UNITED NATIONS

EP

UNEP/MED WG.467/18

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

5 November 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Report of the 7th Meeting of the Ecosystem Approach Coordination Group

UNEP/MAP
Athens, 2019

Table of contents

Introduction

1. The 7th Meeting of the Ecosystem Approach Coordination Group (the Meeting) took place in Athens, Greece, on 9 September 2019. The Meeting aimed to (i) take stock of the activities and main achievements in the framework of the implementation of the Ecosystem Approach (EcAp) roadmap, since the 6th Meeting of the Ecosystem Approach Coordination Group (Athens, Greece, 11 September 2017), and (ii) review a number of important documents related to key aspects of the Integrated Monitoring and Assessment Programme (IMAP) implementation.

Participation

2. The following Contracting Parties to the Barcelona Convention were represented at the Meeting: Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, European Union, France, Greece, Israel, Italy, Lebanon, Malta, Morocco, Slovenia, Spain, and Syria.

3. The following non-governmental organizations and other institutions were represented as observers: the Hellenic Centre for Marine Research (HCMR), the Hellenic Marine Environment Protection Association (HELMEPA), the Mediterranean Association to Save the Sea Turtles (MEDASSET), and the Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE).

4. The UNEP/MAP – Barcelona Convention Secretariat was represented, including its Coordinating Unit, the Mediterranean Pollution Assessment and Control Programme (MED POL), the Priority Actions Programme Regional Activity Centre (PAP/RAC), the Specially Protected Areas Regional Activity Centre (SPA/RAC), the Plan Bleu Regional Activity Centre (PB/RAC), the Regional Activity Centre for Information and Communication (INFO/RAC) and the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC).

5. The list of participants is attached as Annex I to this report.

Agenda Item 1: Opening of the Meeting

6. The Meeting was opened at 9:30 a.m. on 9 September 2019 by Mr. Gaetano Leone, Coordinator of the UNEP/MAP-Barcelona Convention Secretariat.

Agenda Item 2: Organizational Matters

7. In accordance with rule 20 of the Rules of Procedure for meetings and conferences of the Contracting Parties, the Meeting elected its officers, as follows:

- Chair: Ms. Selma Cengic, Bosnia and Herzegovina
- Vice-Chair: Ms. Samira Hamidi, Algeria
- Vice-Chair: Mr. Roberto Giangreco, Italy
- Vice-Chair: Mr. Richard Hanna, Lebanon
- Rapporteur: Ms. Marina Argyrou, Cyprus

8. In his opening statement, Gaetano Leone, UNEP/MAP Coordinator, highlighted the importance of the Ecosystem Approach in the Mediterranean as a fundamental guiding principle underpinning the work of the UNEP/MAP-Barcelona Convention System since the adoption of the relevant Decision at COP15 in Almeria in 2008, and briefly presented the progress achieved on the implementation of the Ecosystem Approach Roadmap during the 2018-2019 biennium, including some key achievements such as the finalization of national IMAPs by all Contracting Parties, the operationalization of the IMAP Pilot Info System, the preparation of a Roadmap and Needs Assessment for the 2023 Mediterranean Quality Status Report (MED QSR), and the work done on strengthening methodological approaches for Good Environmental Status (GES)-integrated assessment, monitoring protocols and assessment criteria, as well as on updating Guidance Factsheets for a number of Common Indicators. The UNEP/MAP Coordinator thanked all Contracting Parties, Observers and Partners for their policy and scientific contributions to the implementation of the Ecosystem Approach Roadmap, and particularly to the implementation of IMAP, which will contribute towards filling the knowledge gaps and achieving a fully data-based 2023 MED QSR, and enabling the region to strengthen action in order to achieve and maintain the GES of the Mediterranean.

9. The Meeting adopted the proposed Provisional Agenda as presented in document UNEP/MED WG.467/1 without changes.

Agenda Item 3: State of Play of the Implementation of Integrated Monitoring and Assessment Programme (IMAP)

10. Tatjana Hema, UNEP/MAP Deputy Coordinator presented document UNEP/MED WG.467/3 on the status of implementation of the Ecosystem Approach Roadmap and the progress made during the 2018-2019 biennium. She highlighted several activities done in follow-up to the 2017 MED QSR, including the preparation of the 2023 MED QSR Roadmap and Needs Assessment, the outputs of which have been integrated in the proposed UNEP/MAP Programme of Work for 2020-2021; the progress made on the revision of existing monitoring programmes, cross-cutting issues related to scales of assessment, monitoring and reporting. The progress on development and review of relevant action plans and programmes was then presented, including the evaluation and update of existing regional policy documents, progress on national programmes of measures, new technical guidelines and guidance, as well as governance and resource mobilization efforts and efforts to ensure full synergies and complementarities between projects to support the Contracting Parties in a most efficient way. Acknowledging the difficulties related to IMAP implementation faced by the Contracting Parties, the need for additional financial resources to support IMAP-related activities in the next Programme of Work for 2020-2021 was pointed out.

11. The Meeting acknowledged the progress achieved on the implementation of the EcAp Roadmap in 2018-2019, emphasizing the importance of this stream of work as a priority for UNEP/MAP, and welcoming the proposed focus on the implementation of the IMAP and the delivery of a data-based 2023 MED QSR, while noting the challenges associated with it.

12. The Meeting stressed the importance of the meetings of experts and of the work of the CORMONs to ensure expert inputs and collaboration on strengthening the monitoring and assessment methodologies and standards in order to address existing knowledge gaps and support the development of a data-based 2023 MED QSR.

