trend for mortality levels would be required for this metric to not impact achievement of GES. Only when all populations are recovered and turtle numbers are improved should mortality rate be considered as a metric for GES assessment, as even with low mortality rates if the bycatch level is high mortality levels may impact population trends.

Threats and survivorship in nearshore foraging areas

73. Data on these metrics are obtained from fisheries bycatch, strandings, telemetry and capture-mark-recapture (CMR) studies, with the latter utilising both bycaught turtles and those observed during nearshore hotspot monitoring. Threats are classified as catch per unit effort per fishery that also records direct mortality rates resulting from the bycatch event. A more detailed assessment of threats and survivorship can be made with the nearshore hotspot CMR projects, where turtles may be observed over extended periods in which they may be impacted and potentially subsequently recover from local threats such as boat strikes, hooking, entanglement and directed trauma. Telemetry data can reveal probable mortality events as demonstrated by Snape et al. (2016), which is useful to assess post-bycaught indirect mortality, but sample sizes need to be large to derive population-level inferences. Threats and survivorship are metrics that can be manipulated for conservation purposes. Efforts to reduce levels of bycatch (through bycatch reduction devices or revised fishing practices) or improve the condition of bycaught turtles (through better handling and release protocols, e.g., Gerosa & Aureggi 2001, FAO & ACCOBAMS 2018) can create positive outcomes at population level. Threat levels and survivorship should be assessed by each Contracting Party and conservation measures put in place as a precautionary measure irrespective of trend in mortality. At national level, each Contracting Party should aim to acquire robust bycatch data that will hopefully show a reduction in mortality, over time, and at the very least to not let the trend in anthropogenic mortality worsen. A stable (from first year of data collection) or negative trend for mortality levels would be required for this metric to not impact achievement of GES. Only when all populations are recovered and turtle numbers are improved should mortality rate be considered as a metric for GES assessment, as even with low mortality rates if the bycatch level is high mortality levels may impact population trends.

Health index in offshore foraging areas

74. Sea turtles to assess and sample for health assessments may be obtained through bycatch and CMR studies. They are measured and weighed, and injuries recorded. Dead turtles can additionally have various organs sampled and assessed for pollutant load and their gastro-intestinal tract examined for debris ingestion (as required for CI 18 of EO10). Although not currently incorporated in demographic modelling, indices of health status are useful indicators for general state of the environment, with loggerhead turtles specifically chosen as indicators for prevalence of marine litter across the Mediterranean. Health indices are not something that can be improved at population level through direct conservation but lessening the amount of plastic pollution that reaches the sea plays a part in improving the situation. However, conservation actions may contribute directly on individuals through rehabilitation projects. Each Contracting Party should obtain data on animal health, specifically those that may contribute to pan-Mediterranean initiatives such as monitoring debris ingestion (CI 18).

Health index in nearshore foraging areas

75. See Health index in offshore foraging areas, above.

Growth rates

76. Growth rates are determined from repeat measuring of individual turtles over an extended period of time, i.e., from months to years. This involves some form of CMR project, that can be nocturnal monitoring of nesting beaches (though adults do not grow very much; Omeyer 2018) or more helpfully from in-water CMR studies that should be carried out at nearshore turtle hotspots (e.g., Rees et al. 2013) and, to a lesser extent, from repeat captures of bycaught turtles (e.g., Casale et al. 2009). Growth rates are useful for determining general age-at-size and age at maturity values and for understanding how long turtles remain in specific ontogenetic categories such as epipelagic juveniles and demersal/benthic juveniles etc. These data are vital to successful stage-based sea turtle life-history models. Growth cannot be manipulated for conservation

purposes, but each Contracting Party should strive to obtain relevant local data on this topic. However, values from other locations across the region may be used in modelling where local data are lacking.

Age and size at sexual maturity

77. These data points require detailed laboratory studies (necropsy and skeletochronology; Casale et al. 2011, Guarino et al. 2020) or invasive surgical techniques (laparoscopy) for individuals obtained as bycatch or strandings, or long-term CMR projects (Casale et al. 2009) incorporating both foraging and breeding areas to elucidate values for individuals that contribute to wider studies. Values for age and size at sexual maturity contribute to stage- and age- based demographic models which are used to assess a population's resilience to threats and stressors (Casale & Heppell 2016) and identify where targeted conservation can be most efficacious. Reaching sexual maturity cannot be manipulated for conservation purposes, but each Contracting party should strive to obtain relevant local data on this topic, especially as regional variation at size of sexual maturity has been demonstrated (Margaritoulis et al. 2003). However, values from other proximate locations may be used in modelling where local data are lacking.

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UNITED NATIONS

EP

UNEP/MED WG. 502/16.Appendix D

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

22 May 2021
Original: English

Fifteenth Meeting of SPA/BD Focal Points

Videoconference, 23-25 June 2021

Agenda Item 7: Status of implementation of the Ecosystem Approach (EcAp) Roadmap

7.1. Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Appendix D: Revised Guidance Fact Sheets for the IMAP Common Indicator 6 related to Non-Indigenous Species

UNEP/MAP
SPA/RAC-Tunis 2021

I. Introduction and objectives

1. The IMAP Common Indicator Guidance Factsheets share a common template, which is illustrated in Table 1 below. The information gathered in the frame of the “Study on trends and outlook of marine pollution from ships and activities and of maritime traffic and offshore activities in the Mediterranean”, and the additional documents consulted, enabled to update the different sections of the factsheets that were discussed with the members of the informal Online Working Group (19 April 2021).

Table 1. Template of IMAP Common Indicator Guidance Factsheets

Indicator Title			
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**	**IMAP Reference No and definition**
Rationale			
Justification for indicator selection			
Scientific References			
Policy Context and targets			**Scientific rationale and marine policy context (including relevant references)**
Policy context description			
Targets			
Policy documents			
Indicator analysis methods			
Indicator Definition			
Methodology for indicator calculation			
Indicator units			
List of Guidance documents and protocols available			**Agreed scientific methodologies in use, including detailed monitoring requirements**
Data Confidence and uncertainties			
Methodology for monitoring, temporal and spatial scope			
Available Methodologies for Monitoring and Monitoring Protocols			
Available data sources			
Spatial scope guidance and selection of monitoring stations			
Temporal Scope guidance			
Data analysis and assessment outputs			
Statistical analysis and basis for aggregation			**Data reporting, analysis and aggregation (outpout)**
Expected assessments outputs			
Known gaps and uncertainties in the Mediterranean			
Contacts and version Date			
Key contacts within UNEP for further information			**Document Registration**
Version No	**Date**	**Author**	

2. The revised Guidance Factsheet of CI6 is reproduced in the Sections II in highlights and strikethrough.

II. Revision of the Guidance Factsheet of CI6

Indicator title	Common Indicator 6: Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species (NIS) particularly invasive, non-indigenous species notably in risk areas (EO2, in relation to the main vectors and pathways of spreading of such species)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Decreasing abundance of introduced NIS in risk areas	Invasive NIS introductions are minimized	Abundance of NIS introduced by human activities reduced to levels giving no detectable impact.
Rational		

Justification for indicator selection

Marine invasive alien species[1] are regarded as one of the main causes of biodiversity loss in the Mediterranean, potentially modifying all aspects of marine and other aquatic ecosystems. They represent a growing problem due to the unprecedented rate of their introduction and the unexpected and harmful impacts that they have on the environment, economy and human health. According to the latest regional reviews, more than 6% of the marine species in the Mediterranean are now considered non-native species as around 1000 alien marine species have been identified. ~~while their number is increasing at a rate of one new record every 2 week (Zenetos et al. 2012) NIS introductions still occur, the rate of NIS introductions decreases in the time period 2006-2017. The decreasing trend can be assigned to polices effectiveness as well as to other reasons, such as decreasing pool of potential NIS species, variations in sampling effort or available expertise (Galil et al., 2018). However only~~ Around 12% of all of NIS in the Mediterranean are today considered as invasive, or potentially invasive (Rotter et al., 2020)[2]. Macrophytes (macroalgae and seagrasses) are the dominant NIS group in the western Mediterranean and Adriatic Sea. Polychaetes, crustaceans, molluscs and fishes are the dominant NIS group in the eastern as well algae for the central Mediterranean (Zenetos et al., 2010, 2012). Although the highest alien species richness occurs in the eastern Mediterranean, ecological impact shows strong spatial heterogeneity with risk areas in all Mediterranean sub-basins (Katsanevakis et al. 2016). Besides, these numbers should be modulated acknowledging that there is no exhaustive knowledge (neither standard monitoring) of all introduced species in most areas of the Mediterranean Sea.

To mitigate the impacts of NIS on biodiversity, human health, ecosystem services and human activities there is an increasing need to take action to control biological invasions. With limited funding, it is necessary to prioritise actions for the prevention of new invasions and for the development of mitigation measures. This requires a good knowledge of the impact of invasive species on ecosystem services and biodiversity, their current distributions, the pathways of their introduction, and the contribution of each pathway to new introductions.

Common indicator 6 is a trend indicator that summarizes data related to biological invasions in the Mediterranean into simple, standardized and communicable figures and is able to give an indication of the degree of threat or change in the marine and coastal ecosystem. Furthermore, it can be a useful indicator to assess on the long-run the effectiveness of management measures implemented for each

[1] Invasive alien species (IAS) are a subset of established NIS which have spread, are spreading, or have demonstrated their potential to spread elsewhere, and which have an effect on biological diversity and ecosystem functioning (by competing with and on some occasions replacing native species), socio-economic values, and/or human health in invaded regions. (Decision IG.22/7)

pathway but also, indirectly, the effectiveness of the different existing policies targeting alien species in the Mediterranean Sea.

However, the overall ecological impact of NIS on the Mediterranean Sea remains relatively difficult to quantify, and it evaluation is mainly qualitative; nevertheless, there have been some good attempts at quantification (Katsanevakis et al., 2014, 2016; Gallardo et al., 2016). In particular, the analyses of Katsanevakis et al. (2014) have led to the conclusion that the majority of the recognized invasive species in the European seas (72%) have both positive and negative effects ~~impacts~~ on the native ~~biota~~ ecosystem . ~~Few have only positive effects (8%), while more (~20%) have only negative effects on the host environment.~~

To take effective actions against biological invasion, knowledge about the-vectors and associated pathways of introduction of NIS is crucial. Corridors and shipping represent the main ~~vector~~ pathway of introduction for NIS in the Mediterranean, ~~followed by vessels~~, though the relative importance of pathways vary among individual countries and current knowledge on vectors and pathways.

Scientific References

Galil BS, Marchini A, Occhipinti-Ambrogi A, Minchin D, Narščius A, Ojaveer H, Olenin S. (2014). International arrivals: widespread bioinvasions in European Seas. Ethol Ecol Evol. 26(2–3):152–171. doi:10.1080/03949370.2014.897651.

Galil BS., Agnese Marchini and Anna Occhipinti-Ambrogi (2018). Mare Nostrum, Mare Quod Invaditur—The History of Bioinvasions in the Mediterranean Sea. In: Queiroz Ana Isabel & Simon Pooley Eds. Editors. Histories of Bioinvasions in the Mediterranean. Springer.

Gallardo, B., Clavero, M., Sánchez, M. I., and Vilà, M. (2016). Global ecological impacts of invasive species in aquatic ecosystems. Glob. Chang. Biol. 22, 151–163. doi: 10.1111/gcb.13004

Katsanevakis, S., Wallentinus, I., Zenetos, A., Leppäkoski, E., Çinar, M. E., Oztürk, B., et al. (2014). Impacts of marine invasive alien species on ecosystem services and biodiversity: a pan-European review. Aquat. Invas. 9, 391–423. doi: 10.3391/ai.2014.9.4.01

Katsanevakis, S., Tempera, F., Teixeira, H., 2016. Mapping the impact of alien species on marine ecosystems: the Mediterranean Sea case study. Diversity and Distributions 22, 694–707.

REMPEC (2020). Study on trends and outlook of marine pollution from ships and activities and of maritime traffic and offshore activities in the Mediterranean".

Rotter Ana, Klun Katja, Francé Janja, Mozetič Patricija, Orlando-Bonaca Martina (2020). Non-indigenous Species in the Mediterranean Sea: Turning from Pest to Source by Developing the 8Rs Model, a New Paradigm in Pollution Mitigation. Frontiers in Marine Science 7: 178. 10.3389/fmars.2020.00178

Zenetos A., Gofas, S., Verlaque, M., Cinar, M. E., García Raso, E., et al., 2010. Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. Mediterranean Marine Science, 11, 2, 381-493.

Zenetos A., Gofas, S., Morri, C., Rosso, A., Violanti, D., et al., 2012. Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. Mediterranean Marine Science, 13/2, 328-352.

Policy Context and targets (other than IMAP)

Policy context description

The Convention on Biological Diversity (CBD) recognised the need for the "compilation and dissemination of information on alien species that threaten ecosystems, habitats, or species to be used in the context of any prevention, introduction and mitigation activities", and calls for "further research on the impact of alien invasive species on biological diversity" (CBD, 2000). The objective set by Aichi Biodiversity Target 9 is that "by 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment". This is also reflected in Target 5 of the EU Biodiversity Strategy (EU 2011). The EU Regulation 1143/2014 on the management of invasive alien species seeks to address the problem of IAS in a comprehensive manner so as to protect native biodiversity and ecosystem services, as well as to minimize and mitigate the impacts that these species can have on the human health or economy. The Regulation foresees three types of interventions; prevention, early detection and rapid eradication, and management and includes a list of 66 (as per second update) Invasive Alien Species (IAS) of European concern for which direct management measures are solicited.

The Marine Strategy Framework Directive (MSFD), which is the environmental pillar of EU Integrated Maritime Policy, sets as an overall objective to reach or maintain "Good Environmental Status" (GES) in European marine waters by 2020. It specifically recognizes the introduction of marine alien species as a major threat to European biodiversity and ecosystem health, requiring Member States to include alien species in the definition of GES and to set environmental targets to reach it. Hence, one of the 11 qualitative descriptors of GES defined in the MSFD is that "non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem" (Descriptor 2).

The updated EU Decision 2017/848, defined a set of Criteria, including criteria elements, and methodological standards are defined, for each descriptor. Under descriptor 2, the following criteria are defined 1) Newly introduced non-indigenous species, 2) Established non-indigenous species, particularly invasive non-indigenous species, which include relevant species on the list of invasive alien species of Union concern adopted in accordance with Article 4(1) of Regulation (EU) No 1143/2014 and species which are relevant for use under criterion D2C3.

Member States shall establish that list through regional or subregional cooperation and 3) Species groups and broad habitat types that are at risk from non-indigenous species, selected from those used for Descriptors 1 and 6. Although Ecological Objective 2 and the Common Indicator 6 were in line with the MSFD descriptor 2 objectives and targets, defined in the EU Decision 2010/477/EU, there is significant difference with the update directive 2017/848. Assessment of CI6 is complementary to first two criteria under D2, however, no assessment of adverse impacts on species and habitats is yet elaborated under IMAP.[3]

Indicator/Targets

Aichi Biodiversity Target 9

EU Biodiversity Strategy Target 5

EU Regulation 1143/2014 targets

MSFD Descriptor 2 and related criteria, indicators and environmental targets

Policy documents

Aichi Biodiversity Targets - https://www.cbd.int/sp/targets/

Action Plan concerning Species Introductions and Invasive Species in the Mediterranean Sea. UN Environment/MAP Athens, Greece 2017.-
https://www.racspa.org/sites/default/files/action_plans/pa_alien_en.pdf

EU Biodiversity Strategy - https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en#ecl-inpage-324

~~EU Regulation 1143/2014 -~~

[3] Text amended to reflect the latest EU Decisions

Marine Strategy Framework Directive - http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN

Commission Decision EU 2017/848 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU - https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0848&from=EN

~~Decision on criteria and methodological standards on good environmental status of marine waters - http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010D0477(01)&from=EN~~

EU Regulation 1143/2014 - http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1143&from=EN

Indicator analysis methods

General definitions (according to Decision IG.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria)

'Non-indigenous species' (NIS; synonyms: alien, exotic, non-native, allochthonous) are species, subspecies or lower taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential. This includes any part, gamete or propagule of such species that might survive and subsequently reproduce. Their presence in the given region is due to intentional or unintentional introduction resulting from human activities. Natural shifts in distribution ranges (e.g. due to climate change or dispersal by ocean currents) do not qualify a species as a NIS. However, secondary introductions of NIS from the area(s) of their first arrival could occur without human involvement due to spread by natural means.

'Invasive alien species' (IAS) are a subset of established NIS which have spread, are spreading or have demonstrated their potential to spread elsewhere and have an effect on biological diversity and ecosystem functioning (by competing with and on some occasions replacing native species), socioeconomic values and/or human health in invaded regions. Species of unknown origin which cannot be ascribed as being native or alien are termed cryptogenic species. They also may demonstrate invasive characteristics and should be included in IAS assessments.

In order to provide basis for development of relevant policies to address NIS, assessment of pathways of introduction is needed.

Indicator Definition

For the needs of Common Indicator 6, the following definitions apply:

- 'Trend in abundance' is defined as ~~the interannual~~ change between assessment periods in the estimated population density/ranks ~~total number~~ of ~~individuals of~~ a non-indigenous species ~~population~~ in a specific marine area.
- 'Trend in temporal occurrence' is defined as the ~~interannual~~ change between assessment periods in the estimated number of new introductions and the total number of non-indigenous species in a specific country or preferably the national part of each subdivision, preferably disaggregated by pathway of introduction.
- 'Trend in spatial distribution' is defined as ~~the interannual~~ change of the total marine 'area' occupied by non-indigenous species. This area should be defined according to the scale of assessment.