13. The Meeting also welcomed the development of the IMAP Pilot Info System, as a useful tool for the implementation of the IMAP and the delivery of the 2023 MED QSR. At the same time, concerns were expressed regarding certain Common Indicators and the coherence between Data

Standards, common indicator Guidance Factsheets and national IMAPs, noting the importance of a strong and coherent reporting system, and the importance to avoid duplication of efforts.

14. The main conclusions and recommendations regarding this agenda item are presented under Agenda Item 11.

Agenda Item 4: 2023 MED QSR Roadmap and Needs Assessment

15. The Deputy Coordinator introduced document UNEP/MED WG.467/4 on the 2023 MED QSR Roadmap and Needs Assessment, which was prepared through a broad consultation process with the EcAp Coordination Group and CORMON Meetings, under the guidance of the Bureau of the Contracting Parties. The vision and main processes and milestones identified towards the 2023 MED QSR were presented, as well as specific outputs proposed for each milestone, and their respective delivery timelines. An important number of 2023 MED QSR-related activities have been mainstreamed in the proposed UNEP/MAP Programme of Work for 2020-2021, underlining the importance given to IMAP in the 2020-2021 Programme of Work.

16. The Meeting acknowledged the importance of the 2023 MED QSR Roadmap and Needs Assessment to ensure quality-assured data for the development of the 2023 MED QSR. Specific comments were provided on the Roadmap, including the need for more precise timelines to ensure that activities under different processes are well synchronized, as well as the need for more details on specific activities and responsibilities. It was proposed to include information about the basic structure of the 2023 MED QSR in the Roadmap. The timeline for the Data Management Policy was also discussed, as its timely application would be an important element in the preparation of the QSR. The Secretariat indicated that the IMAP data policy will be finalized by the end of 2021, based on consultations with CORMONs during the next biennium.

17. The Meeting highlighted several important challenges in relation to achieving a full data-based 2023 MED QSR, particularly given the different levels of maturity of Common Indicators, and the different timelines and frequency of IMAP Common Indicators monitoring among the Contracting Parties, at times incompatible with the proposed 2023 MED QSR timelines. It was recommended to adopt a strategic approach and to identify as early as possible those Common Indicators for which a quantitative assessment would be feasible for the 2023 MED QSR, and those for which an approach similar to the one adopted for the 2017 MED QSR would be required.

18. The Meeting also recommended to consider the experience of similar assessment processes such as OSPAR, to inform the monitoring and assessment work of the UNEP/MAP system. In addition, it was suggested that the technical documents developed in the Adriatic Basin in the framework of the work of the EU could also be considered when defining GES assessment approaches and tools.

19. In response, the Secretariat acknowledged the comments received, reminding the process undertaken for the development of the 2023 MED QSR Roadmap and Needs Assessment and explaining the reasons behind opting for the suggested level of detail of the presentation of the Roadmap. The Secretariat proposed at this stage to adopt this global approach and endorse the overall vision and structure of the 2023 MED QSR Roadmap at the level of Ecological Objectives. Technical discussions focusing on specific indicators and countries would then take place in 2020 in CORMONs and Online Working Groups, to define the detailed steps, timelines for implementation and concrete achievable numbers of datasets, taking into account the needs of the respective Contracting Parties as well as the specificities of measurement frequencies for each indicator. The Secretariat reminded that the focus of the work in the next biennium will be on supporting Contracting Parties to deliver the data, report it in the IMAP Info System and develop national assessment factsheets for all indicators,

which each Contracting Party is expected to deliver. The national assessment factsheets per indicator will then be aggregated by the Secretariat at the regional (and possibly sub-regional) level to produce the 2023 MED QSR, similarly to the process undertaken by OSPAR. During that stage, each MAP component will be responsible for their respective cluster and will work with the support of Online Working Groups and country experts; Contracting Parties are invited to take the lead on specific Ecological Objectives, should they wish so.

20. The Meeting underlined the need for the re-establishment of Online Working Groups in order to ensure continuous work on the preparation of the 2023 MED QSR.

21. The main conclusions and recommendations adopted by the Meeting regarding this agenda item following these discussions are presented under Agenda Item 11.

Agenda Item 5: The Methodological Approach for Mapping the Interrelations between Sectors, Activities, Pressures, Impacts and State of Marine Environment

22. Jelena Knezevic (MED POL Programme Monitoring and Assessment Officer) presented document UNEP/MED. WG.467/7, addressing the methodologies proposed for a GES-integrated assessment based on the DPSIR approach in order to support the integrated assessment, under IMAP, of the predominant pressures and their impacts on the marine and coastal environment. The proposed methodologies aim to ensure better interlinkages between activities/pressure/impacts, which is of crucial importance for improving the GES assessment. Furthermore, the document explains the interrelation between three proposed approaches, providing detailed elaboration of GRID, risk-based assessment and Scoreboard semi-quantitative methods. The proposed approaches were presented at and reviewed at and adjusted following several meetings. The CORMON Meeting recommended to continue the testing of these approaches, favoring in particular risk-based methods, combining monitoring data obtained through the IMAP implementation with vulnerability assessment, in order to ensure more reliable scientifically based quantification of the magnitude of impacts.

23. Following this presentation, the Meeting approved the methodologies as a living document and for testing purposes. The main conclusions and recommendations regarding this agenda item are presented under Agenda Item 11.

Agenda Item 6: IMAP Pilot Info System and Related Quality Assurance Issues; Data Standards and Data Dictionaries; MAP Data Management Policy

24. Arthur Pasquale (INFO/RAC Senior Officer) presented the work on the IMAP Pilot Info System (document UNEP/MED WG.467/12), operational since the 1st of July 2019, and Data Standards and Data Dictionaries related to the three main clusters (Biodiversity, Coast and Hydrography, and Pollution and Marine Litter - documents UNEP/MED WG.467/8, UNEP/MED WG.467/9, UNEP/MED WG.467/10). These exist for 11 Common Indicators, are aligned with the Guidance Factsheets and have been approved by respective thematic focal points meetings. The Secretariat also provided a brief update on the Roadmap for the preparation of the UNEP/MAP Data Management Policy (document UNEP/MED WG.467/11), and on initially proposed elements for Quality Assurance and Quality Control in the IMAP Pilot Info System, which would support the delivery of a data-based 2023 MED QSR.

25. The representative of MED POL further presented Quality Assurance and Quality Control schemes related to the IMAP Cluster on Pollution (document UNEP/MED WG.467/13), building on an almost 20 years-long experience of the MED POL Monitoring Database, which were agreed and recommended for submission to the 7th Meeting of the EcAp Coordination Group following the Meetings of the CORMON on Pollution and of the MED POL Focal Points. The document defines the

three levels for Quality Assurance for data, data assessment and database quality management, which will help to ensure that the 2023 MED QSR is based on quality-assured data, if applied accordingly.

26. The Meeting welcomed the work on the IMAP Pilot Info System, on Data Standards and Data Dictionaries and Quality Assurance and Quality Control, recognizing their contribution to ensuring quality assured data. The Meeting emphasized in particular the importance of the testing phase, and noted that more work was required to finalize the documents and to ensure that they are in line with the IMAP Common Indicator Guidance Factsheets, and that therefore, the Data Standards and Data Dictionaries are to be endorsed as a living document, for further testing and further discussion by the CORMONs. Questions were raised regarding the functioning of the IMAP Pilot Info System in instances where Contracting Parties are not able to report on all items, and regarding the use of data uploaded during the testing phase for the preparation of the 2023 MED QSR. Clarifications were requested related to the implications of the proposed Quality Assurance/Quality Control (QA/QC) schemes on national laboratory practices, as well as to further address specific comments raised related to Data Standards and Data Dictionaries (i.e. complexity of Data Standards and Data Dictionaries; need to strengthen data models; etc.) in close consultations with the future Meetings of the respective CORMONs. It was suggested to define separate categories for agriculture in the Data Standards and Data Dictionaries for Common Indicators related to Pollution and Marine Litter, to be brought as a proposal to the next Meeting of the CORMON on Marine Litter.

27. The Secretariat, acknowledging the comments received, emphasized the need for the Meeting to formally adopt Data Standards and Data Dictionaries, as approved by the Meetings of respective CORMONs and MAP Component thematic focal points, reminding that the IMAP Pilot Info System is in full testing phase and open to adjustments and modifications that may be required to support data monitoring, and proposed to submit proposals for indicator adjustments to the CORMON Meetings in 2020 and 2021. It was further clarified that the Data Standards and Data Dictionaries are aimed at organizing and harmonizing the data collected as part of national monitoring programmes, taking into account specific national needs and capacities, and are not intended at modifying national monitoring requirements. While noting the importance of aligning the Data Standards and Data Dictionaries with Guidance Factsheets, a more flexible approach had been proposed to allow the inclusion of country-specific parameters.

28. The main conclusions and recommendations regarding this agenda item are presented under Agenda Item 11. The Working Documents contained in Annex III include changes made based on discussions during the Meeting, while the comments submitted by some Contracting Parties in writing will be considered at the next Meetings of relevant CORMONs.

Agenda Item 7: Updated IMAP Guidance Factsheets for Common Indicators 13, 14, 15, 16, 17, 18, 20 and 21; New proposal for Candidate Indicators 25, 26 and 27

29. The representative of MED POL presented the updated IMAP Guidance Factsheets for Common Indicators 13, 14, 17, 18, 20 and 21 related to the Pollution cluster of IMAP (document UNEP/MED WG.467/5). The updated versions of the Guidance Factsheets have been considered by the Meetings of the CORMON on Pollution and of the MED POL Focal Points. The Secretariat reminded the reservations expressed by Morocco regarding the more detailed elaboration of the statistical method to discriminate the sampling frequency between different eutrophication classes and presented some proposed changes and clarifications made in the Guidance Factsheets. New proposed Guidance Factsheets for Candidate Indicators related to EO11 were also presented, based on the results of the projects QuietMed 1 and 2. The update of the IMAP Guidance Factsheets related to Common Indicators 13, 14, 17, 18, 20 and 21 has been agreed upon at the Meetings of the CORMON

on Pollution and of the MED POL Focal Points, while recommending to gather more knowledge before incorporating the two Candidate Indicators 26 and 27 into regular monitoring programmes.

30. Marko Prem (PAP/RAC Deputy Director) presented the updated IMAP Guidance Factsheets for Common Indicators 15 and 16, and the new Factsheet for Candidate Indicator 25 related to the Coast and Hydrography cluster (document UNEP/MED WG.467/6). The Guidance Factsheet for Common Indicator 15 has been simplified, and the Guidance Factsheet for Common Indicator 16 slightly updated to reflect the conclusion of the CORMON that the definition of GES and targets should take into account national circumstances. The Data Dictionaries and Data Standards presented under Agenda Item 6 related to these updated Guidance Factsheets will be revised as soon as the updated Factsheets are approved. Candidate Indicator 25 related to Land Cover has been recommended by the CORMON for inclusion in the IMAP list of Common Indicators, taking national specificities into account. The potential for collaboration with existing monitoring systems was noted, particularly for data collected by the EEA, and resources mobilized through the GEF-funded MedProgramme and other programmes and projects were suggested as a possible source of funding to support implementation in countries in the South Mediterranean.