In order for this trend indicator to become operational, at least two assessment periods of relevant data are necessary, in order to allow a minimal comparison of two annual datasets.

Methodology for indicator calculation

To estimate Common Indicator 6, a trend analysis (time series analysis) of the available monitoring data needs to be performed, aiming to extract the underlying pattern of NIS number variability over time, which may be hidden by noise. A formal regression analysis is the recommended approach to estimate such trends. This can be achieved through a simple linear regression analysis or through more sophisticated modelling tools (when extensive datasets are available), such as the generalized linear or additive models (GLM/GAM). See details in document "S*cales of monitoring & assessment, assessment criteria and thresholds values of the IMAP EO2/CI6: non-indigenous species"*

~~To monitor trends in temporal occurrence, two parameters [A] and [B] should be calculated on a predefined time period yearly basis. Parameter [A] provides an indication of the introductions of "new" species (in comparison with the prior year), and parameter [B] gives an indication of the increase or decrease of the total number of non-indigenous species:~~

~~[A]: The number of non-indigenous species at Tn that was were not present at Tn-1. To calculate this parameter the non-indigenous species lists of both years are compared to check which species were recorded in year n, but were not recorded in year n-1 regardless of whether or not these species was present in earlier years. To calculate this parameter the total number of non-indigenous species is used in the comparison.~~

~~[B]: The total number of known non-indigenous species at Tn minus the corresponding total number of non-indigenous species at by Tn-1. Hereby Tn stands for the year of reporting.~~

Indicator units

'Trends in abundance': absolute value and % change per assessment period ~~year~~

'Trends in temporal occurrence': number and % change in new introductions or number and % change in the total number of alien species per assessment period ~~year (or per decade if there are gaps in the availability of annual data)~~

'Trends in spatial distribution': absolute value and % change in the total marine surface area occupied or absolute value and % change in the length of the occupied coastline (in the case of shallow-water species that are present only in the coastal zone).

List of guidance documents and protocols available

As provided for in the Decision IG.23/6 on the 2017 MED QSR (COP 20, Tirana, Albania, 17-20 December 2017), Monitoring Protocols for IMAP Common Indicator related to Non-Indigenous species were approved by the 7th Meeting of the Ecosystem Approach Coordination Group (Athens, Greece, 9 September 2019)[4].

~~There are no established standard protocols for the monitoring of NIS. However,~~ Consistent NIS monitoring protocols are already implemented in many Mediterranean countries, in relation to several monitoring obligations linked with the Ballast Water Convention, the EU Water Framework Directive, and the EU Marine Strategy Framework Directive, and as provided by specialised agencies or institutions (e.g. IUCN for MPAs, CIESM). These methods may be useful to complement the estimation of Common Indicator 6.

Several guidelines for NIS monitoring and assessment are available at: European and Regional Sea conventions https://mcc.jrc.ec.europa.eu/main/dev.py?N=20&O=407&titre_chap=D2%20Non-indigenous%20species&titre_page=Monitoring%20&%20assessment (accessed 13/04/2021). Some guidance on the monitoring of biodiversity (including for monitoring non-indigenous species) within the context of the MSFD is provided in:

[4] UNEP/MED WG.467/16, Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species.

- Zampoukas et al. (2014) Technical guidance on monitoring for the Marine Stategy Framework Directive;
- JRC Scientific and Policy Reports (EUR collection), Publications Office of the European Union, EUR 25009 EN – Joint Research Centre, doi: 10.2788/70344, ISBN: 978-92-79-35426-7, 166p;
- Olenin, S., Alemany, F., Cardoso, A.C., Gollasch, S., Goulletquer, P., Lehtiniemi, M., McCollin, T., Minchin, D., Miossec, L., Ambrogi, A.O. and Ojaveer, H., 2010. Marine Strategy Framework Directive–Task Group 2 Report–Non-indigenous Species, vol. 10.

HELCOM (Helsinki Commission, the RSC for the Baltic Sea) has published online guidance notes for the application of eRAS (extended Rapid Assessment Survey) in the monitoring of NIS (https://helcom.fi/media/publications/Guidelines-for-monitoring-of-non-indigenous-species-by-eRAS.pdf)

The EU Project BALMAS has provided guidelines for the monitoring of NIS in ballast water:

- David M. and Gollasch S. 2015. BALMAS Ballast Water Sampling Protocol for Compliance Monitoring and Enforcement of the BWM Convention and Scientific Purposes. BALMAS project, Korte, Slovenia, Hamburg, Germany. 55 pp

Data confidence and uncertainties

The trend analysis should be accompanied by an evaluation of confidence and uncertainties. Standard regression methods (simple linear regression, generalized linear or additive models, etc.) provide estimates of uncertainty (standard errors and confidence intervals of estimated trends). Such uncertainty estimates should accompany all reported trends. Only long-term follow-ups of all the relevant parameters (states and pressures), will ultimately make it possible to precisely quantify the GES and gradually reduce the amount of uncertainty between the changes due to natural variations and those resulting from anthropogenic pressures.

Furthermore, the issue of imperfect detectability should be properly addressed, as it may cause an underestimation of the relevant state variables (abundance, occupancy, geographical range, species richness). Many available methods properly tackle the issue of imperfect detection when monitoring biodiversity, by jointly estimating detectability (see Katsanevakis et al. 2012 for a review).

Methodology for monitoring, temporal and spatial scope

Available methodologies for monitoring and monitoring protocols

It is recommended to use standard monitoring methods traditionally being used for marine biological surveys, including, but not limited to plankton, benthic and fouling studies described in relevant guidelines and manuals. However, specific approaches may be required to ensure that alien species are likely to be found, e.g. in rocky shores, port areas and marinas, offshore areas and aquaculture areas.

As a complimentary measure and in the absence of an overall NIS targeted monitoring programme, rapid assessment studies may be undertaken, usually but not exclusively at marinas, jetties, and fish farms (e.g. Pederson et al. 2003). Besides, a review (as exhaustive as possible) of all scientific publications on (more or less) recent new introductions of species, besides the taxonomic status of these NIS, is pre-required to have the minimum basis of knowledge. This is also very often the main and only data sources for assessment when monitoring is not in place.

[With rigorous quality control in place, national and regional citizen science campaigns are ideal for NIS monitoring purposes. Members of local communities, due to their broad geographic distribution and familiarity with their natural environment, can in fact, be of great help to track invasive species in both terrestrial and aquatic systems (Delaney et al., 2008). A renewed drive to identify components of the natural world, through 'bioblitz'[5] events organized round the globe, is bolstering the interaction between formal scientists and informal/citizen ones, also through the availability of low-budget underwater photography and video-capture hardware on the market.] ~~The compilation of citizen scientists' input, validated by taxonomic experts, can be useful to assess the geographical ranges of established species or to early record new species.~~

For the estimation of Common Indicator 6, it is important that the same sites are surveyed each monitoring period, otherwise the estimation of the trend might be biased by differences among sites. The exact geographical location of each selected sampling station in both risk areas and MPAs should be recorded through GPS coordinates, so as to enable consistent sampling on successive occasions.

Standard methods for monitoring marine populations include plot sampling, distance sampling, mark-recapture, removal methods, and repetitive surveys for occupancy estimation (see Katsanevakis et al. 2012 for a review specifically for the marine environment).

To provide guidance to the Contracting Parties to the Barcelona on field methodologies for monitoring NIS CI6 in identified risk areas and MPAs, guidelines for monitoring NIS in the Mediterranean (UNEP/MED WG.467/16, 2019) was developed by reviewing recognised good practices in the field of NIS monitoring protocols :

1. UNEP/MED WG.467/16, 2019, Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species, 7th Meeting of the Ecosystem Approach Coordination Group, Athens, Greece, 9 September 2019. p.118-130
2. Katsanevakis S, et al., 2012. Monitoring marine populations and communities: review of methods and tools dealing with imperfect detectability. Aquatic Biology 16: 31–52.
3. Pederson J, et al., 2003 Marine invaders in the northeast: Rapid assessment survey of non-native and native marine species of floating dock communities, August 2003 (available in https://dspace.mit.edu/bitstream/handle/1721.1/97032/MITSG_05-3.pdf?sequence=1)

Available data sources

Marine Mediterranean Invasive Alien Species database (MAMIAS) - http://dev.mamias.org/ [Version Beta]

European Alien Species Information Network (EASIN) - http://easin.jrc.ec.europa.eu/

CIESM Atlas of Exotic Species in the Mediterranean - http://www.ciesm.org/online/atlas/

World Register of Introduced Marine Species (WRiMS) - http://www.marinespecies.org/introduced

Global Invasive Species Database - http://www.iucngisd.org/gisd/

CABI Invasive Species Compendium - https://www.cabi.org/isc

AquaNIS - http://www.corpi.ku.lt/databases/index.php/aquanis

For taxonomic status: World Register of Marine Species (WoRMS) - http://www.marinespecies.org/

NEMESIS - Smithsonian Environmental Research Center's National Estuarine and Marine Exotic Species Information System - https://nemesis.nisbase.org/nemesis/

Spatial scope guidance and selection of monitoring stations

~~The monitoring of NIS generally should start on a localised scale, such as "hot-spots" and "stepping stone areas" for alien species introductions. Such areas include ports and their surrounding areas, docks, marinas, aquaculture installations, heated power plant effluents sites, offshore structures. Areas of~~

[5] A BioBlitz is a celebration of biodiversity. It's an event that focuses on finding and identifying as many species as possible in a specific area over a short period of time. Students, scientists, naturalists, and community members join together in these events to explore the natural world. Typically led by educators, scientists, or Park/MPA rangers, BioBlitzes are an opportunity to take a snapshot of the biodiversity of a place. Participants of all ages can learn techniques for observing and collecting data within a designated area and time frame.

~~special interest such as marine protected areas, lagoons etc. may be selected on a case by case basis, depending on the proximity to alien species introduction "hot spots". The selection of the monitoring sites should therefore be based on a previous analysis of the most likely "entry" points of introductions and "hot spots" expected to contain elevated numbers of alien species.~~

[It is recommended that NIS surveys are conducted within both risk areas (harbours, ports, marinas, marine culture, etc.) and within vulnerable marine areas (where the environmental conditions promote the establishment of NIS) and Marine Protected Areas (MPAs).

Risk areas are defined as the most feasible entry/introduction points for NIS by virtue of:

(i) a preliminary desk study which identifies particular site-specific features (e.g. a harbour frequented by a number of vessels at risk of introduction of NIS, or marine culture) or

(ii) a high number and/or abundance of NIS already established within the confines of risk and vulnerable areas

Typically, Risk areas would include site typologies such as harbours, ports, yacht marinas, mariculture cages, offshore structures and thermal effluent discharge locations. Sites not necessarily in close proximity to these 'conventional' risk areas could also be considered within this same category, including locations subject to intense anchoring pressure during the tourist season.

In terms of NIS risk areas, UNEP/MAP (2019)[6] recommends that NIS monitoring is conducted following the provided guidance at least in two risk areas locations per potential introduction pathway, most notably commercial shipping, recreational boating and aquaculture. The same report provides guidance in the form of criteria, which should be applied when selecting candidate hotspot locations, as follows:

- Past research has shown them to be hotspots for non-indigenous species that can be transported with the transport vector concerned;
- The species communities at the two risk areas have minimal direct influence each other;
- Vulnerable areas with prospects for invasion by new introductions.

In terms of MPAs, a minimum of two sampling stations per MPA are recommended, with the two stations being located within different management zones within the same MPA. In terms of the specific positioning of the two NIS monitoring stations within each MPA, it is recommended to ensure a high degree of geographical and ecological representability. This can be ensured in a variety of ways, including:

a) opting for a minimum threshold of physical distance between the two sampling stations, expressed as a percentage of the total lateral extent of the MPA in question (e.g. the distance between the two sampling stations should not be inferior to 25% of the total lateral extent of the MPA);
b) opting for sampling stations dominated by different marine biocoenoses (e.g. algal-dominated rocky reef versus seagrass meadow);
c) opting for sampling stations incorporated within anthropogenic or ecological features of interest, with potential candidates including wrecks (which are considered as promoting the establishment of NIS – e.g. Bariche [2012]), a benthic area heavily impacted by anchoring or a sea urchin barren.]

It is important to establish a network of monitoring sites at regional level in which common protocols are applied so that Common Indicator 6 can be assessed at national, sub-regional and regional levels.

The use of Habitat Suitability Models and Ecological Niche Modelling (ENM) may be considered at a later stage of IMAP to identify priority monitoring sites and to predict the spread of NIS.

[6] UNEP/MED WG.467/16 Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species, 7th Meeting of the Ecosystem Approach Coordination Group, Athens, Greece.

A revision and agreement on the nested areas (bottom-up approach) is needed that includes integration of monitoring scales based on nested approach, proposing the list of monitoring and reporting units in the Mediterranean Sea. The geographical distribution of NIS, showing a higher presence in the Aegean and Levantine basin, should be taken into consideration when defining monitoring stations. The nested approach has to consider the differences in NIS occurrence in the different sub-basins.
Temporal Scope guidance ~~Monitoring at "hot-spots" and "steppingstone areas" for alien species introductions would typically involve more intense monitoring effort, e.g. sampling at least once a year at ports and their wider area and once every two years in smaller harbours, marinas, and aquaculture sites.~~ Sampling should be done on an annual / seasonal basis depending on the species group or target habitat's types. See details in document "Scales of monitoring & assessment, assessment criteria and thresholds values of the IMAP EO2/CI6: non-indigenous species".
Data analysis and assessment outputs
Statistical analysis and basis for aggregation Standard statistics for regression analysis should be applied to estimate trends and their related uncertainties.
Expected assessments outputs - Graphs of the time series of the calculated metrics (abundance, occurrence, spatial extent), including confidence intervals; - Distribution maps of the selected NIS, highlighting temporal changes in their spatial distribution; - National ~~annual~~ inventories (and also by the national part of each marine subdivision, if relevant) of non-indigenous species and respective year of introduction if known; - National inventories clustering NIS according to main pathways of introduction (e.g. seaways, shipping, mariculture, etc.) if known;
Known gaps and uncertainties in the Mediterranean The lack of regular dedicated and coordinated monitoring at national and regional scale implies a low confidence in the assessment of NIS, even if the continuous and regular occurring of new introductions are demonstrated~~.~~ NIS identification is of crucial importance, and the lack of taxonomical expertise has already resulted in several NIS underestimated for certain time periods. The use of molecular approaches including bar-coding are sometimes needed to confirm the results of conventional taxonomic species identification. Sampling effort currently greatly varies among Mediterranean countries and thus on a regional basis current assessments and comparisons may be biased. Evidence for most of the reported impacts of alien species is weak, mostly based on expert judgement; a need for stronger inference is needed based on experiments or ecological modelling. The assessment of trends in abundance and spatial distribution is largely lacking.
Contacts and version Date
Key contacts within UNEP for further information car-asp@spa-rac.org

Version No	**Date**	**Author**

V.1	20/07/2016	SPA/RAC
V.2	14/04/2017	SPA/RAC
V.3	30/09/2020	SPA/RAC-REMPEC

UNITED NATIONS

EP

UNEP/MED WG.502/16.Appendix E

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

22 May 2021
Original: English

Fifteenth Meeting of SPA/BD Focal Points

Videoconference, 23-25 June 2021

Agenda Item 7: Status of implementation of the Ecosystem Approach (EcAp) Roadmap

7.1. Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Appendix E: Monitoring and Assessment Scales, Assessment Criteria and Thresholds Values for the IMAP Common Indicator 6 related to Non-Indigenous Species

In charge of the study at SPA/RAC

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EXECUTIVE SUMMARY

To address the risk NIS pose on marine ecosystems, the Contracting Parties to the Barcelona Convention have updated the Action Plan concerning species introduction and invasive species in the Mediterranean Sea and updated/developed their national monitoring programmes based on the Integrated Monitoring and Assessment Programme (IMAP) Common Indicators. With regards to Non-Indigenous Species (i.e. Ecological Objective 2 or EO2), the Common Indicator 6 (CI6) i assesses “Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species”. The national implementation and harmonization of IMAP across all Mediterranean countries requires the elaboration of a number of parameters, namely monitoring and assessment scales as well as assessment elements (i.e. assessment criteria, thresholds and baseline values).

This report aims to develop monitoring and assessment scales as well as assessment criteria and to make recommendations for establishing threshold values for CI6, based on the available data for the non-indigenous species in the Mediterranean. In order to facilitate discussions and ensure input from all the Contracting Parties (CPs), a questionnaire addressing these issues was sent to 10 non-EU CPs (Albania, Algeria, Egypt, Israel, Lebanon, Libya, Montenegro, Morocco, Tunisia and Turkey), complementing similar work carried out in the framework of Marine Strategy Framework Directive (MSFD) reporting for the 8 EU CPs (Croatia, Cyprus, France, Greece, Italy, Malta, Slovenia and Spain). The results and recommendations presented herein integrate responses by national experts from all these 18 CPs and make use of data derived from recent (2017-2020) publications and the Hellenic Centre for Marine Research (HCMR) offline data base.

Assessment Criteria

Assessment criteria for preparing validated check lists of NIS to be used for assessing GES include a) taxa (all taxa or excluding phytoplankton, parasites); b) species to be considered in trends indicator (extinct species, cryptogenic species, crypto-expanding, questionable species); c) pathways to be considered (all pathways or excluding unaided expanding species, e.g. Lessepsian immigrants).

The views of the national experts were generally in good agreement and the majority of them proposed that **partly native species, NIS introduced through natural dispersal, unicellular marine algae, parasites, extinct and freshwater species** should be reported in NIS lists but considered in CI6 assessments on a case-by-case basis.

Spatial and Temporal Scales of Monitoring and Assessment

Broad Geographic Units: Assessment of threshold values based on the trends indicator (CI6) calculated to date can be achieved at the basin and country level, although it is more meaningful to be assessed at the subregional level (i.e. EcAp subregional units) and, accordingly, at the national part of a subregion for each country, e.g **Greece:** EMED, CMED, ADRIA; **Italy:** WMED, CMED, ADRIA, **Tunisia**: WMED, CMED. It is recommended that the geographic borders of the Mediterranean EcAp subregions should be fully harmonized, during the review of the EcAp roadmap and IMAP phases, with those proposed by EU countries and adopted by the European Environment Agency (i.e. MSFD delimitations).

Broad Temporal Scales: For consistency and harmonization reasons, it is recommended that the assessment period of CI6 should be the same across all Mediterranean countries and follow the assessment and reporting 6-year periods already established for EU countries under the MSFD. Specifically, the next assessment should cover the 2018-2023 period, such that the reference year to set national NIS baselines should be 2017 at the earliest, taking also into account reporting lags. Trends in new marine NIS introductions are consistently increasing throughout the Mediterranean and, in many countries, this is the result of increased scientific effort, (bringing to light species already widely established in the region). Therefore, for some countries even 2017 as the reference year, may be premature.

Finer scales for NIS monitoring

At basin scale, there are no established standard protocols for the monitoring of NIS. However, guidelines for monitoring NIS in the Mediterranean were developed and endorsed by the CPs to the Barcelona Convention in 2019 under the framework of the EcAp/IMAP (UNEP/MED WG.467/16 (2019) “Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species”).

Responses to the questionnaires revealed that the majority of countries do not have a dedicated strategy but have a monitoring strategy including marine NIS applied either at hot-spot areas of the country (i.e. ports, aquaculture units, marine protected areas) or in specific subregions through a related network of sampling stations. Targets of NIS monitoring include mainly the detection of new NIS and the measurement of abundance/coverage/biomass of established and/or invasive NIS, while only a small number of countries monitor the impact of established/invasive NIS on the native communities.

The **IMAP Common Indicator Guidance** propose more intense monitoring effort at “hot-spots” and “steppingstone areas” for non-indigenous species introductions, e.g. sampling at least once a year at ports and their wider area and once every two years in smaller harbours, marinas, and aquaculture sites. Importantly, the same sites should be surveyed each monitoring period, to avoid biases potentially caused by differences among sites.

<u>Threshold Values</u>

Currently, threshold values for the number of new introductions of non-indigenous species have not been set neither at the EU or the Mediterranean level. Ongoing work in the framework of the MSFD (Tsiamis et al., 2021b) has concluded that the most suitable approach for setting threshold values for D2C1 is to adopt the percentage reduction of new NIS and the exact value of percentage reduction should be decided at regional and/or subregional scale, based on the pathways pressure and level of monitoring coverage of each region/subregion.

Preliminary analysis of the available data for the Mediterranean between 1970-2017 for the purposes of this report demonstrated that there is a significant increase in the rate of new NIS entering all EcAp subregions after 2000 (presumably as a result of increased scientific effort) and that this parameter is significantly different between EcAp subregions. Consequently, the initial recommendations are that i) the threshold values for CI6 in the Mediterranean need to be set at subregional level and not at regional level and ii) we need to consider data only after 2000s in order to establish today's threshold values. Furthermore, for Mediterranean region/subregions that have not been efficiently monitored in terms of NIS during the previous decades, a shorter time span of 6-years cycle periods should be preferred, e.g. 3 years.

Conclusively, threshold values should be established separately for each of the Mediterranean subregions and should be sought by examining the data of the last two decades, if not an even more recent time period. At the same time, a consensus needs to be reached about which species groups will be included in the calculations and how their environmental impact will be taken into account. These are decisions that will determine the definition of GES for EO2 and will affect the management obligations of Contracting Parties to the Barcelona Convention. As such, it is proposed that further work takes into account the contribution of regional experts not only from the fields of taxonomy, monitoring and assessment but also conservation and management and last, but not least, ecologists with strong statistical/mathematical background.

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INTRODUCTION

1. There are currently about 1000 marine non-indigenous species (NIS) in the Mediterranean marine waters, two thirds of which have established viable populations (Zenetos & Galanidi, 2020). A subset of the established species exhibits invasive behaviour and have negative impacts on marine ecosystem services and biodiversity (Streftaris & Zenetos, 2006, Galil, 2007, Katsanevakis et al. 2014; 2016; Korpinen et al., 2019). Cumulative impacts of invasive NIS (CIMPAL; Katsanevakis et al., 2016) were estimated on the basis of the distributions of invasive species and ecosystems, and both the reported magnitude of ecological impacts and the strength of such evidence.

2. To address the risk NIS pose on marine ecosystems, the Contracting Parties to the Barcelona Convention have updated the Action Plan concerning species introduction and invasive species in the Mediterranean Sea (Decision IG.22/12 of the CoP 19) and updated/developed their national monitoring programmes based on the Integrated Monitoring and Assessment Programme (IMAP) Common Indicators per each cluster namely Biodiversity and Non-indigenous species (NIS), Pollution and Marine Litter, and Coast and Hydrography.

3. The project "Towards achieving the Good Environmental Status of the Mediterranean Sea and Coast through an Ecologically Representative and Efficiently Managed and Monitored Network of Marine Protected Areas" (hereinafter IMAP-MPA project) aims to support the national implementation of IMAP, and for the delivery of reliable data for IMAP common indicators on three clusters: (i) biodiversity and NIS, (ii) pollution and marine litter (iii) and coast and hydrography. The IMAP-MPA project will also enable the development and implementation of integrated monitoring programmes at the sub-regional level which address the same above-mentioned IMAP clusters, and particularly in areas which are known to be under human activity pressure. This project also includes another important aspect which is the elaboration of monitoring and assessment scales as well as assessment elements (i.e. assessment criteria, thresholds and baseline values) per each IMAP cluster with a focus on biodiversity and hydrography.

4. This report aims to develop monitoring and assessment scales as well as assessment criteria and to establish threshold values based on the available data for the non-indigenous species IMAP common indicator 6 (CI6) under the Ecological Objective 2 (EO2). CI6 requires "Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species", particularly invasive, non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species in the water column and seabed, as appropriate. To date the only measurement for assessing the Good Environmental Status (GES) is the number of new NIS per 6 years.

5. The environmental status of marine waters of European Union (EU) Mediterranean countries in the context of the Marine Strategy Framework Directive (MSFD) was assessed by the Member States (MSs) as part of the reporting obligations linked to the MSFD initial assessment, for most MSs in 2012 (Palialexis et al., 2014) taking 2011 as reference year for baseline. Updates of the baseline NIS check lists (Tsiamis et al., 2019) that were reported and validated my Member States are provided in Tsiamis et al. (2021b).

6. During 2018-2020, EU MSs among which eight Mediterranean countries, have, in response to their 2018 "reporting" obligations, reported on MSFD Descriptor 2 (D2) information for the last 6-year MSFD reporting cycle, following the Article 17 requirements of updating Articles 8, 9 and 10. A number of inconsistencies in D2 implementation, including the spatial and time coverage of D2 application among the MSs was highlighted by Palialexis et al. (2014) and Tsiamis et al. (2021a).

7. In order to facilitate the discussions towards the establishment of threshold values for D2 criterion 1 (D2C1)/EO2 CI6 at national, regional and inter-regional level, a questionnaire was distributed by the European Commission's Joint Research Centre (JRC) to all EU members and to the representatives of the Regional Seas Conventions and relevant stakeholders. A similar, less extensive questionnaire (see Annex and Table 1) was circulated to national NIS experts from 10 non-EU Contracting Parties (CPs) to the Barcelona Convention (namely Albania, Algeria, Egypt, Israel, Lebanon, Libya, Montenegro, Morocco, Tunisia and Turkey). The topics presented and discussed herein are based largely on the results of the aforementioned questionnaires, the resulting report for the Mediterranean EU countries (Tsiamis et al., 2021b), and data derived from recent (2017-2020) publications and the HCMR offline data base.

Table 1: Queries addressed to national experts

<table>
<tr><td rowspan="2">Species in baseline lists</td><td>Unicellular plankton species</td><td>Parasitic species</td><td>NIS introduced through natural dispersal</td><td>Cryptogenic species</td><td>Questionable species</td><td>Extinct species</td></tr>
<tr><td colspan="6"><u>To tick</u>
✔ Species reported and considered when measuring GES based on CI6
✔ Species reported but <u>not</u> considered when measuring GES based on CI6
✔ Decision should be made species-by-species, based on the available data
✔ Other</td></tr>
<tr><td rowspan="2">Monitoring schemes</td><td>at full national level</td><td>only in specific subregions of the country</td><td colspan="3">only in hotspot areas of the country
<u>to tick</u>
✔ ports
✔ aquaculture units
✔ marine protected areas
✔ other</td><td><u>NO</u> dedicated monitoring</td></tr>
<tr><td colspan="6">Monitoring efforts include
<u>To tick</u>
✔ the detection of new NIS introductions
✔ the spread of the established and/or invasive NIS
✔ the measurement of abundance/coverage/ biomass of established and/or invasive NIS
✔ the impact of established and/or invasive NIS on the native communities</td></tr>
</table>

8. This report is articulated in 3 parts, namely:

A. Assessment criteria towards preparing the baseline check lists for evaluating CI6;

B. Scales of monitoring and assessment which examines spatial and temporal scales for monitoring;
C. Thresholds values of the IMAP CI6 which examines potential thresholds under different scenarios towards EO2.

A. ASSESSMENT CRITERIA

Scope: Develop the assessment criteria for the IMAP CI6

9. Assessment criteria for preparing validated check lists of NIS to be used for assessing GES include a) taxa (all taxa or excluding phytoplankton, parasites); b) species to be considered in trends indicator (extinct species, cryptogenic species, crypto-expanding, questionable species); c) pathways to be considered (all pathways or excluding unaided expanding species, e.g. Lessepsian immigrants). With regards to the temporal scales of assessment (yearly or every 6 years) it is discussed in section B.

10. The discussions on the assessment criteria are based on the responses to the questionnaires as described earlier. The results are presented in Figure 1 and summarised in Table 3.

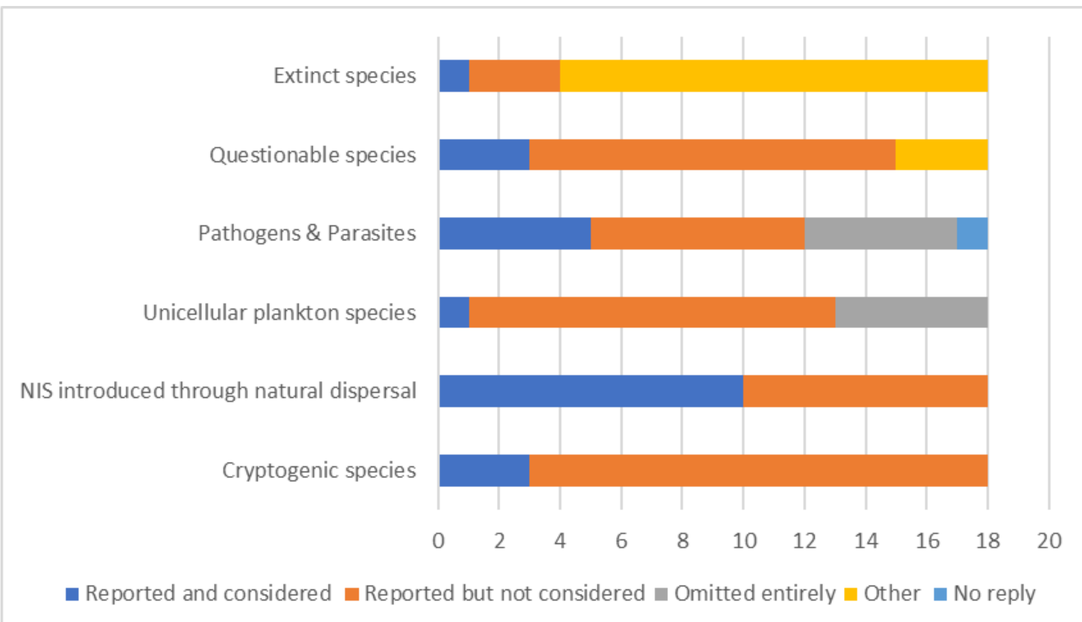

Figure 1: Responses to questionnaires by 18 Mediterranean countries

A.1. Cryptogenic species

11. Species with no definite evidence of their native or introduced status according to Carlton (1996) such is the case for some species witnessed in the old times (e.g. prior to 1800). Characteristic examples include the shipworm Teredo navalis Linnaeus, 1758, one of the earliest invasive species in the Mediterranean and most harmful marine invaders worldwide. It is not clear, whether it invaded Europe from South East Asia or whether it originated in Europe and invaded the rest of the world from there. Often NIS experts disagree on the status of a cryptogenic species in a specific area. As a result, these species may be treated as non-indigenous in some countries, while in neighbouring countries they are reported as

cryptogenic; such is the case of the ragged sea hare Bursatella leachii Blainville, 1817, a well-established species in the Mediterranean that is reported as cryptogenic in Libya and Italy but non-indigenous in Greece and Cyprus. Moreover, the status of cryptogenic can be altered in time, based on new available research data coming into light, thus changing their status. A good example is that of the annelid Chaetozone corona Berkeley & Berkeley, 1941: the species was initially reported as cryptogenic in the Mediterranean Sea (Çinar & Ergen, 2007), but it was later reported from the eastern Atlantic coast as NIS that was introduced by shipping from the East Coast of the USA (Le Garrec et al., 2017). Therefore, the species can be considered as an established NIS in the Mediterranean Sea. Cryptogenic species were not analyzed in Tsiamis et al. (2019) baseline inventories, but they were simply listed in an annex.

12. According to the questionnaires, with the exception of Algeria and Montenegro, the national experts of the CPs to the Barcelona Convention agreed that they should be reported but not considered in assessing CI6 (Figure 1). Israel suggested that they are reported separately from NIS, pending proof (taxonomic identity, status), while Lebanon suggested that in the case where the species has a significant impact, it is better to give an idea of this positive or negative impact.

13. <u>Suggestion</u>. *As the status of cryptogenic species may change in the future to NIS with new data coming to light, they should be included in NIS lists but not considered in assessing GES under CI6 unless proven to be NIS.*

A.2. Crypto-expanding species

14. Crypto-expanding species are those with no definite evidence of their native or non-indigenous status due to unclear mode of introduction from the native range (natural spread or human mediated) (Zenetos et al., 2020a). Such species in the past were classified either as alien with high degree of uncertainty with regards to their mode of introduction, or as cryptogenic or as range expanding. In the case of certain introduction that the origin is known but the pathway is dubious, it is best to assign a species to the crypto-expanding category. The term fits best species of Atlantic origin with a disjunct distribution. A good example is that of the fangtooth moray Enchelycore anatina (Lowe, 1838) that appeared in Israel in the 1970s and has established in the eastern Mediterranean, while it spread to the central Mediterranean in the 2010s but is still absent from the western Mediterranean. Another typical example is that of the nimble spray crab Percnon gibbesi (H. Milne Edwards, 1853), one of the most recent invasive species in the Mediterranean that was hitherto reported as alien. Yet, because of the high uncertainty regarding its introduction pathway (vessels, aquarium escapee, range expansion), Italy and other countries have changed its status to “cryptogenic”. Indeed, sensu lato and based on Carlton 1996 the species also falls under the term cryptogenic. However, the term crypto-expanding fits better as it specifies the cause of the cryptogenic uncertainty. There are many other cases of east Atlantic species that due to their rarity, we cannot eliminate the possibility that they have been introduced in recent years by human interference, e.g. the tropical African hermit crab Pagurus mbizi (Forest, 1955) that was reported from the Alboran Sea (García Raso et al., 2014).

15. <u>Suggestion</u>. *The status of crypto-expanding species may change in the future to NIS with new data coming to light and so they should be included in NIS lists but not considered in assessing GES.*

A.3. Range expanding and vagrant species

16. By definition, natural shifts in distribution ranges (e.g. due to climate change or dispersal by ocean currents) do not qualify a species as a NIS. This category concerns:

a) Atlanto-Mediterranean species: There are many species in the Mediterranean NIS check lists, of Atlantic origin, that have expanded their geographic range via natural dispersal; and

b) Vagrant species: The term 'vagrant' has been used for large species belonging to the offshore nekton (mainly perciform fishes, sharks, large cephalopods and marine mammals) recorded occasionally as isolated animals.

17. Essl et al. (2019) proposed the term "neonative" for those taxa that have expanded geographically beyond their native range and that now have established populations, whose presence is due to human-induced changes of the biophysical environment, but not as a result of direct movement by human agency, intentional or unintentional, or to the creation of dispersal corridors such as canals, roads, pipelines, or tunnels.