31. The Meeting welcomed the work and activities contributing to implementing the national monitoring programmes through the application of the IMAP Common Indicators Guidance Factsheets. The success of the approach followed to support the operationalization of indicators through testing was underlined, noting the challenge of high turn around in national institutions, and it was recommended to assist countries for other Common Indicators.

32. Israel raised concerns regarding the feasibility of the monitoring of Common Indicator 15, noting the knowledge gap of the actual impact of hydrographic alterations on Mediterranean habitats and the extent and complexity of the relevant parameters, and recommended that more research is needed to support the development of a monitoring programme for this Common Indicator.

33. Some concerns were raised with regards to suggested increased sampling frequency for eutrophication, given the fact that the variability of nutrients is not homogenous per year and noting the challenge for many countries to comply with a monthly frequency. It was suggested to clarify in the Guidance Factsheet that the proposed frequency is provided for guidance only, taking into account local conditions of each area. Furthermore, the need was pointed out to revise the reference conditions and boundary values for nutrients to be applied for assessments related to Common Indicator 14. Some adjustments in the temporal scope guidance for Common Indicator 17 were further suggested, recommending to change the frequency of biota sampling to 1-4 years.

34. In response to the comments, the Secretariat acknowledged the reservations expressed by some Contracting Parties regarding the feasibility of several specific indicators, as previously raised in relevant CORMON meetings, and suggested to hold further discussions with CORMONs in the next biennium based on the results of the ongoing implementation of national IMAPs, and to develop a joint overall proposal for adjustments of indicators for consideration at COP 22. Regarding the comments related to eutrophication, the Secretariat explained that the present Guidance Factsheets related to Common Indicators 13 and 14 foresee the elaboration of a sound statistical method for defining the sampling frequency through the discriminant limit of two adjacent mean values. Therefore, the sampling frequency suggested in updated Guidance Factsheets provides guidance to be considered for defining the discriminant limit between eutrophic-mesotrophic and oligotrophic waters. It should be applied when the thresholds and boundaries for key nutrients will be available, thereby considering the specific local conditions. To this aim, the Secretariat proposed adjusted wording in the Guidance Factsheet. Further work on establishing the reference and boundary values for nutrients is included in the 2023 MED QSR Roadmap and Needs Assessment and will be assigned to the relevant Online Working Group.

35. Following these clarifications, the Meeting approved the updated Guidance Factsheets.

36. The main conclusions and recommendations regarding this agenda item are presented under Agenda Item 11. The Working Documents contained in Annex III include changes made based on discussions during the Meeting, while the comments submitted by the Contracting Parties in writing will be considered at the next Meetings of relevant CORMONs.

Agenda Item 8: Monitoring Protocols for IMAP Common Indicators Related to Pollution and Guidance on monitoring concerning IMAP Common Indicators related to Biodiversity and Non-Indigenous Species

37. Mehdi Aissi (SPA/RAC Project Officer) presented the Draft Updated Reference List of Marine Habitat Types for the Selection of Sites to be included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean (document UNEP/MED WG.467/14). The updated Reference List includes recent habitat types identified since 1999 and is aligned with the updated structure of the revised marine components of EUNIS habitats classification, thus ensuring a coherent use of the list in national inventories and monitoring programmes. The Secretariat also presented the Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species (document UNEP/MED WG.467/16).

38. The representative of MED POL then presented the report on the most representative species for the IMAP Candidate Indicator 24 (document UNEP/MED WG.467/15), elaborated with the aim to improve knowledge on the impact of marine litter on marine fauna and to facilitate the development of the IMAP Candidate Indicator 24. The Secretariat also introduced the Monitoring Protocols elaborated in conjunction with the report for monitoring interactions between marine litter and marine turtles, mainly focusing on ingestion and entanglement. A regional strategy and approach for implementation will be defined in the next phase of the development of the IMAP Candidate Indicator 24.

39. The Meeting welcomed the documents, recognizing the importance of the work conducted. France proposed for new species to be included in the document defining the Most Representative Species for IMAP Candidate Indicator 24 and related Monitoring Protocol, and for the document to take into account the discussions of the Technical Group on Marine Litter under the Marine Strategy Framework Directive (MSFD). Several participants had specific comments, which were submitted to the Secretariat in writing. A special point was made on the difficulties to identify the source of litter ingested by marine turtles due to their mobility and concerns were expressed over the cost effectiveness of this Common Indicator monitoring. Insufficiency of resources needed for full reporting at this stage in relation to Ecological Objective 1, and the overall difficulty of carrying out the monitoring required at the lower sub-levels of classification specified in the Data Dictionaries and Classifications of Marine Habitat Types was also pointed out. In response, the Secretariat suggested to bring all issues raised to the attention of the next Meetings of the respective CORMONs, for in depth technical review.

40. The main conclusions and recommendations regarding this agenda item are presented under Agenda Item 11.

Agenda Item 9: Science-Policy Interface: achievements and challenges for the implementation of IMAP

41. Elen Lemaitre-Curri (Plan Bleu/RAC Director) presented the document “Strengthen, Secure and Sustain a Science Policy Interface (SPI) for IMAP Implementation in the Mediterranean: Summary of Final Report” (document UNEP/MED WG.467/17), produced in the context of the EU-

funded EcAp MED II project. The document provides proposals and recommendations on how to strengthen the Science Policy Interface for IMAP implementation, at regional and at national level, and lays out critical principles as well as recommendations along five pillars (formalization, simplicity, accessibility of information, enabling conditions and mainstreaming of SPI into projects). Overall, the report recognizes the large potential of the knowledge that is generated, and possible activities to be developed in the future to ensure that the knowledge is fully taken advantage of.