18. As the term is rather complicated, we suggest the use of the term Range expansion. Range expanding species were initially included in the first annotated list of alien species in the Mediterranean Zenetos et al (2005, 2008) but were subsequently excluded (Zenetos et al., 2012). Table 2 includes 35 taxa classified as range expanding, and six as vagrant species in Zenetos et al. (2012). To these, some additional species are included while 2 species have been re-assigned to other categories. In particular, Fistularia petimba reported from Spain was considered as range expanding until it was discovered in Israel (Stern et al., 2017) where it is considered a Lessepsian immigrant. In contrast, Halavi's guitarfish (Glaucostegus halavi), which was reported from Egypt by Tortonese (1951), is added to the list as a very old record of a vagrant species.

19. In recent publications addressing NIS, range expanding species are listed as introduced and/or newcomers but are not considered as NIS (Evans et al., 2015; Grimes et at., 2018). In the Marine Mediterranean Invasive Alien Species (MAMIAS) Database, range expanding species are included but clearly classified as such.

20. <u>*Suggestions*</u>*. Range expanding species should not be included in NIS lists for assessing GES.*

Table 2: Range expanding and vagrant species in the Mediterranean. In bold, recent changes

group	Species	Zenetos et al. 2012		
Crustacea	***Cancer bellianus***		range expansion	2012, Spain: Carrido & Pena-Rivas in Mytilineou et al., 2016
Crustacea	*Scaphocalanus amplius*	range expansion	range expansion	
Crustacea	*Scaphocalanus brevirostris*	range expansion	range expansion	
Crustacea	*Scolecithrix valens*	range expansion	range expansion	
Crustacea	*Sphaeroma venustissimum*	range expansion	range expansion	
Crustacea	*Synalpheus tumidomanus africanus*	range expansion	range expansion	
Echinodermata	***Coronaster briareus***		range expansion	2015, Malta: Evans et al, 2016
Echinodermata	***Luidia atlantidea***		range expansion	2013, Spain: Gallardo-Roldan et al., 2015
Elasmobranchii	*Carcharhinus altimus*	vagrant	vagrant	
Elasmobranchii	*Carcharhinus falciformis*	vagrant	vagrant	
Elasmobranchii	*Galeocerdo cuvier*	vagrant	vagrant	
Elasmobranchii	***Glaucostegus halavi***		vagrant	Egypt: Tortonese, 1951
Elasmobranchii	*Isurus paucus*	vagrant	vagrant	
Elasmobranchii	***Mobula japanica***		vagrant	2014, Tunisia: Capape, 2015
Elasmobranchii	*Rhizoprionodon acutus*	vagrant	vagrant	
Elasmobranchii	*Sphyrna mokarran*	vagrant	vagrant	
Macroalgae	*Osmundea oederi*	range expansion	range expansion	
Miscellanea	*Clytia mccradyi*	range expansion	range expansion	
Miscellanea	*Eirene viridula*	range expansion	range expansion	
Osteichthyes	*Acanthurus monroviae*	range expansion	range expansion	
Osteichthyes	*Aluterus monoceros*	range expansion	range expansion	
Osteichthyes	*Anarhichas lupus*	range expansion	range expansion	
Osteichthyes	*Beryx splendens*	range expansion	range expansion	
Osteichthyes	*Cephalopholis taeniops*	range expansion	range expansion	
Osteichthyes	*Dicologlossa hexophthalma*	range expansion	range expansion	
Osteichthyes	*Diodon hystrix*	range expansion	range expansion	
Osteichthyes	*Diplodus bellottii*	range expansion	range expansion	
Osteichthyes	*Enchelycore anatina*	range expansion	**Crypto-expanding**	
Osteichthyes	*Fistularia petimba*	range expansion	**ALIEN**	
Osteichthyes	*Gephyroberyx darwini*	range expansion	range expansion	
Osteichthyes	*Gymnammodytes semisquamatus*	range expansion	range expansion	
Osteichthyes	*Halosaurus ovenii*	range expansion	range expansion	
Osteichthyes	*Kyphosus incisor*	range expansion	range expansion	
Osteichthyes	*Microchirus boscanion*	range expansion	range expansion	
Osteichthyes	*Pagellus bellottii*	range expansion	range expansion	
Osteichthyes	*Pisodonophis semicinctus*	range expansion	range expansion	
Osteichthyes	*Scorpaena stephanica*	range expansion	range expansion	
Osteichthyes	*Seriola carpenteri*	range expansion	range expansion	
Osteichthyes	*Seriola fasciata*	range expansion	range expansion	
Osteichthyes	*Seriola rivoliana*	range expansion	range expansion	
Osteichthyes	*Solea senegalensis*	range expansion	range expansion	
Osteichthyes	*Sphoeroides marmoratus*	range expansion	range expansion	
Osteichthyes	*Sphoeroides pachygaster*	range expansion	range expansion	
Osteichthyes	*Synaptura lusitanica*	range expansion	range expansion	
Osteichthyes	*Syngnathus rostellatus*	range expansion	range expansion	
Osteichthyes	***Taractes rubescens***		range expansion	2014, Italy: Fiorentino et al. in Karachle et al., 2016
Osteichthyes	*Trachyscorpia cristulata echinata*	range expansion	range expansion	
Osteichthyes	***Zenopsis conchifer***		range expansion	2004, Tunisia Ben Souissi et al, 2007

A.4. Partly-native species

21. Several species are native in a Mediterranean country while they are non-indigenous in other Mediterranean countries. A typical example is that of the macroalgae *Fucus spiralis* Linnaeus. At the frontiers of its native range (Morocco and southern Spain) it is considered as native (marginal dispersal), but is alien in France (Verlaque et al., 2015). Two molluscan species, are considered as partly alien in the Mediterranean:

- *Gibbula albida* (Gmelin, 1791) has been considered a native species to the Adriatic Sea, but an alien in the western Mediterranean Sea due to recent introductions into the Ebro Delta (Spain) and the French Mediterranean lagoons (see Zenetos et al., 2010). Molecular data is necessary to elucidate whether past and current western Mediterranean distributions of *G. albida* are due to human activities.
- *Siphonaria pectinata* (Linnaeus, 1758) is native to the South Mediterranean from the Strait of Gibraltar, the African coastline up to Algeria and the Spanish coastline up to Murcia/Valencia area. While the species was considered as alien in Croatia and Greece, the known historical range of *S. pectinata* sensu stricto in the Mediterranean basin is unclear and widely debated (Crocetta, 2016). However, in the absence of past sightings, there is a general agreement in considering that the Greek and Croatian records are the result of a human induced introduction.

22. Other species falling into this category are zooplanktonic species such as the colonial jellyfish *Muggiaea atlantica* (Cunningham, 1892). Since the mid-1980s, *M. atlantica* has progressively colonized the Western Mediterranean (Riera et al.,1986) and Adriatic where it was initially considered as alien (Kršinic & Njire, 2001); However, its presence is probably in response to hydrological variability that occurred under the forcing of large-scale climate oscillations (Licandro et al., 2012).

23. Suggestion: *Partly native NIS should be reported under CI6 but be considered case by case when measuring GES at the subregional scale.*

A5. NIS introduced through natural dispersal / Lessepsian species

24. For most species introduced via the Suez Canal, there is some uncertainty as to the vector of their introduction in the Mediterranean. We call Lessepsian those Red Sea species that have invaded the Mediterranean. In the first area, they were detected / reported the assigned pathway to them is Corridor. When they spread to neighbouring countries / seas, the most appropriate pathway is “unaided”. This applies well to fishes. However, in many cases there is no evidence that the species is exclusively transferred unaided and not through human-mediated activities, such as shipping (Palialexis et al. 2014).

25. At pan-European scale, Tsiamis et al. (2021b) suggested that these NIS should be reported in D2C1 application. However, there was a debate if these NIS should be also considered when measuring GES based on D2C1. This debate is more intense within Mediterranean countries (Figure 1). Apart from Cyprus, all Levantine countries suggested that they are included and considered, arguing that they are NIS and require management as such.

26. Suggestion*: Unaided NIS should be handled case-by-case for CI6 based on pathways certainty, availability of data, and the impact caused by them. For example, for fish species that are exclusively*

transferred unaided (true Lessepsian immigrants), such data should be omitted. However, NIS that are included in the Union concern list of the EU Invasive Alien Species Regulation 1143/2014 such as the striped eel catfish Plotosus lineatus ((Thunberg, 1787) and the pufferfish Lagocephalus sceleratus (Gmelin, 1789) (candidate for inclusion in 2021), must be reported and considered for GES in CI6 assessments. It was further suggested that a list of Lessepsian fish among the invasive ones with documented considerable impact on biodiversity be prepared and agreed by the countries for inclusion in assessing GES.

6. Unicellular plankton species

27. The introduction of marine microalgae in the Mediterranean Sea is hard to document. The list of Indo-Pacific taxa in the Mediterranean (Lakkis & Zeidane, 2004) is full of dubious or poorly known species. Zenetos et al (2005) compiled an extensive list of phytoplanktonic species (alien, cryptogenic and questionable) which in subsequent updates was removed (Zenetos et al., 2010). Phytoplankton invasions go totally unobserved in the case of rare species, which are a conspicuous part of the phytoplankton biodiversity in all seas. In addition, to prove that a species is an alien requires very sound background knowledge of the species of a given area. Unfortunately, the diversity of marine microalgae is scarcely known in wide areas of the Mediterranean Sea, e.g. the southern shores, where only a few sites have been investigated, or the offshore waters, where studies are limited to occasional sampling during cruises. Even in the northern Mediterranean waters the knowledge of the distribution of these unicellular organisms in a given area is far from being exhaustive (Zenetos et al., 2010).

28. Most of the recent checklists on Mediterranean NIS have excluded unicellular taxa (Zenetos et al., 2017; Galil et al, 2018) because the origin of many unicellular taxa is in doubt and subject to revisions. Recently, Gomez (2019) argued that most diatoms and dinoflagellates reported in the literature as NIS are in fact examples of marginal dispersal associated with climatic events instead of species introductions from remote areas. He concluded that the number of non-indigenous phytoplankton species in European Seas has been excessively inflated.

29. In response to the questionnaire, five countries proposed omission of unicellular plankton species until molecular-based evidence clarifies taxonomic and biogeographical identity. Apart from Turkey that suggested full consideration of phytoplankton, all other countries proposed that they are reported but not considered in assessing GES (Figure 1).

30. Suggestion: *It is proposed that unicellular plankton NIS should be treated with caution (e.g. flagged with high uncertainty) until further research clarifies their enigmatic status. Therefore, their consideration in assessing GES should be decided on a case-by-case basis.*

A.7. Pathogens and parasites

31. Pathogens and parasites have been included in Mediterranean NIS lists both at basin level (Zenetos et al., 2008) and at country level (e.g. Libya: Shakman et al., 2019; Tunisia: Ounifi-Ben Amor et al., 2016; Israel: Galil et al., 2020). The Aquatic Animal Health Directive (2006/88/EC; EU, 2006) covers pathogens and parasites on marine farmed animals, but in the Mediterranean and in particular the eastern and central subregions, the vast majority of the alien parasites are platyhelminthes, all reported as fish parasites, that have co-invaded the Mediterranean through the Suez Canal on Red Sea immigrant hosts. Parasitic NIS may have a substantially high impact on the native communities. El-Rashidy & Boxshall (2009) provided evidence of alien parasites switching to native hosts.

32. The responses to the questionnaires varied (Figure 1) but the majority suggested omission or inclusion in the list but not to be considered in measuring GES. Five countries (EL, TR, IL, LY, AL) suggested that they are included and considered. Israel argued that parasites are important ecologically and economically and as such they ought to be reported.

33. Suggestion*: Parasites and pests NIS should be reported under CI6, but considered when measuring GES case by case - excluding parasites and pathogens that fall under the Animal Health Directive, e.g. those transferred with oysters, mussels.*

A.8. Questionable species

34. Questionable species are those species with unresolved taxonomic status: species complexes, or non-validated NIS entries coming from citizen-science, or records not supported by morphological studies and lack reference material, and which in most cases are likely to be misidentifications of native species; or records showing discrepancies in morphology and/or ecology that might suggest the occurrence of an overlooked undescribed native species. Many polychaete species fall in this category. Questionable species were not further analyzed in Tsiamis et al. (2019) baseline, but they were simply listed in an annex.

35. Questionable records are included in MAMIAS and in many Mediterranean NIS checklists (Langeneck et al., 2020; Stulpinaite et al., 2020). According to Tsiamis et al. (2021b), there was a unanimous agreement to report questionable species, but not consider them when measuring GES. Greece, Cyprus and Algeria suggested inclusion, but the majority of the national experts suggested that they should be listed but not considered until their status is resolved, or omitted from NIS lists (Figure 1). Lebanon suggested that in the case where the non-indigenous species has a significant impact, it is better to give an idea of this positive or negative impact.

36. Suggestion*: As the status of questionable species may change in the future to NIS with new data coming to light, they should be included in NIS lists but not considered in assessing GES until the status of a particular species is fully resolved.*

A.9. Extinct species

37. In the Mediterranean Science Commission (CIESM) atlas series, alien species recorded before 1920 (of Indo-Pacific origin) or 1950 (of Tropical Atlantic origin) were excluded as extinct. In an ongoing review, any species reported only once before 1970 is removed from NIS lists. Moreover, for mollusca, any record based on empty shells reported only once before 2010 is excluded (Zenetos et al. in preparation). However, all extinct and excluded species are marked as such with low confidence level.

38. Tsiamis et al (2021b) agreed that these species should be investigated in terms of: a) dates of old records, b) continuity of records, c) size of the species, d) difficulty on taxonomic identification, e) area's conditions and characteristics, f) monitoring effort and its continuity, and g) possible pathway of introduction, e.g. very old records of species released from aquaria should be excluded.

39. According to the questionnaire responses, most countries (14/18) suggested that the decision should be made species by species depending on taxon, research effort, regional data, etc.

40. Suggestion*: In agreement with Tsiamis et al (2021b), the majority of the national experts proposed to include such species in the reports, on a case by case based on the available data* (Figure 1).

A.10. Freshwater species

41. In the first EU baseline inventory for D2 (Tsiamis et al., 2019), freshwater species were not considered although they were included by several MSs when these species have been also found in their coastal waters. Examples of freshwater species reported from Mediterranean lagoons are the Chinese mitten crab *Eriocheir sinensis* H. Milne Edwards, 1853, the red swamp crayfish *Procambarus clarkii* (Girard, 1852) and the Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758). Although these species live in freshwater ecosystems, they can withstand brackish waters and inhabit estuarine habitats. *Eriocheir sinensis*, which was reported from France and Italy, was to date missing from marine aliens check lists until it reappeared in the Adriatic (Crocetta et al., 2020). An undetected population already thriving in the area is suspected, as the Adriatic Sea could be a new perfect house for this invader. *Procambarus clarkii,* which is included along with *E. sinensis* in the list of species of Union concern pursuant to Regulation (EUR-lex, 2016), is present in a Mediterranean coastal lagoon in the Albufera Natural Park, Valencia, Spain since 1976 and continues to be present for four decades (Martín-Torrijos et al., 2021). *Oreochromis niloticus* is present in the coastal lagoon of Italy (Azzurro & Cerri, 2021) and Turkey (Innal, 2020).

42. Suggestion. *CI6 assessments should include all NIS found regardless of their marine/freshwater status provided they are found in coastal systems of the country.*

Table 3:Summary of responses to the questionnaire

Species categories	To be reported	To be considered for the assessment
Cryptogenic	YES	NO
Crypto-expanding	YES	NO
Range-expanding	NO	NO
Partly native	YES	Per case
NIS introduced through natural dispersal	Case by case	Per case
Questionable	YES	NO
Unicellular marine algae	YES	Per case
Parasites	YES	Per case

Extinct species	Case by case	Per case
Freshwater	YES	Per case

43. From the above categories, it is suggested that **partly native species, NIS introduced through natural dispersal, unicellular marine algae, parasites, extinct and freshwater species** should be considered in CI6 assessments on a case-by-case basis.

B. SCALES OF MONITORING & ASSESSMENT

Scope:

- **Revise the existing scale of monitoring and further work on developing adequate scales of monitoring for the IMAP CI related to NIS**
- **Develop scale of assessment**

B1. Geographical unit for implementation of CI6

44. Assessment of threshold values based on the trends indicator (CI6) calculated to date can be achieved at the basin and country level, although it is more meaningful to be assessed at the national part of a subregion, e.g **Greece:** EMED, CMED, ADRIA; **Italy:** WMED, CMED, ADRIA, **Tunisia**: WMED, CMED. For borders between subregions see Figures 2 ~~and 3~~.

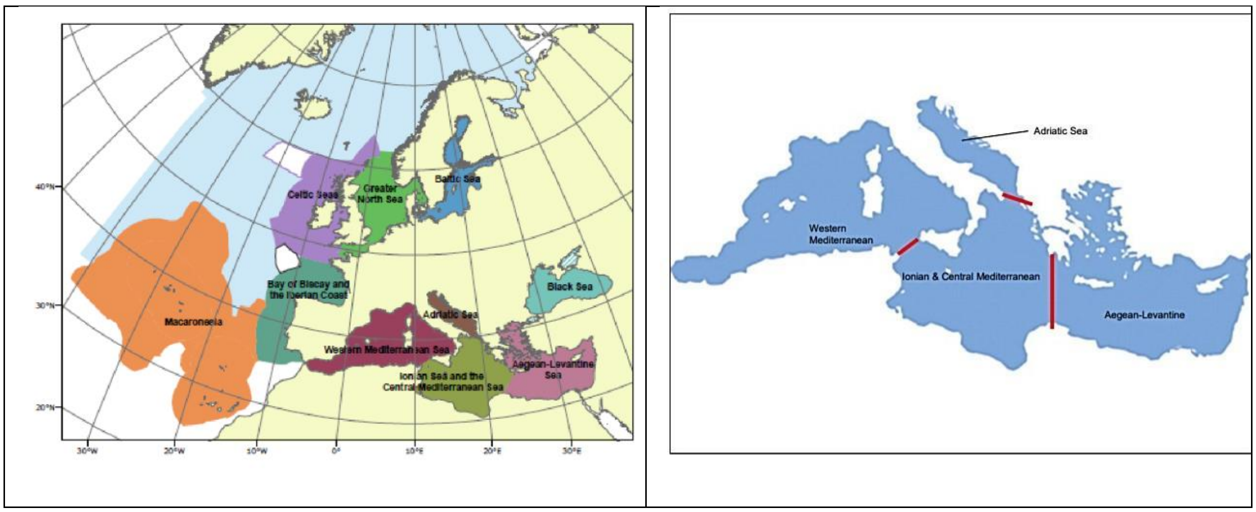

Figure 2. left: Representation of the marine regions and subregions of MSFD Article 4. (from Jensen et al., 2017) -right: EcAp subregions for the Mediterranean adopted by the CPs of the Barcelona Convention (Decision IG.20/4, 2012)[1]

45. <u>Suggestion</u>*: The geographic borders of the Mediterranean EcAp subregions be fully harmonized with those proposed by EU countries and adopted by the European Environment Agency (Jensen et al., 2017). (Figures 2 ~~and 3~~).*

B.2. Monitoring of marine NIS

46. The monitoring of NIS generally should start on a localized scale, such as risk areas and "steppingstone areas" for non-indigenous species introductions. Such areas include ports and their surrounding areas, docks, marinas, aquaculture installations, heated power plant effluents sites, offshore

[1] Disclaimer: The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries."

structures. Areas of special interest such as marine protected areas, lagoons etc. may be selected on a case-by-case basis, depending on the proximity to non-indigenous species introduction risk areas . The selection of the monitoring sites should therefore be based on a previous analysis of the most likely “entry” points of introductions and risk areas expected to contain elevated numbers of alien species. (Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria, UN Environment/MAP Athens, Greece,2017).

47. With the application of the risk-based approach, it is possible to obtain an overview of the NIS present at a large spatial scope while only monitoring a relatively small number of locations. While Rapid assessment protocols (Pedersen et al., 2003; Ashton et al., 2006) target all fouling macroinvertebrate taxa, “rapid assessment surveys” target a predefined list of species, involve an onsite team of experts, and generally last an hour (Katsanevakis et al., 2011). As the most effective monitoring method, a Rapid Assessment Survey (RAS) is suggested to be carried out in risk areas (e.g. ports and their surrounding areas, docks, marinas, aquaculture installations, heated power plant effluents sites, offshore structures).

48. The IMAP Common Indicator Guidance Factsheets (Biodiversity and Fisheries) propose Monitoring at “hot-spots” and “steppingstone areas” for NIS introductions would typically involve more intense monitoring effort, e.g. sampling at least once a year at ports and their wider area and once every two years in smaller harbours, marinas, and aquaculture sites.

49. For the estimation of Common Indicator 6, it is important that the same sites are surveyed each monitoring period, otherwise the estimation of the trend might be biased by differences among sites. Standard monitoring methods traditionally being used for marine biological surveys, including, but not limited, to plankton, benthic and fouling studies described in relevant guidelines and manuals are suggested for studying NIS.

50. At basin scale, monitoring protocols of the IMAP CI6 on NIS in the Mediterranean were developed and endorsed by the CPs to the Barcelona Convention in 2019 under the framework of the EcAp/IMAP process (UNEP/MED WG.467/16 (2019) “Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species”).

51. In some EU Mediterranean countries, monitoring protocols are used in implementing EU policies such as the Ballast Water Management Convention, the EU Water Framework Directive, and the Marine Strategy Framework Directive. These methods may be useful for the estimation of CI 6. The EU Project BALMAS has provided guidelines for the monitoring of NIS in ballast water (David & Gollasch, 2015). An international standardized monitoring protocol for sessile fouling species, developed by the Smithsonian Environmental Research Center (SERC), the SERC protocol, was employed for the first time in La Spezia, Mediterranean Sea (Tamburini et al., 2019). The second Summer School on “Monitoring marine alien species in ports with the SERC protocol”, organized by the University of Pavia (Italy) and the Smithsonian Environmental Research Center (USA), has been scheduled in Pavia (Italy), June28-July 2,2021 (http://aliensummerschool.unipv.it).

52. The compilation of citizen scientists’ input, validated by taxonomic experts, can be useful to assess the geographical ranges of established species or to early record of new species. Recent developments in citizen science (CS) provide an opportunity to improve data flow and knowledge on NIS. At the same time advances in technology, particularly on-line recording and smartphone apps, along with the development of social media (Table 4), have increased connectivity while new and innovative analysis techniques are emerging to ensure appropriate management, visualization, interpretation and use and sharing of the data (Roy et al., 2018).

Table 4. Citizen Science networks/ FaceBook groups in the Mediterranean, focusing / including NIS, that are active at county or basin level.

Citizen science name	Manager	Geographic coverage	Link
Oddfish	FB group	Mediterranean	https://www.facebook.com/groups/1714585748824288/
Is it Alien to you? Share it!!!	NGO	Greece and Cyprus	https://www.facebook.com/groups/104915386661854/
Mediterranean Marine Life	FB group	Mediterranean	https://www.facebook.com/groups/396314800533875/
البحر اللبناني —Sea Lebanon	FB group	Lebanon	https://www.facebook.com/groups/109615625861815/
Marine Life and Biodiversity in	FB group	Lebanon	https://www.facebook.com/groups/351425191625456/
Invasive Species in Albanian Coast	NGO	Albania	https://www.facebook.com/groups/1377118565724588/
AlienFish	NGO	Italy	https://www.facebook.com/alienfish/?ref=br_rs
Marine Biology in Libya	NGO	Libya	https://www.facebook.com/MarineBiologyinlibya/
Aliens in the Sea	Project	Italy	https://www.facebook.com/Progetto-Aliens-in-the-sea-
Spot the Alien	FB group	Malta	https://www.facebook.com/aliensmalta/
Ellenic Network on Aquatic	Network	Greece	https://elnais.hcmr.gr/
Seawatchers	Web Based Platform	Mediterranean	https://www.observadoresdelmar.es/
MedMIS	IUCN	Mediterranean	http://www.iucn-medmis.org/?c=About/show
Opisthobranchia	Network	Mediterranean	https://opistobranquis.info/en/
Hellenic Conches	Malacologists	Greece	https://www.facebook.com/groups/helleniconches/
i-naturalist	Web Based Platform	Global	https://www.inaturalist.org/

53. The monitoring on marine NIS differs across Mediterranean countries. According to questionnaires, to date, only one Mediterranean country has a monitoring scheme on marine NIS applied at fully national level (Table 5), while five countries have no monitoring running or at least not implemented yet. In Algeria for example, the network of observing areas and sampling stations has been identified in the

Algerian monitoring programme but not implemented yet. In Tunisia, the Ministry of Environment had established "The strategy and an action plan for the prevention, management and control of invasive alien species in Tunisia" since 2018, but the implementation may take some time. However, individual initiatives are conducted in hotspot areas (lagoons, ports, marinas and MPA's).

54. On the other hand, the majority of countries do not have a dedicated strategy but have a monitoring strategy including marine NIS applied either at risk areas of the country or in specific subregions through a related network of sampling stations, e.g. Saronikos Gulf in Greece. Hot-spot areas for NIS monitoring include mainly ports and marine protected areas (Table 6). NIS related data in the majority of countries, where no monitoring is in place, come mainly from various research projects. In EU countries, NIS data is derived from monitoring under the WFD and/or the MSFD.

Table 5. Monitoring strategy on marine NIS in the Mediterranean Sea

	CY	EL	ES	FR	IT	HR	MT	SI	EG	LY	LB	DZ	MA	IL	TN	AL	ME	TR
NIS monitoring at full national level through a network of sampling stations						1												
NIS monitoring only at specific subregions of the country through a network of sampling stations										1	1							
NIS monitoring only in hot-spot areas of the country	1	1	1	1	1		1	1	1			1						1
NO dedicated monitoring on NIS exists													1	1	1	1	1	

Table 6. Hot-spot areas for marine NIS monitoring in the Mediterranean Sea. (NA= no monitoring)

	CY	EL	ES	FR	IT	HR	MT	SI	EG	LY	LB	DZ	MA	IL	TN	AL	ME	TR
Ports		1	1	1	1		1	1	1	1		1						
Aquaculture units				1	1			1										
Marine protected areas	1		1				1		1	1		1						1
Other			1					1	1			1	NA	N A	N A	N A	NA	

55. Targets of NIS monitoring include mainly the detection of new NIS and the measurement of abundance/coverage/biomass of established and/or invasive NIS (Figure 3).

56. Many countries study NIS (coverage, impact) through the study of specific habitats, e.g. Morocco under the monitoring of some key habitats such as coralligenous and seagrass beds; Tunisia by monitoring algae and phanerogams and lately fauna. Studies are often conducted in the framework of MSc and PhD theses.

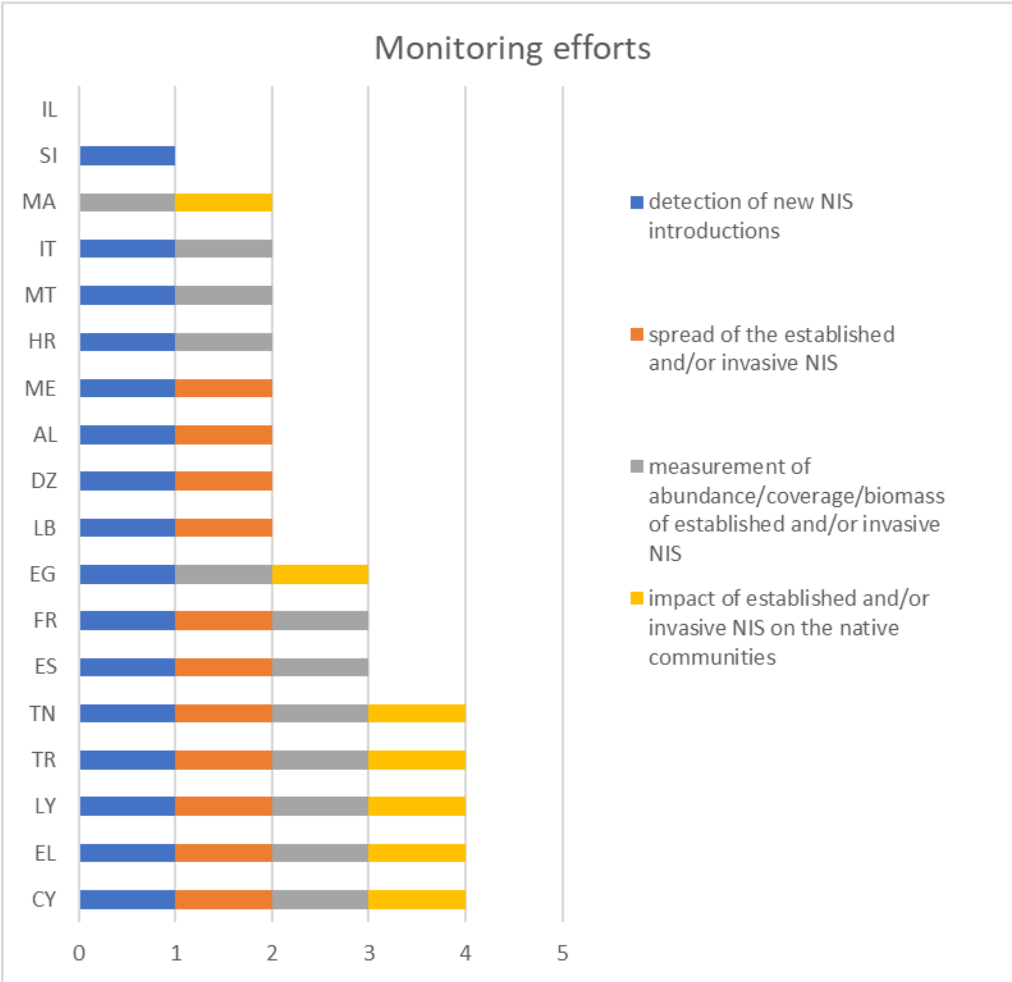

Figure 3. Targets of marine NIS monitoring in the Mediterranean as reported by the countries. Israel and Montenegro did not reply as they stated there is no monitoring in place To be revised with new ME data

B3. Assessment period for CI6 implementation

57. Based on EU (2017) assessment criteria for D2, the assessment period covers a 6-years period measured from the reference year as reported for the initial assessment (2011, reported in 2012). However, not all EU countries reported in 2012 for the 2006-2011 period; nor in 2018 for the 2012-2017 period (Tsiamis et al., 2021a). Considering the time lags in reporting NIS, which vary a lot (Figure 4) among Mediterranean countries and taxonomic groups (Zenetos et al., 2019), a baseline for IMAP CI6 should be covered sufficiently (be representative of the NIS status by **2017).** EU MSs have agreed that the next assessment should cover the 2018-2023 period. For consistency and harmonization reasons, the assessment period of CI6 should be the same across Mediterranean countries.

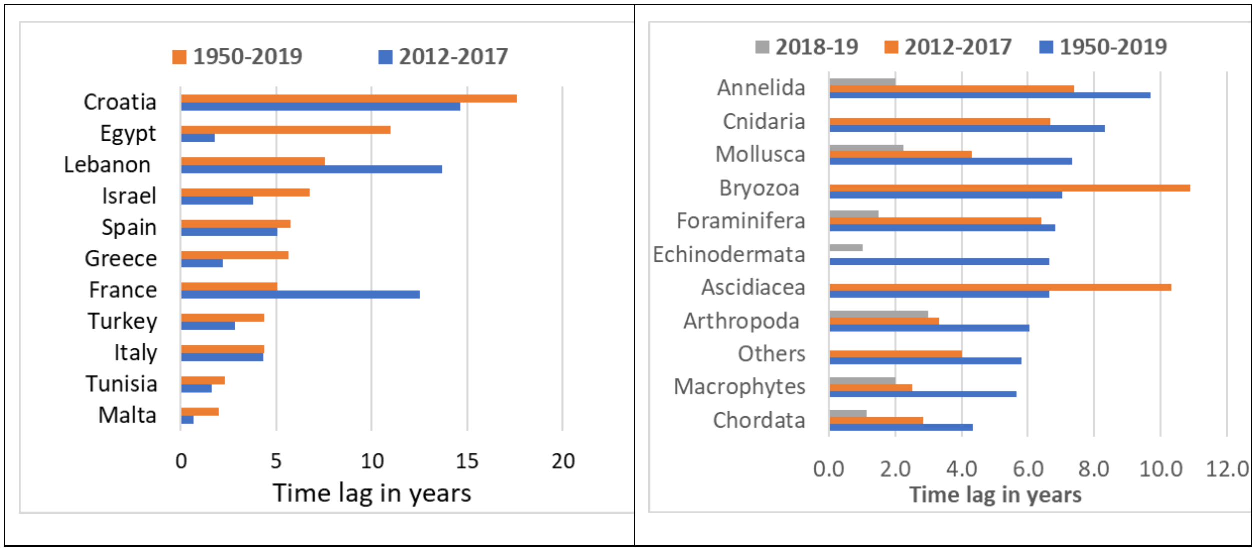

Figure 4. Average time lags in reporting of NIS in association with the country (left) of their first collection in the Mediterranean and their main taxonomic groups (right). Source: Zenetos et al., 2019

58. CI6 assessments are missing from non-EU Mediterranean countries but trends in new introductions can be deducted from recent publications [Algeria (Grimes et al., 2018; Bensari et al., 2020; Bakalem et al., 2020, Libya (Shakman et al., 2019); Montenegro (Petović et al., 2019; Pešić et al., 2020); Israel (Galil et al., 2020)], and updates. Figure 5 depicts the cumulative number of NIS in Libya and Algeria, while Figure 6 shows the trends in new NIS as required by CI6.