42. The Meeting noted in particular the importance to take into account existing regional and transnational practices and to streamline the SPI within existing processes such as the work of the CORMONs, and also taking into account the relevant work conducted by the EU, rather than creating new bodies. The importance of pilot projects at national level was highlighted, and a combined top-down and bottom-up approach was proposed to ensure stronger participation of Contracting Parties.

43. The Secretariat took note of the comments, clarifying that the options proposed in the document are open to further discussion and that endorsement was not requested at this stage, and invited participants to submit additional feedback to support the preparation of recommendations for the next UNEP/MAP Medium-Term Strategy.

44. The main conclusions and recommendations regarding this agenda item are presented under Agenda Item 11.

Agenda Item 10: Any Other Business

45. The representative of INFO/RAC presented the draft roadmap for stronger cooperation between UNEP/MAP and the General Fisheries Commission for the Mediterranean (GFCM) in the framework of the Memorandum of Understanding between UNEP/MAP and GFCM-FAO, which aims to ensure that relevant data collection can be shared within the EcAp process and to avoid duplication of reporting efforts. The Draft proposal of the Terms of Reference for cooperation between GFCM and UNEP/MAP on data collection will be discussed further and endorsed during the next annual meeting of the GFCM in November 2019.

46. Nikos Streftaris (Hellenic Centre for Marine Research, HCMR) presented the progress on the implementation of the EU-funded MEDREGION project and planned activities, focusing on synergies with the implementation of the IMAP. The project aims to support Mediterranean countries which are EU Member States in the implementation of the new GES Decision of the MSFD by addressing gaps in monitoring data, supporting the implementation of indicators and data collection, supporting the development of regional measures to support monitoring programmes, and conducting pilot studies to test the applicability and effectiveness of approaches developed within the activities of the project. UNEP/MAP plays an important role in the project, as member of the Advisory Board, and member of the Competent Authority Board, and as partner through the contributions of RACs.

47. Participants welcomed the efforts to strengthen collaboration between work of UNEP/MAP on ecosystem approach roadmap and IMAP in particular and the MEDREGION Project. The importance of the MEDREGION Project was stressed, as it brings together Competent Authorities from several countries, and starts the implementation of the second MSFD phase, and will therefore be of great support to the synergistic implementation of the EcAp Roadmap and MSFD.

48. The main conclusions and recommendations regarding this agenda item are presented under Agenda Item 11.

Agenda Item 11: Conclusions and Recommendations

(Note: The text of the Conclusions and Recommendations presented below has been agreed upon and adopted at the Meeting and therefore is not subject to any further amendments)

40. The Participants reviewed, commented and adopted the draft Conclusions and Recommendations, as amended. The final text of the adopted Conclusions and Recommendations is presented below. The Appendices to the Conclusions and Recommendations, including those documents that were modified during the Meeting, are presented in Annex III to the present report.

Final Conclusions and Recommendations of the 7th Meeting of the Ecosystem Approach Coordination Group as adopted on 9 September 2019 in Athens, Greece

State of Play of the Implementation of Integrated Monitoring and Assessment Programme (IMAP)

1. Following the Secretariat's Update on the implementation of the Ecosystem Approach Roadmap (document UNEP/MED WG.467/3), the Meeting acknowledged the progress achieved for the implementation of the Ecosystem Approach Roadmap and of related Decisions of the Contracting Parties to the Barcelona Convention and its Protocols, since the 6th Meeting of the Ecosystem Approach (EcAp) Coordination Group held in Athens, Greece, on 11 September 2017, and pointed out the need for stronger efforts by all Contracting Parties in advancing the implementation of the national Integrated Monitoring and Assessment Programmes (IMAP) and reporting quality-assured data to support the development of the 2023 Mediterranean Quality Status Report (2023 MED QSR) as provided for in Decision IG.23/6, while remaining conscious of some implementation challenges and limitations faced by the Contracting Parties.

2023 MED QSR Roadmap and Needs Assessment

2. Following the Secretariat's presentation of the 2023 MED QSR Roadmap and Needs Assessment (document UNEP/MED WG.467/4), the Meeting endorsed the 2023 MED QSR Roadmap and Needs Assessment as contained in Appendix I of these conclusions, as amended, and requested the Secretariat and MAP Components to further define in 2020, together with the Contracting Parties and CORMONs, concrete requirements and deadlines of output delivery at the level of Common Indicators per each Contracting Party in order to ensure effective data collection and to address knowledge gaps to enable the entire MAP system to successfully deliver the 2023 MED QSR.

3. While noting the constraints and challenges relating to the implementation of the 2023 MED QSR Roadmap and the need to further discuss concrete steps and timeframes for implementation of the 2023 MED QSR with the Contracting Parties and CORMONs in 2020, the Meeting called upon the Contracting Parties to fully commit and contribute to this major process; actively participate to CORMON meetings; complete relevant Common Indicators (CI) assessment factsheets at national level; report datasets in the IMAP Info System and take the lead for the preparation of thematic chapters of the 2023 MED QSR with the full support of the Secretariat and MAP components. It requested the Secretariat to develop a proposal of the Table of Content of the 2023 MED QSR in 2020 for review by the CORMONs and by the EcAp Coordination Group members.

4. The Meeting pointed out the importance of re-establishing the Online Working Groups (OWG) for all IMAP clusters, to work to support the process of the preparation of the 2023 MED QSR under the guidance of the CORMONs, including on the scales of monitoring along the scales of assessment, and to identify and apply nested assessment areas in order to support

the development of aggregated assessment products as well as assessment criteria and thresholds across Common Indicators.