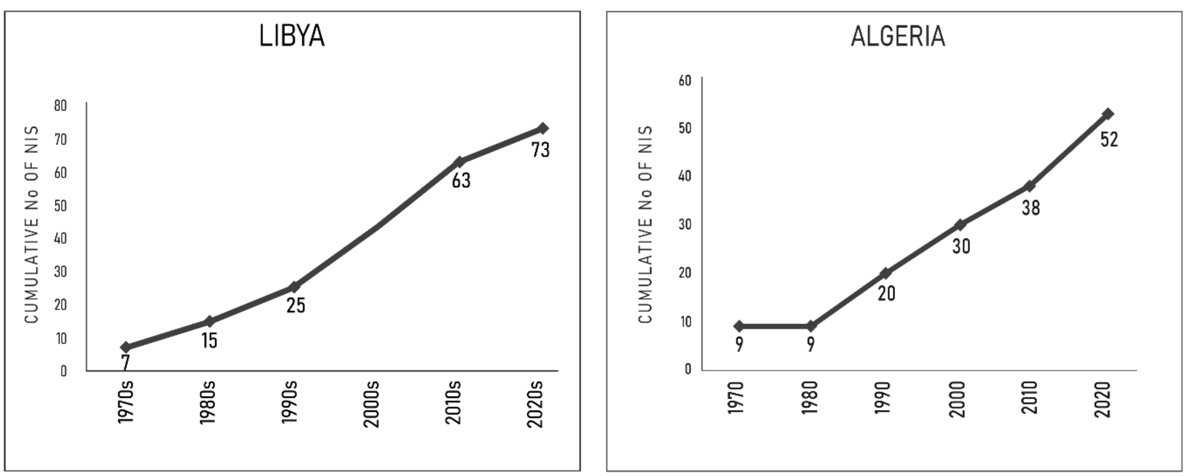

Figure 5. Cumulative trend in NIS reported for Libya (Shakman et al., 2019) and Algeria (Grimes et al., 2018; Bensari et al., 2020; Bakalem et al., 2020).

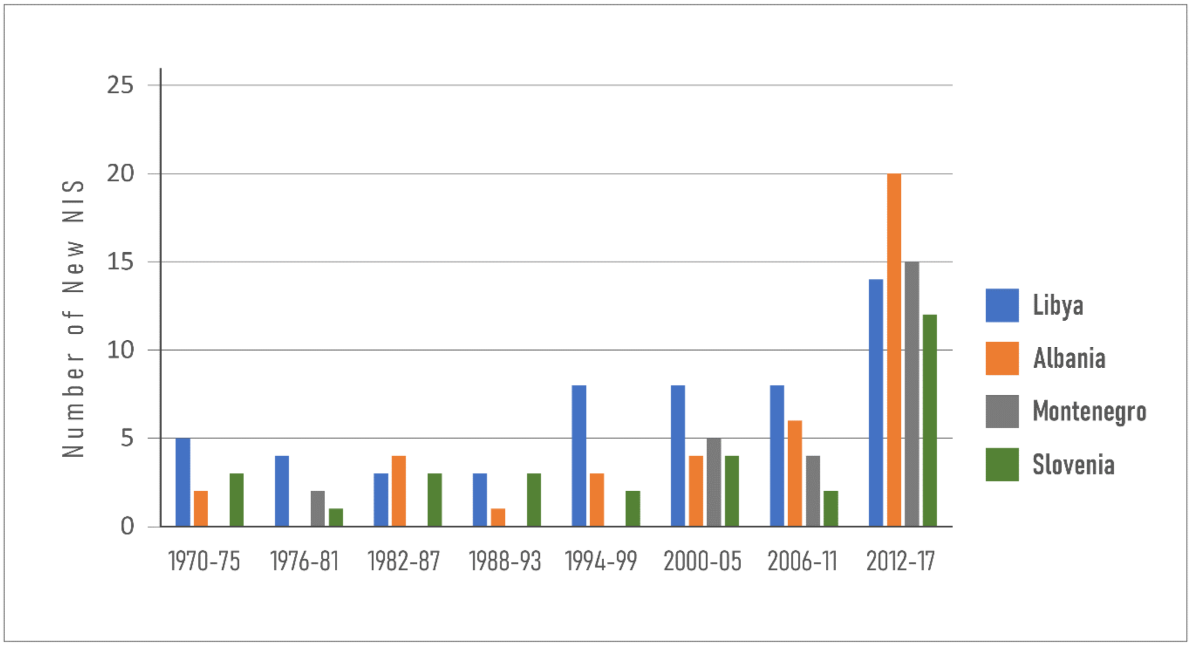

Figure 6. Trends in new marine NIS per 6 year since 1970 (source: HCMR database)

59. The high number of new NIS in all countries is clearly the result of increased scientific effort. In Slovenia, Montenegro and Albania for example, approximately half of NIS detected until 2017 resulted from the BALMAS project (Ballast water management system for Adriatic Sea protection) that run in the period November 2013 – March 2016 (Petović et al., 2019; Spagnolo et al., 2019). On the other hand, recent research in Tripoli harbour (Libya) and the contribution of citizen scientists (Mannino et al., 2021) has revealed more than 13 new NIS in the last 3 years (2018-2020) some of which, such as gastropods *Cerithium scabridum* Philippi, 1848 and *Diodora ruppellii* (G.B. Sowerby, 1835) are among the older Mediterranean invaders (known since 1883 and 1939 respectively) that were presumably undetected (Rizgalla et al., 2019a,b). Therefore, for some countries **even 2017 as the reference year, appears to be premature**.

60. Considering all pathways, it is clear that the rate of new introductions differs significantly among subregions and is increasing with time (Zenetos et al., 2012). However, as reported by Zenetos (2019), this increase does not necessarily imply increasing introduction but rather increasing scientific effort.

61. Suggestion: *For harmonization of assessments between EU and non-EU countries, it is proposed to keep the main assessing periods as proposed for EU (Tsiamis et al., 2021b) but take 2017 as baseline (reference year).*

Summarizing Indicator: Number of New NIS

Scale of monitoring and assessment	
Geographic	Country and subregional revel
Reference year	At least 2017 as baseline
Frequency of reporting	Every six years

C. THRESHOLDS VALUES OF THE IMAP EO2/CI6 "NON-INDIGENOUS SPECIES"

Scope: Develop the thresholds values for IMAP CI related to NIS

62. In order to define threshold values, validated check lists of NIS are needed. EU has prepared such validated lists considering all the aforementioned criteria as much as possible (Tsiamis et al., 2019; 2021b). The information on dates of first introductions and pathways of NIS can be used for establishing thresholds for D2/CI6 by analyzing time trends of new NIS introductions. At IMAP level, baseline lists validated by local experts are under preparation. In preparing these lists both published and grey literature were considered.

63. According to the Commission Decision (EU) 2017/848 of 17 May 2017 "The number of non-indigenous species which are **newly introduced via human activity** into the wild, per assessment period (**6 years**), measured from the **reference year** as reported for the initial assessment under Article 8(1) of Directive 2008/56/EC, is **minimized and where possible reduced to zero**". Moreover "Member States shall **establish the threshold value** for the number of new introductions of non-indigenous species, through regional or subregional cooperation".

64. As stated by Tsiamis et al. (2021b), for establishing the threshold values, the percentage reduction of new NIS can be used. The exact value of percentage reduction should be decided at regional and/or subregional scale, based on the pathways pressure and level of monitoring coverage of each region/subregion. The number of the previous 6-years cycle periods which will serve as the basis for defining the percentage reduction of new NIS should be ideally long, e.g. starting from the 1970s. However, the exact number of the previous 6-years cycle periods should be decided at regional and/or subregional scale, based on the history of monitoring and pathways intensity in each region/subregion.

65. At Mediterranean level, according to the description of IMAP CI6 'Trend in spatial distribution' is defined as the interannual change of the total marine 'area' occupied by a non-indigenous species. To estimate Common Indicator 6, a trend analysis (time series analysis) of the available monitoring data needs to be performed, aiming to extract the underlying pattern, which may be hidden by noise. A formal regression analysis is the recommended approach to estimate such trends. This can be done by a simple linear regression analysis or by more complicated modelling tools (when rich datasets are available), such as generalized linear or additive models.

66. The Indicator units were defined in the Guidance factsheet of CI6 as follow:

- 'Trends in abundance': absolute value and % change per assessment period
- 'Trends in temporal occurrence': number and % change in new introductions or number and % change in the total number of alien species per assessment period
- 'Trends in spatial distribution': absolute value and % change in the total marine surface area occupied or absolute value and % change in the length of the occupied coastline (in the case of shallow-water species that are present only in the coastal zone)

67. Time trends analyses can support establishing suitable thresholds for CI6 per marine subregion. The number of new NIS at subregional scale in the Mediterranean after 1970 is presented in Table 7. At first sight the highest number of NIS were detected in the 2000-2005 period. The period 2018-2020 was not considered in the analyses as the time lags between detecting and reporting a new NIS may skew the true invasion pattern (Zenetos et al., 2019).

Table 7. Number of New NIS in the EcAp subregions after 1970 (cryptogenic, crypto-expanding, questionable species, Parasites and Lessepsian fish excluded). Note: the figures are provisional. They need to be updated after validation of the national checklists (work in progress in the framework of the elaboration of a baseline of NIS in the Mediterranean)

	WMED	CMED	ADRIA	EMED
1970-75	11	13	6	25
1976-81	32	15	8	21
1982-87	29	8	10	29
1988-93	23	18	13	44
1994-99	27	18	17	74
2000-05	**37**	**30**	**26**	**78**
2006-11	30	31	33	57
2012-17	39	53	31	71
2018-20	8	9	6	31

68. As a first step, a linear regression analysis was performed for the period 2000 to 2020 at basin level (Figure 7). However, the results are inconclusive.

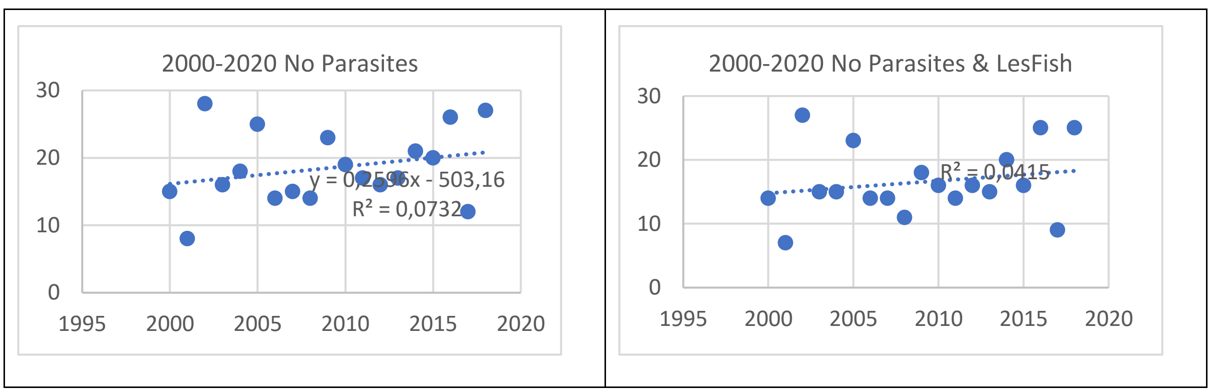

Figure 7. Number of NIS introduced (no cryptogenic, crypto-expanding, questionable species) in the Mediterranean yearly: left: excluding all parasites, right=excluding parasites and Lessepsian fish

69. Regression analysis of trends per subregion (Figure 8) depicts the variation in the rate of new NIS introductions, which ranges from 2.54 species per 6-year period in the WMED to 8.08 species per 6-year period in the EMED. A linear fit was deemed statistically acceptable based on a number of diagnostics (residual errors are normally distributed according to the Anderson-Darling test and independent according to the Durbin-Watson test), however there is still the indication of a non-linear pattern, both in the data used for the regression and in the residuals' plots. Nevertheless, the linear fit is provided as a first indication of the rate of new NIS introductions per EcAp subregion and how these rates differ between areas. Further analysis with a richer dataset is required to better elucidate these patterns.

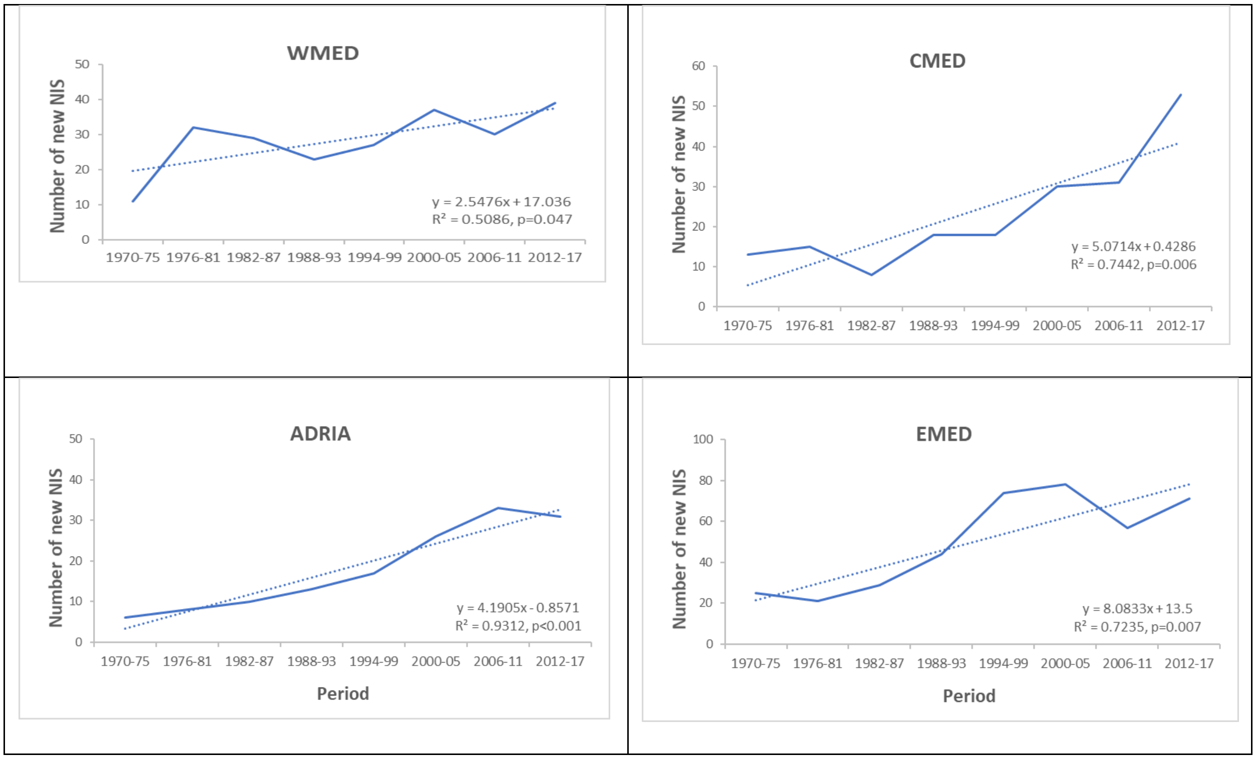

Figure 8. Trend in NIS introductions per 6-year cycle at EcAp subregions level (data in Table 7)

70. Analysis of Variance was performed on the yearly average number of new introductions to compare the values by ~~MSFD~~ EcAp area before and after the year 2000. The choice to split the data set at that particular point in time was made based on a first visual inspection of the data which indicates that an increase in the number of new introductions took place (or was reported in the literature) between 1994 and 2005.

71. The analysis was also repeated between two different time periods (1970-1993 and 1994-2017 – not shown here) with an equal number of observations per period, it resulted however in a much larger, and significant, interaction term between area and time (MS=11.529, F=4.99, p=0.008), due to the different behaviour of the response variable between the west and the east Mediterranean.

72. The analysis was performed on the raw (untransformed data) as they met the statistical requirements of normality and homogeneity of variance. Both the factors subregion (WMED, CMED, ADRIA, EMED) and time period were significant (see Table 8) but there was no significant interaction between the two factors, meaning that the number of new NIS varied in a similar way before and after 2000 for all the ~~MSFD~~ EcAp areas. More specifically, the analysis demonstrates that there is a significant increase in the rate of new NIS entering all EcAp subregions after 2000 and that this parameter is significantly different between EcAp subregions. Consequently, **the threshold values for CI6 in the Mediterranean need to be set at subregional level and not at regional level.**

Table 8. Results of the Analysis of Variance with yearly average of new NIS introductions per 6-year period as the response and EcAp subregions & Time period as the fixed factors. The levels of the two

factors were a) for EcAp subregions: WMED, CMED, ADRIA, EMED and b) for Time: before 2000 (five 6-year periods, i.e. 1970-75, 1976-81, 1982-87, 1988-93, 1994-99) and after 2000 (three 6-year periods, i.e. 2000-05, 2006-11, 2012-17).

Source	df	Ads SS	Adj MS	F value	p value
Ecap subregions	3	223.02	77.764	23.81	<0.001
Time	1	137.42	137.42	42.12	<0.001
EcAp subregions *Time	3	16.65	5.552	1.7	0.193
Error	24	78.3	3.262		
Total	31	455.49			

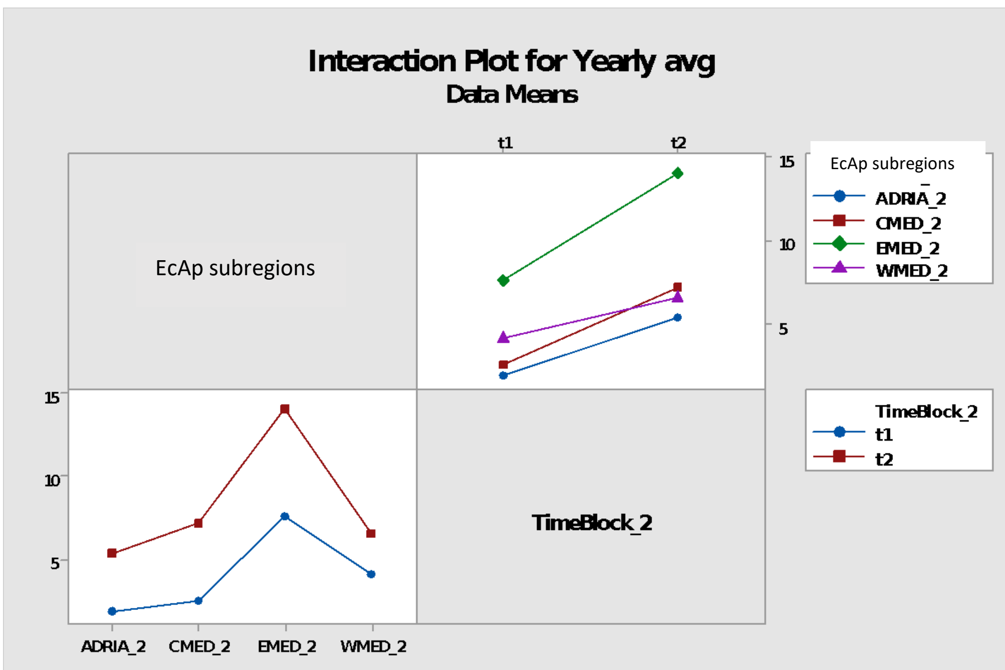

Figure 9. Interaction plot illustrating the main effects of the two separate factors (EcAp subregions and Time period) and the lack of an interaction between them.

73. The data was also analysed separately per EcAp subregion, with one-way ANOVA and time as the single factor (levels as above). In all EcA subregions, there is a clear increase in the rate of new NIS introductions after 2000, which was statistically significant in every subregion (see Table 9). This is graphically illustrated in Figure 11, where it can be seen that the number of new NIS entering/being reported per year at the sub-regional level after 2000 has roughly doubled for 3 out of 4 subregions, compared with before 2000, and is 1.5 times higher in the West Mediterranean.

74. In conclusion, we need to consider data only after 2000s in order to establish today's threshold values.

Table 9. Summary of results for the separate one-way ANOVAs for each EcAp subregions, comparing the yearly average number of new NIS introductions before and after the year 2000.

AREA	DF	F	p	R-sq
WMED	1	7.93	0.003	56.9
CMED	1	16.8	0.006	73.7
ADRIA	1	43.5	0.001	87.9
EMED	1	9.1	0.024	60.2

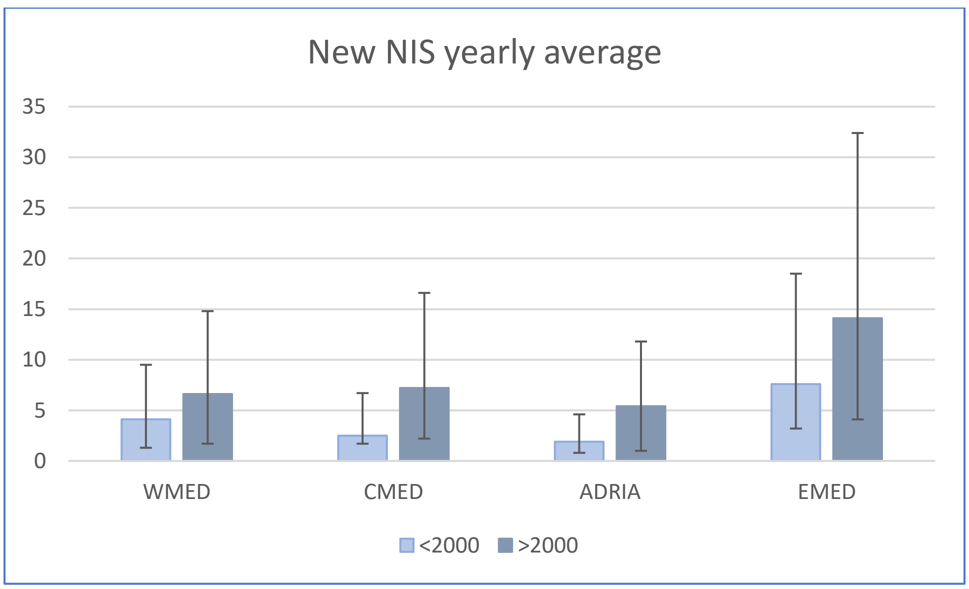

Figure 10. Yearly average number of new NIS introductions per EcAp subregion before and after the year 2000. Error bars represent 95% Confidence Intervals.

75. Trends in new NIS on 6-years cycle at national level against trends at sub-regional level were tested (Table 10) for three countries in each basin.

- ✔ For the WMED, trends were based on data provided for: Algeria (Grimes et al., 2018; Bensari et al., 2020); Morocco (MAMIAS database), and western Italy (Servello et al., 2019; Tsiamis et al., 2021b).
- ✔ For the Central Mediterranean, South Tunisia (Sghaier et al., 2017; Ounifi-Ben Amor et al., 2016; Chebaane et al., 2019); Malta (Evans et al, 2015; Tsiamis et al., 2021) and Libya (Shakman et al., 2019; Rizgalla et al., 2019a,b).

- For the Adriatic, Slovenia (Tsiamis et al., 2021), Albania (GEF ADRIATIC PROJECT) and Montenegro (Petović et al., 2019; Pešić et al., 2020)
- For the Eastern Mediterranean, Cyprus (Tsiamis et al., 2021), Greece (Zenetos et al., 2020b) and Israel (Galil et al., 2020)

76. Data in the aforementioned countries were cleaned for cryptogenic, crypto-expanding, range expanding and questionable species. Parasites, oligohaline species were not considered.

Table 10. Year Average (Yravg) of new NIS at subregional and country/region level.

Basin scale Yravg >2000	WMED=6.6	CMED=7.2	ADRIA=5.4	EMED=14.1
Country level	Algeria=0.8 Morocco=0.4 W. Italy =4.1	S. Tunisia=3.8 Malta=2.9 Libya=1.9	Slovenia=1 Montenegro=1.3 Albania=1.7	Israel=9.4 Cyprus=4.1 E. Greece=4.9

77. On looking at Table 10, it is clear that, even excluding the influx of Lessepsian NIS into the Mediterranean, which is considered a major threat for the basin, the yearly number of new NIS per country is by far lower than the average value calculated at basin scale. This would lead to the assumption that the Mediterranean coastal areas have a good GES, based on NIS. However, this assumption is contradicting the increasing trend observed in figure 8. Any trends observed are an artefact affected by a monitoring bias, which appears to be the main factor influencing the number of new NIS introductions reported both by EU and Non-EU Mediterranean countries. This was highlighted for EU countries (Zenetos, 2019; Servello et al., 2019; Zenetos et al., 2020b) but is even more evident in non-EU countries where recent research projects have attributed to a burst of new NIS, e.g. the BALMAS and GEF Adriatic Projects for Montenegro and Albania.

78. Tsiamis et al. (2021b) agreed that the most suitable approach for setting threshold values for D2C1 is to adopt the percentage reduction of new NIS, meaning that: a) the threshold is a quantitative measure, i.e. specific number of new NIS introductions during the assessment period, and b) the number of new NIS introductions is defined based on a specific percentage reduction of new NIS compared to the average number of new NIS introductions that occurred in the previous 6-years cycle periods.

79. HELCOM (2018) has set the threshold value for D2C1 = **zero new NIS**. OSPAR (2018) highlights that the relative change of the number of new NIS introductions seen over subsequent assessment periods (e.g. 6 years) can facilitate the specification of threshold values; however, OSPAR has not yet concluded in specific values.

80. For the Mediterranean, some threshold values are only indicative.

81. For Mediterranean region/subregions that have not been efficiently monitored in terms of NIS during the previous decades, a shorter time span of 6-years cycle periods should be preferred, e.g. 3 years. Moreover, dedicated monitoring of marine NIS should be established and be constant in space, time and

across taxonomic groups. Prioritization should be given to hot-spot areas of new NIS introductions, such as ports, aquaculture units and marine protected areas. This should be a prerequisite for applying the CI6 of IMAP properly, at both national and subnational level.

82. The current work is a first exploration of the available data and the concepts that will need to underpin the formulation of the threshold for CI6. While the baseline data is still being validated, further statistical analysis will be necessary to elucidate the patterns of NIS introductions in the Mediterranean such that more robust suggestions can be made both at the temporal and at the sub-regional scale**.**

83. Some initial conclusions are that thresholds should be established separately for each of the Mediterranean subregions and should be sought by examining the data of the last two decades, if not an even more recent time period. At the same time, a consensus needs to be reached about which species groups will be included in the calculations and how their environmental impact will be taken into account. These are decisions that will determine the definition of GES for EO2 and will affect the management obligations of Contracting Parties to the Barcelona Convention. As such, it is proposed that further work takes into account the contribution of regional experts not only from the fields of taxonomy, monitoring and assessment but also conservation and management and last, but not least, ecologists with strong statistical/mathematical background.

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Annex

Elaboration of the scales of monitoring and assessment, assessment criteria and thresholds values of the IMAP EO2/CI6 regarding NIS in the context of the EcAp process of the Barcelona Convention

Questionnaire

Experts on marine NIS are invited to fill-in the questionnaire below, which has largely a multiple-choice format.

Definition of NIS

Non-indigenous species (NIS; synonyms: alien, exotic, non-native, allochthonous) are species, subspecies or lower taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential. This includes any part, gamete or propagule of such species that might survive and subsequently reproduce. Their presence in the given region is due to intentional or unintentional introduction resulting from human activities.

Natural shifts in distribution ranges (e.g. due to climate change or dispersal by ocean currents) do not qualify a species as a NIS. **However, secondary introductions of NIS from the area(s) of their first arrival could occur without human involvement due to spread by natural means.** In the latter case, the species should be still considered as NIS.

Species that appear in a new area as the result of a natural dispersal coming from an area that the species is considered as native, with the facilitation of the availability of new substrate (e.g. artificial reef), are not qualified to be considered as NIS.

Non-indigenous species can include also very old introductions, that occurred even before 1492.

Question #1: **Unicellular plankton species in E02/CI6**

Unicellular plankton species have high uncertainty regarding the native *vs* non-indigenous status in European seas. There have been scattered records across Europe, but no consistency in their treatment. In Tsiamis et al. (2019) baseline there was high variance of the number of planktonic species included in the inventories, even between neighboring countries, reporting either long lists of them or just a few. More recently, Gomez (2019) argued that there is not enough evidence for tagging any plankton species in Europe as non-indigenous. For the implementation of **CI6**, unicellular planktonic NIS species should be (put a "X" in the appropriate answer):

a) reported and considered when measuring GES based on CI6	b) reported but **not** considered when measuring GES based on CI6	c) omitted entirely from CI6 assessments	d) other
(...)	()	(...)	(...)

Question #2: **Parasitic species in E02/CI6**

In Tsiamis et al. (2019) baseline parasitic NIS were omitted since from a legislative perspective they are managed under the Aquatic Animal Health Directive (2006/88/EC; EU, 2006).. However, several countries have included parasitic NIS in their **CI6**, lists. For the implementation of **CI6**, parasitic NIS species should be (put a "X" in the appropriate answer):

a) reported and considered when measuring GES based on CI6	b) reported but **not** considered when measuring GES based on CI6	c) omitted entirely from CI6 assessments	d) other
(…)	(…)	(...)	(...)

Question #3: **NIS introduced through natural dispersal in criterion CI6**

The primary criterion CI6 measures "*The number of non-indigenous species which are newly introduced* ***via human activity*** *into the wild, per assessment period (6 years), ...*". It has been argued that NIS introduced exclusively through natural dispersal from already infested areas to other neighboring areas (e.g. a NIS introduced from Lebanon to Cyprus through natural dispersal) should not be taken into consideration for defining GES based on **CI6**, unless there is evidence that the species is transferred also through human-mediated activities, Several Lessespian species fall under this category. For the implementation of **CI6**, NIS that have been introduced into country **exclusively** through natural dispersal should be (put a "X" in the appropriate answer):

a) reported and considered when measuring GES based on CI6 (…)	b) reported but **not** considered when measuring GES based on CI6 (...)	c) other (…)

Question #4: **Cryptogenic species in criterion CI6**

Cryptogenic species are those with no definite evidence of their native or non-indigenous status (due to unknown origin natural spread *vs* human mediated). Characteristic example is *Antithamnionella spirographidis* in the Mediterranean Sea. Due to the lack of enough data, it is not uncommon that NIS experts disagree on the status of cryptogenic species in a specific area. As a result, these species may be treated as non-indigenous in some countries, while in neighboring countries they are reported as cryptogenic or even as native species. For the implementation of **CI6**, species that are considered by the NIS experts as cryptogenic should be (put a "X" in the appropriate answer):

a) reported and considered when measuring GES based on CI6 (...)	b) reported but **<u>not</u>** considered when measuring GES based on CI6 (…)	c) other (...)

<u>Question #5</u>: Questionable species in criterion CI6

Questionable species are those with unresolved taxonomic status or new NIS entries not verified by experts (e.g. records coming from citizen-science but not yet validated by experts, or records in technical reports without providing the necessary taxonomic evidence). In the recent JRC exercise on pathways and dates of first introductions of NIS in each country and subregion, questionable species were excluded. Similarly, questionable species were not further analyzed in Tsiamis et al. (2019) baseline, but they were simply listed in an annex. For the implementation of **CI6**, species that are considered by the NIS experts as questionable should be (put a "X" in the appropriate answer):

a) reported and considered when measuring GES based on CI6 (…)	b) reported but **<u>not</u>** considered when measuring GES based on CI6 (…)	c) other (...)

<u>Question #6</u>: Extinct species in criterion CI6

Several NIS have been reported in a country several decades ago (even in the 19th century or before) but never recorded again in the wild in these countries, and thus are considered as extinct; presumably that the NIS did not survive in its new environment. However, it is difficult to prove if a NIS has been truly extinct from a marine area or country due to monitoring difficulties and the continuum of the marine environment. When a presumably extinct NIS is reported during the last assessment period from the same or adjacent area that was originally reported in a country, then (put a "X" in the appropriate answer):

a) it should be considered as a new introduction and measured in CI6C1 assessment (…)	b) it should **<u>not</u>** be considered as a new introduction, the species should had been overlooked (...)	c) the decision should be made species-by-species, based on the available data (…)	d) other (...)

<u>Question #7</u>: Monitoring of marine NIS for CI6

For your country, is there a dedicated monitoring scheme for marine NIS? (put a “X" in the appropriate answer):

<table>
<tr><td rowspan="2">a) <u>YES</u>, at full national level through a related network of sampling stations
(...)</td><td rowspan="2">b) <u>YES</u>, but only in specific subregions of the country through a related network of sampling stations
(…)</td><td colspan="2">c) <u>YES</u>, but only in hotspot areas of the country
(...)</td><td colspan="2">d) <u>NO</u> dedicated monitoring on NIS exists
(...)</td></tr>
<tr><td>hotspot areas include (multiple</td><td>ports (…)</td><td>relevant data on marine NIS come from</td><td>IMAP biodiversity monitoring (...)</td></tr>
</table>

		choices can be marked):	aquaculture units (...) marine protected areas (...) other (...)	(multiple choices can be marked):	various research projects (...) other (...)

Monitoring efforts on marine NIS in your country include (put a "X" in the appropriate answer; multiple choices can be marked):			
a) the detection of new NIS introductions (…)	b) the spread of the established and/or invasive NIS (…)	c) the measurement of abundance/coverage/biomass of established and/or invasive NIS (...)	d) the impact of established and/or invasive NIS on the native communities (...)

UNITED NATIONS

EP

UNEP/MED WG.502/16.Appendix F

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

22 May 2021
Original: English

Fifteenth Meeting of SPA/BD Focal Points

Videoconference, 23-25 June 2021

Agenda Item 7: Status of implementation of the Ecosystem Approach (EcAp) Roadmap

7.1. Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Implementation of the second phase (2019-2021) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and non-indigenous species) in the framework of the EcAp Roadmap

Appendix F: Progress in the Development of the Baseline Values for the IMAP Common Indicator 6 related to Non-Indigenous Species

UNEP/MAP
SPA/RAC-Tunis, 2021

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Regional and national experts consulted for various taxa:

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1. Introduction

1. Non-indigenous, invasive species are globally acknowledged as one of the major threats to biodiversity, ecosystems and the services they provide (CBD, 2010; EU, 2011). Therefore, they constitute one of the elements that are taken into consideration when assessing the health of the environment and formulating management strategies to achieve and sustain good ecological status (EU, 2008; UNEP/MAP, 2016). In the framework of the Integrated Monitoring and Assessment Programme for the Mediterranean Sea (IMAP), NIS are addressed with Common Indicator 6 (CI6), which assesses “Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas (EO2, in relation to the main vectors and pathways of spreading of such species)”. The national implementation and harmonization of IMAP across all Mediterranean countries requires the elaboration of several parameters, among which the establishment of a refined and authoritative baseline of the NIS present at the national and regional level is fundamental as a starting point for any further evaluations.

2. The present work aims to collect the available material on the presence of marine NIS in the Mediterranean countries in the form of existing national inventories, combine it with new and up-to-date information on new species records, the taxonomy and biogeography of the registered species and agreed methodological standards, to arrive at refined NIS baselines at the national and regional level. The outcome will be the result of a collaborative process at national and regional levels, involving detailed exchange of information between designated experts and the building of consensus on the final lists, as these will constitute a tool for the determination of thresholds for CI6 and will have management implications for the Contracting Parties.