5. The Meeting took note of the information provided by the Secretariat regarding the streamlining of 2023 MED QSR outputs in the 2020-2021 Programme of Work and pointed out the need to mobilize external resources for its implementation and appreciated the efforts made by the Secretariat in this respect.

The Methodological Approach for Mapping the Interrelations between Sectors, Activities, Pressures, Impacts and State of Marine Environment

6. The Meeting reviewed the methodologies proposed for GES-integrated assessment based on the DPSIR approach (document UNEP/MED WG.467/7), and approved them as contained in Appendix II to these conclusions, for their testing by the Contracting Parties with the aim to present related main findings to the next meetings of respective CORMONs in 2020 and 2021.

IMAP Pilot Info System and Related Quality Assurance Issues; Data Standards and Data Dictionaries; MAP Data Management Policy

7. Following the review of the progress achieved with regards to the IMAP Pilot Info System and Related Quality Assurance Issues, Data Standards and Data Dictionaries and MAP Data Management Policy (documents UNEP/MED WG.467/8, UNEP/MED WG.467/9, UNEP/MED WG.467/10, UNEP/MED WG.467/11, UNEP/MED WG.467/12, UNEP/MED WG.467/13), the Meeting endorsed them as state of the art, taking into account their evolving nature and the need to adjust them in line with the further development of IMAP.

8. With regards to Data Standards and Data Dictionaries documents (documents UNEP/MED WG.467/8, UNEP/MED WG.467/9, UNEP/MED WG.467/10), the Meeting, taking into account their evolving nature, endorsed them as slightly revised and presented in Appendices III, IV and V to these conclusions, as amended, and requested INFO/RAC to adjust them as need be in 2020 in consultation with MAP components and CORMONs following the outcome of the testing process and other relevant IMAP developments. The meeting encouraged the Contracting Parties to fully participate in the testing process.

9. The Meeting requested INFO/RAC, MED POL, SPA/RAC and PAP/RAC to further work to guide the Contracting Parties to deliver satisfactory quality data in the IMAP Info System in a harmonized way; as well as to build Quality Assurance/Quality Control within Database Quality Management of the IMAP Info System to estimate the validity of datasets submission for preparation of the 2023 MED QSR.

Updated IMAP Guidance Factsheets for Common Indicators 13, 14, 15, 16, 17, 18, 20 and 21; New proposal for Candidate Indicators 25, 26 and 27

10. Following the review of Working Documents UNEP/MED WG.467/5 and UNEP/MED WG.467/6, the Meeting reviewed and approved the updated IMAP Common Indicator Guidance Factsheets 13, 14, 15, 16, 17, 18, 20 and 21 as slightly revised and contained in Appendices VI and VII of these conclusions, as amended, as well as the recommendations arising from relevant CORMON meetings, pointing out the need for their update as necessary, and noting the importance of testing exercises in order to support the Contracting Parties to move forward.

11. The Meeting expressed its appreciation for the work undertaken by ACCOBAMS and the Secretariat to prepare the Guidance Factsheets for Candidate Indicators 26 and 27 (document UNEP/MED WG.467/5) related to EO11 (Energy including underwater noise), and approved these Guidance Factsheets, included in Appendix VI to these conclusions, pointing out the need for further work to gather relevant knowledge, including through the testing of the

Guidance Factsheets for Candidate Indicators 26 and 27 on an indicative basis as appropriate, prior to incorporating them into IMAP upon completion of its initial phase.

12. The Meeting endorsed the Guidance Factsheet for IMAP Candidate Indicator 25 “Land Cover Change” (document UNEP/MED WG.467/6) and invited the Contracting Parties to test it during the next biennium, at appropriate spatial assessment scales, with the view to be included in the list of Common Indicators at COP 22 for its consideration.

Monitoring Protocols for IMAP Common Indicators Related to Pollution and Guidance on monitoring concerning IMAP Common Indicators related to Biodiversity and Non-Indigenous Species

13. The Meeting reviewed Working Documents UNEP/MED WG.467/14, UNEP/MED WG.467/15 and UNEP/MED WG.467/16, and endorsed them, as contained in Appendices VIII, IX and X to these conclusions, as amended. The Meeting also took note of the comments made by several Contracting Parties related to the inclusion of new indicator species for IMAP Candidate Indicator 24, as well as minor adjustments of monitoring parameters, and requested the Secretariat and MAP Components to bring them to the attention of respective CORMONs in 2020.

Science-Policy Interface: achievements and challenges for the implementation of IMAP

14. The Meeting reviewed recommendations to strengthen the structure and sustain a Science-Policy Interface (SPI) for IMAP implementation in the Mediterranean (UNEP/MED WG.467/17) and appreciated the work done. The Meeting provided a number of comments noting the importance of avoiding duplication and of the necessity to use existing structures, as well as to take into account existing regional and transnational practices that could serve as a model. The Meeting asked the Contracting Parties to further review this document and provide feedback regarding the recommendations provided in order to feed the discussion for further IMAP implementation and preparation of the 2023 MED QSR and the next cycle of the UNEP/MAP Mid-Term Strategy.

Any Other Business

15. The Meeting welcomed the efforts made towards greater cooperation between GFCM and UNEP/MAP with the view to support data, and requested the Secretariat to conclude this Agreement related to collaboration with GFCM as early as possible.

16. The Meeting appreciated the efforts of the EU-funded MEDREGION Project partners to coordinate their work with IMAP and the EcAp Roadmap implementation, and encouraged their further collaboration with the UNEP/MAP-Barcelona Convention System.