2. Methodology for the elaboration of the NIS Baseline in the Mediterranean

<u>National Inventories – species records</u>

3. SPA/RAC requested the Contracting Parties to designate national expert(s) on NIS that will be in charge of the development of national list of NIS. Designated national experts exchanged information and agreed to use a template, commonly endorsed by EU member states in the framework of the MSFD. National lists received from the main Contracting Parties are detailed here after.

4. The national inventories of EU Mediterranean countries submitted to JRC in January 2021 for the purposes of the 2012-2017 assessment cycle, were made available and formed the starting point for the revision process of these 8 countries. These included data up until 2017 and were further updated with collated data up to 2020, based on major national/regional reviews (Zenetos et al., 2017 and Zenetos & Galanidi, 2020 for the whole Mediterranean, Katsanevakis et al., 2020 for previously unpublished records, Servello et al., 2019 for Italy, Zenetos et al., 2020 for Greece and publications of individual records for Croatia, Cyprus, France, Malta, Slovenia, Spain). For the rest of the Mediterranean countries, national NIS inventories were provided by national experts as per the request of SPA/RAC, for Albania, Algeria, Egypt, Israel, Lebanon, Libya, Morocco, Tunisia and Turkey. For a small number of countries that had not submitted national inventories (see Table 1 in Section 4), national baselines were created based on literature with data retrieved from the HCMR offline database.

5. Revisions of these inventories were made according to recently published literature and checklists, e.g. Algeria: Grimes et al., 2018; Libya: Shakman et al., 2019; Israel: Galil et al. 2020; Tunisia: Ounifi-Ben Amor et al., 2016; Lebanon: Bitar et al., 2017 marine plants, Bariche et al., 2020 fishes; Turkey: series

of publications on Turkish marine fauna and flora in 2014, Turan et al., 2018 for fishes, Çinar et al., 2021 for the most recent comprehensive update; Montenegro: Petović et al., 2019 and/or Pešić et al., 2020; Egypt: reviews by taxonomic group, e.g. Zakaria, 2015 for zooplankton, Akel & Karachle, 2017 for fishes; Halim & Abdel Messeih, 2016 for ascidians; Syria: Ammar, 2019 for zoobenthos, Ali, 2018 for fishes, and individual publications.

6. Additional records were sought in global biodiversity databases, i.e., Global Biodiversity Information Facility (GBIF) and Ocean Biodiversity Information System (OBIS) as appropriate and validated through personal communications with local and taxonomic experts where necessary.

Taxonomic groups

7. Unicellular plankton species were not included in the inventories, as most of the recent checklist on Mediterranean NIS have excluded them (Zenetos et al., 2017; Galil et al, 2018) because their origin is in doubt and subject to revisions. In exceptional cases they will be listed (case by case).

8. Parasites on the other hand were included in accordance with the latest recommendations (UNEP/MED WG. 500/7 - Zenetos, 2021) and recent literature (at the basin level see Zenetos et al., 2008 and at country level e.g., Libya: Shakman et al., 2019; Tunisia: Ounifi-Ben Amor et al., 2016; Israel: Galil et al., 2020).

Other Assessment Criteria

9. Preparing the baseline inventories needs to consider assessment criteria regarding alien status and establishment success as well as pathway of introduction (Tsiamis et al., 2021, UNEP/MED WG. 500/7). Each species entry is followed by two classifications, namely Alien Status and Establishment Success.

10. The establishment success of each species is reported as

- Established: Species with >2 records distributed in space and time, indicating self-sustaining populations, according to recent literature. Includes locally established species.
- Casual: Species with 1 or 2 records of live specimens.
- Invasive: Species with evidence of large populations, extensive spread and impacts on biodiversity and ecosystem services.
- Unknown: Species with 1 or 2 records of live specimens after 2010, where reporting lags may conceal their true establishment status.
- Excluded: records of species based on non-living animals (applies mostly to Mollusca) and records of species not reported in the wild (e.g., polychaeta, bryozoa found only on ship hulls).

11. The alien status is reported as

- Alien: species with clear evidence of their non-native origin and strong indication of an anthropogenic mode of introduction.
- Partly native: i.e., species that are native in a Mediterranean country while they are non-indigenous in other Mediterranean countries.
- Cryptogenic i.e., species that cannot be demonstrably classified as native or non-indigenous in a particular region.
- Range-expanding: i.e., species that may have entered the Mediterranean through natural range expansion. Crypto-expanding: species with some evidence on their non-indigenous status but

with uncertainty due to unclear mode of introduction from the native range (natural spread *vs* human mediated).

- Questionable: Species with insufficient information (e.g., no voucher or description provided) or with uncertain identification. Species complexes also fall under this category. Questionable species will be reported in a separate Annex/Worksheet in the final regional baseline (following Tsiamis et al., 2019).

12. Native and range-expanding species were excluded from the inventories during the validation process.

Geographic scales

13. Following the compilation of the national inventories, the regional baseline will be developed and submitted both at the pan-Mediterranean level and at the sub-regional level (4 marine subregions, according to the EcAp/IMAP and the MSFD, i.e., Eastern Mediterranean, Central Mediterranean, Adriatic Sea and Western Mediterranean). Establishment success will also be determined at these scales.

3. Reference year

14. The reference year for the baseline was selected based on two parameters. The first is related to the trends of new introduction of non-indigenous species in the Mediterranean, as revealed by preliminary analysis of the relevant data in recent publications [e.g., Algeria (Grimes et al., 2018; Bensari et al., 2020; Bakalem et al., 2020, Libya (Shakman et al., 2019); Montenegro (Petović et al., 2019; Pešić et al., 2020); Israel (Galil et al., 2020)] and the HCMR database (UNEP/MED WG. 500/7; Zenetos & Galanidi, 2021). The second is motivated by the need to harmonise with the timeframe of similar work carried out for the purposes of MSFD. Trends in new marine NIS introductions between 1950 and 2019 are consistently increasing throughout the Mediterranean and, in many countries, this is the result of increased scientific effort, thus the reference year should be the most recent year practical. Following the assessment and reporting 6-year periods already established for EU countries under the MSFD, where the next assessment will cover the 2018-2023 period, it was recommended that the reference year to set national NIS baselines for the Mediterranean should be 2017.

15. Nevertheless, national inventories, as well as the regional and subregional datasets were prepared and will be submitted with data until 2020, i.e., species detected until December 2020 and published until April 2021. This facilitates the updating of regional platforms (i.e. MAMIAS and EASIN) with the most up-to-date information and enables the publication of a truly authoritative work on the current state of marine NIS in the Mediterranean. Furthermore, it contributes to the continuous work necessary to carry out the forthcoming status assessment (2023) in the framework of IMAP, as well as reporting for the MSFD for the subset of EU Mediterranean countries.

4. National NIS inventories

16. National inventories of Non-indigenous species are delivered for 19 Mediterranean countries. These are listed in Table 1, along with the original data source and the status of the validation process. By the 13th of May, 12 countries had returned validated the revised spreadsheets. 9 inventories are finalised, 3 are in progress, with continuous communication with the national experts, while 6 national inventories are still pending validation, awaiting a status update by the national experts responsible.

Table 1. Status of revisions of the NIS national inventories (table updated on 10th May 2021).

Country	Revision	Validation
Albania (AL)	Yes	Yes
Algeria (DZ)	Yes	Yes
Bosnia-Herzegovina	No	NA
Croatia (HR)	Yes	pending
Cyprus (CY)	Yes	Yes
Egypt (EG)	Yes	pending
France (FR)	Yes	In progress
Greece (GR)	Yes	Yes
Italy (IT)	Yes	In progress
Israel (IL)	Yes	pending
Lebanon (LB)	Yes	Yes
Libya (LY)	Yes	Yes
Malta (MT)	Yes	Yes
Monaco	NA	NA
Montenegro (ME)	No	Yes
Morocco (MA)	Yes	Yes
Slovenia (Sl)	Yes	In progress
Spain (ES)	Yes	In progress
Syria (SY)	No	NA
Tunisia (TN)	Yes	pending
Turkey (TR)	No	In progress

17. Major changes relevant for all countries include:

Updating all lists with species records detected until December 2020, published to April 2021.

- ✓ The addition of Foraminifera following Stulpinaite et al., 2020.
- ✓ The revision of Isopoda following Castello et al., 2020.
- ✓ The revision of Polychaeta following Zenetos et al., 2017 and Langeneck et al., 2020.
- ✓ The revision of macroalgae based on Verlaque et al., 2015.
- ✓ The revision of Mollusca based on Albano et al., 2021.
- ✓ Removing molluscan records based exclusively on empty shell e.g., single records of:
    - *Canarium mutabile, Cerithium nesioticum, Conus arenatus arenatu*s from Israel (pers commun with H. Mienis, the investigator who has reported them).
    - *Anadara broughtonii* from Turkey (based on pers comm with S. Albayrak).
    - *Doxander vittatus* from Turkey.
- ✓ Removing records not in the wild. e.g,
    - the polychaete *Hydroides albiceps* (Grube, 1870) from ship hull only (France- Zibrowius, 1979)
    - the bryozoan *Celleporaria pilaefera* (Canu & Bassler, 1929) recorded once on oyster baskets and cages off Malta (Agius et al., 1977).

- the molluscs *Hyotissa hyotis, Planostrea pestigris,* recorded from a gas platform in Israel towed from Australia (Mienis, 2004).

✓ Removing records which recently are widely accepted as cryptogenic e.g the nimble spray crab *Percnon gibbesii*.

✓ Inserting a new category for alien status, namely crypto-expanding, i.e. those species with no definite evidence of their native or non-indigenous status due to unclear mode of introduction from the native range (natural spread or human mediated). The term fits best species of Atlantic origin with a disjunct distribution.

18. For EU countries, the Tsiamis et al. (2021) baseline lists up to 2017 were updated to include recent records as well as parasites.

19. Nomenclature was revised for the species listed in Table 2 following WoRMS.

Table 2. Species whose nomenclature was recently revised and where they were encountered.

Old name	Valid name	Countries
Chelidonura fulvipunctata	*Biuve fulvipunctata*	IL, TR
Flabellina rubrolineata	*Coryphellina rubrolineata*	IL, TR
Hippocampus fuscus	*Hippocampus kuda*	IL
Melicertus hathor	*Penaeus hathor*	IL
Musculista perfragilis	*Arcuatula perfragilis*	IL
Pillucina vietnamica	*Rugalucina angela*	IL
Erosaria turdus (Lamarck, 1810)	*Naria turdus* (Lamarck, 1810)	TN, LY
Polysiphonia fucoides (Hudson) Greville	*Vertebrata fucoides* (Hudson) Kuntze, 1891	TN
Hamimaera hamigera (Haswell, 1879)	*Linguimaera caesaris* Krapp-Schickel, 2003	TN, LY, DZ, TR
Haminoea cyanomarginata Heller & Thompson, 1983	*Lamprohaminoea ovalis* (Pease, 1868)	LY, ES, CY, TR
Apoglossum gregarium	*Phrix spatulata*	ES, IT
Gonioinfradens paucidentatus	*Gonioinfradens giardi*	CY, TR
Grateloupia lancelata	*Pachymeniopsis lanceolata*	IT
Garveia franciscana	*Calyptospadix cerulea* Clarke, 1882	IT
Synagrops japonicus (Döderlein, 1883)	*Acropoma japonicum Günther, 1859*	IT
Parviturbo dibellai	*Conradia eutornisca*	TR
Pyrgulina maiae	*Pyrgulina pupaeformis*	TR
Miliolinella fichteliana	*Triloculina fichteliana*	TR, GR
Sillago sihama (Forsskal, 1775)	*Sillago suezensis*	EG

20. A number of discrepancies concerning the alien status of some cryptogenic and/or questionable species arose as a result of experts' differing opinions. These need to be discussed and resolved, preferably at the pan-Mediterranean level, as the validation process continues. Some examples include:

- The polychaetes *Metasychis gotoi* (Izuka, 1902) and *Neopseudocapitella brasiliensis* Rullier & Amoureux, which are considered cryptogenic in the most recently updated JRC catalogue (present in Italy, Spain and Cyprus – see Tsiamis et al., 2021) but are accepted as alien species in Turkey

(Çinar et al., 2021). In the current work they were retained as questionable, following Langeneck et al. (2020) and Eduardo López (pers. comm.).

- Taxonomic groups for which recent revisions point to possible misidentifications or to doubts about the alien origin of certain species. Such is the case e.g., for Foraminifera, where this work follows the revision by Stulpinaite et al (2020), which is only partially accepted by Çinar et al. (2021). As a result, there is a large number of discrepancies regarding foraminifera species. Similarly, the work of Schuchert (2007, 2009, 2010) highlights our poor knowledge of the global distribution of hydrozoan species and indicates a number of possible misidentifications for Mediterranean records. Other authors however accept as alien some of these and other, inadequately documented, records (e.g., see Gravili et al., 2013).

- Newly described species with the Mediterranean as the type locality. This typically occurs in taxonomic groups that are generally poorly studied and have seen a recent surge in the collection of new material and the discovery of new species. For example, several new species of Porifera have been recently described from the eastern Mediterranean (Vacelet et al., 2007; Idan et al., 2021), among which only *Niphates toxifera* Vacelet, Bitar, Carteron, Zibrowius & Pérez, 2007 was highlighted as a possible Lessepsian migrant by Vacelet et al. (2007). Nevertheless, the species was not included in the national inventories of Lebanon or Israel, where it was also recorded (Idan et al., 2018), but is included as an alien in the Turkish inventory (Çinar et al., 2021; see also Evcen et al., 2020).
  Following Chapman & Carlton's (1991) criteria, the lack of previous records on a basin scale, the mentioned occurrences from confined areas such as lagoons and harbors, the notably poor capabilities of active or passive spreading by natural means of the genus, and its likely exotic evolutionary origin, cumulatively support the hypothesis of a human-mediated introduction. On the other hand, genetic studies of world-wide material, when it is available, may be the only way to truly determine the phylogenetic relationships and origins of the new species/populations (e.g. Belmaker et al., 2021 for an interesting hypothesis on *Brachidontes rodriguezii* (d'Orbigny, 1842)).

21. No changes were made to the establishment success of species at the national level, even when there were differences with the provided data, assuming that the countries have potentially better and more diverse information on the establishment status of NIS in their coastal waters.

22. Furthermore, no changes were made in the pathway column when it was supplied. A species can be introduced via different pathways in different areas, and it is up to each country to fill in.

23. In contrast with the JRC baselines for EU countries, which only partially cover cryptogenic species, a full list of cryptogenic species is included for each Mediterranean country, as recommended by the document on assessment criteria (UNEP/MED WG. 500/7; Zenetos & Galanidi, 2021), for future reference and for use in MAMIAS and EASIN. This increases the contribution of the current work to national and Mediterranean/European databases. The other important contribution is the significant number of updates to the 2017 JRC baselines, which will be used in the framework of the MSFD to set thresholds for D2 indicators and perform the status assessments for the 2018-2023 assessment period.

5. Next steps

24. Step 1. Finalisation of the remaining national inventories. The inventories of Spain, Turkey and Slovenia are currently in progress, with ongoing discussions with the national experts to clarify differences and changes made. It is anticipated that these 3 countries will be finalised by the end of May, depending on the availability of the national experts. The same steps will be followed for the inventories of Croatia, Egypt, Italy, Israel and Tunisia, who are in the process of validating the revised spreadsheets. The timeline for completion is difficult to predict as it is important to achieve a consensus on the changes implemented, with detailed exchange of information between national and regional experts. Nevertheless, the agreed deadline of July 15th for the submission of the final regional baseline is expected to be met.

25. Step 2. As records of non-indigenous species are continuously published in the literature some additions have been made after the validation of national inventories had been completed. This process will continue until the final regional baseline is submitted and considered closed, whereby any species additions will be shared with national experts. Currently these species are:

Synanceia verrucosa – Cyprus in 2020: Akbora et al., 2021
Terapon puta – Turkey in 2020: Manasırlı & Mavruk, 2021
Pterois miles – Albania in 2019: Di Martino & Stancanelli, 2021
New NIS for the Mediterranean: *Sargocentron spinosissimum* and *Sargocentron tiereoides* – Egypt: Deef, 2021

26. Step 3. Compilation of the subregional and regional baselines. Once all national inventories are completed, data will be aggregated at two levels, the EcAp subdivision level and the pan-Mediterranean level. Year of first detection and establishment success of each species will be adjusted accordingly. Regarding pathway of introduction, at the regional and subregional level, pathways will be assigned according to the most likely means of primary introduction of the first record in the region/each subregion respectively.

27. The finalised spreadsheet will contain the following information: Species name and authority, taxonomic classification (Kingdom, Phylum, Class, Order, Family), origin, year of first detection, country of first detection, citation for the first record, alien status, overall establishment success in the Mediterranean, primary pathway of introduction. Separate spreadsheets will be prepared with similar information per each EcAp subdivision. The establishment success of the recorded species is not included in the supplementary data files of Tsiamis et al. (2021) for EU Member States D2 reporting, it will be included however in the Mediterranean baseline as it offers valuable information that can inform the implementation of CI6. Any unresolved differences with regards to alien status of species or the validity of specific records will be explicitly presented. A report will accompany the final baseline, containing descriptive statistics at different geographic scales and detailing the major changes made during the validation process.

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