Agenda Item 12: Closure of the Meeting

41. The Chair closed the Meeting at 18:30, on Monday, 9 September 2019.

Annex I
List of Participants

LIST OF PARTICIPANTS / LISTE DES PARTICIPANT(E)S

MONDAY 9 SEPTEMBER 2019

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Annex II
Agenda of the Meeting

Agenda

Agenda Item 1: Opening of the Meeting

Agenda Item 2: Organizational Matters

Agenda Item 3: State of Play of the Implementation of Integrated Monitoring and Assessment Programme (IMAP)

Agenda item 4: 2023 MED QSR Roadmap and Needs Assessment

Agenda Item 5: The Methodological Approach for Mapping the Interrelations between Sectors, Activities, Pressures, Impacts and State of Marine Environment

Agenda Item 6: IMAP Pilot Info System and Related Quality Assurance Issues; Data Standards and Data Dictionaries; MAP Data Management Policy

Agenda Item 7: Updated IMAP Guidance Factsheets for Common Indicators 13, 14, 15, 16, 17, 18, 20 and 21; New Proposal for Candidate Indicators 25, 26 and 27

Agenda Item 8: Monitoring Protocols for IMAP Common Indicators related to Pollution and Guidance on Monitoring concerning IMAP Common Indicators related to Biodiversity and Non-Indigenous Species

Agenda Item 9: Science-Policy Interface: Achievements and Challenges for the Implementation of IMAP

Agenda Item 10: Any Other Business

Agenda Item 11: Conclusions and Recommendations

Agenda Item 12: Closure of the Meeting

Annex III
Appendices to the Conclusions and Recommendations

List of Appendices

Appendix	Working Document Reference	Title
Appendix I	UNEP/MED WG.467/4	2023 MED QSR Roadmap and Needs Assessment
Appendix II	UNEP/MED WG.467/7	Cross-Cutting Issues and Common Challenges: The Methodological Approach for Mapping the Interrelations between Sectors, Activities, Pressures, Impacts and State of Marine Environment for EO5 and EO9
Appendix III	UNEP/MED WG.467/8	Data Standards and Data Dictionaries for Common Indicators related to Pollution and Marine Litter
Appendix IV	UNEP/MED WG.467/9	Data Standards and Data Dictionaries for Common Indicators related to Biodiversity and Non-Indigenous Species
Appendix V	UNEP/MED WG.467/10	Data Standards and Data Dictionaries for Common Indicators related to Coast and Hydrography
Appendix VI	UNEP/MED WG.467/5	IMAP Guidance Factsheets: Update for Common Indicators 13, 14, 17, 18, 20 and 21; New proposal for Candidate Indicators 26 and 27
Appendix VII	UNEP/MED WG.467/6	Indicator Guidance Factsheets for EO7 and EO8 Coast and Hydrography Common Indicators 15, 16 and 25
Appendix VIII	UNEP/MED WG.467/14	Draft Updated Reference List of Marine Habitat Types for the Selection of Sites to be included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean
Appendix IX	UNEP/MED WG.467/15	Defining the Most Representative Species for IMAP Candidate Indicator 24 and related Monitoring Protocols
Appendix X	UNEP/MED WG.467/16	Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species

Appendix I

UNEP/MED WG.467/4
2023 MED QSR Roadmap and Needs Assessment

UNITED NATIONS

EP

UNEP/MED WG.467/4

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

UNEP

8 August 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Agenda Item 4: 2023 MED QSR Roadmap and Needs Assessment

2023 MED QSR Roadmap and Needs Assessment

UNEP/MAP
Athens, 2019

Note by the Secretariat

At their 19th Ordinary Meeting (COP 19, Athens, Greece, 9-12 February 2016), the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) adopted a novel and ambitious Integrated Monitoring and Assessment Programme and related Assessment Criteria (IMAP) (Decision IG. 22/7) based on region-wide Ecological Objectives and Common Indicators.

In line with the above-mentioned decision and in the context of implementing the Ecosystem Approach Roadmap adopted by the Contracting Parties to the Barcelona Convention and its Protocols in 2008 (Decision IG.17/6), the UNEP/MAP system delivered during the biennium 2016-2017, the first ever Quality Status Report for the Mediterranean (2017 MED QSR).

Decision IG. 23/6 on the 2017 MED QSR (COP 20, Tirana, Albania, 17-20 December 2017) has underlined the gaps of the pioneering 2017 MED QSR and requested the Secretariat to make all possible efforts to overcome them and recommended general directions towards a successful 2023 Mediterranean Quality Status Report (2023 MED QSR) and prepare in the first year of the biennium 2018-2019, a Roadmap accompanied with a Needs Assessment on how to improve data collection to address knowledge gaps and strengthen the capacities of the system (2023 MED QSR Roadmap).

The 87th Meeting of the Bureau considered and welcomed the 2023 MED QSR Roadmap and Needs Assessment that was thereafter presented to the members of the EcAp Coordination Group for written consultation and consequently concluded by the end of 2018, as requested by COP 20.

In this regard, the Contracting Parties were asked for their feedback and Malta and Montenegro have provided the Secretariat with their suggestions. Malta suggested that including the minimal number of datasets required in the table of the Roadmap is premature, given that the Common Indicator Guidance Factsheets are still being discussed and are subject to regular updates, and the Contracting Parties are still in the process of implementing their monitoring programmes according to the IMAP requirements. It added that ideally the number of datasets required for each Ecological Objective are decided under the CORMON process in cooperation with Contracting Parties, such that the optimal level of monitoring required reflects the Contracting Parties' practical experience in carrying out their monitoring programmes. Montenegro would like to emphasize a further need for optimal integration of the 2023 MED QSR Roadmap within the PoW 2020-2021 in order to be able to successfully deliver the 2023 Mediterranean Quality Status Report. It added that the needs of the Contracting Parties related to implementation of the IMAP and 2023 MED QSR Roadmap milestones have to be supported by planning appropriate technical and financial means.

The present paper was presented in the Joint Meeting of the Ecosystem Approach Correspondence Group on Marine Litter Monitoring and ENI SEIS II Assessment of Horizon 2020/National Action Plans of Waste Indicators (Podgorica, Montenegro, 4-5 April 2019). It represents the Secretariat's approach for the development of the 2023 MED QSR Roadmap in line with the above-mentioned COP 20 mandate, which is being integrated into the proposal of the UN Environment/MAP Programme of Work for 2020-2021 currently under development. As such it details the main processes and milestones and the related outputs and timelines.

List of Abbreviations / Acronyms

BACs	Background Assessment Criteria
COP	Conference of the Parties
CORMON	Correspondence Group on Monitoring
DPSIR	Driving Forces-Pressures-State-Impacts-Responses
EACs	Environmental Assessment Criteria
EcAp	Ecosystem Approach
EO	Ecological Objective
GES	Good Environmental Status
GFCM	General Fisheries Commission for the Mediterranean
GIS	Geographic Information System
IMAP	Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria
MAP	Mediterranean Action Plan
MED POL	Programme for the Assessment and Control of Marine Pollution in the Mediterranean Sea
MED QSR	Mediterranean Quality Status Report
MoU	Memorandum of Understanding
NIS	Non-Indigenous Species
SEIS	Shared Environmental Information System
UNEP/MAP	United Nations Environment Programme/Mediterranean Action Plan

Table of Contents

I. From the 2017 MED QSR to the 2023 MED QSR

1. In the context of implementing the Ecosystem Approach Roadmap adopted by the Contracting Parties to the Barcelona Convention and its Protocols in 2008 (Decision IG.17/6), the UN Environment/MAP system delivered during the last biennium 2016-2017, the first ever Quality Status Report for the Mediterranean (hereinafter referred to as 2017 MED QSR, https://www.medqsr.org/). This is an assessment product based on region-wide Ecological Objectives and Common Indicators that is built upon existing data and complemented with inputs from numerous diverse sources.

2. Underlining the importance of this major and innovative MAP achievement, Decision IG. 23/6 on the 2017 MED QSR (COP 20, Tirana, Albania, 17-20 December 2017) pointed out several gaps (as laid out in Chapter II of this document) and requested the Secretariat "to prepare in cooperation with the Contracting Parties through the Ecosystem Approach governance structure, in the first year of the biennium 2018-2019, a Roadmap accompanied with a Needs Assessment on how to improve data collection to address knowledge gaps and strengthen the capacities of the system (the QSR 2023 Roadmap). To this aim, priority activities needed to successfully deliver the 2023 Mediterranean Quality Status Report shall be identified for inclusion in the Programme of Work".

3. Following up on Decision IG.23/6, the Bureau at its 85th meeting (Athens, Greece, 18-19 April 2018) requested "that the Roadmap and Needs Assessment for the 2023 MED QSR, prepared in close collaboration with the EcAp Coordination Group, is presented at its 86th meeting".

4. The 87th Meeting of the Bureau considered and welcomed the 2023 MED QSR Roadmap and Needs Assessment that was thereafter presented to members of the EcAp Coordination Group for written consultation, and consequently concluded by the end of 2018, as requested by COP 20.

5. The present paper describes the Secretariat's approach for the development of the 2023 MED QSR Roadmap in line with the above-mentioned COP 20 mandate. As such, it contains a narrative section describing findings of the initial assessment of key needs and the proposed milestones and steps needed to address such identified needs. Details are then contained in tabular form of the initial 2023 MED QSR Roadmap with Vision, Main Processes and Milestones and related Outputs (with proposed timelines), including the necessary involvement of the Ecosystem Approach governance mechanism.

6. The current document presenting the 2023 MED QSR Roadmap, which is being integrated into the proposal of the UN Environment/MAP Programme of Work for 2020-2021 currently under development, will be shared with the EcAp Coordination Group members in the CORMON meetings of all four clusters, Biodiversity, Pollution Monitoring, Marine Litter Monitoring and Coast and Hydrography for their information.

II. Assessment of key needs to address knowledge gaps and strengthen the capacities of the system

7. Decision IG. 23/6 on the 2017 MED QSR pointed out several gaps and recommended the following general directions in order of successfully deliver the 2023 MED QSR:

i. Harmonization and standardization of monitoring and assessment methods;
ii. Improvement of availability and ensuring of long time series of quality assured data to monitor the trends in the status of the marine environment;
iii. Improvement of availability of the synchronized datasets for marine environment state assessment, including use of data stored in other databases where some of the Mediterranean countries regularly contribute;

iv. Improvement of data accessibility with the view to improving knowledge on the Mediterranean marine environment and ensuring that Info-MAP System is operational and continuously upgraded, to accommodate data submissions for all the Integrated Monitoring and Assessment Programme (IMAP) Common Indicators.

8. To specifically address the above-mentioned main directions in the development of the 2023 MED QSR, the Secretariat and MAP Components have reviewed the state of play of national implementation of IMAP, focusing on best practices and challenges faced with regards to different aspects of its implementation at national level, and initiated a discussion on a number of cross-cutting issues and region-wide challenges, that are crucial for ensuring the effective integrated GES assessment. An initial needs assessment on how to improve data collection to address knowledge gaps and strengthen the capacities of the system was developed in the “Progress Report on the implementation of Decision IG.22/7 on the Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria” (UNEP/MED WG.450/3). This document was presented at the Regional Meeting on IMAP Implementation: Best Practices, Gaps and Common Challenges (10-12 July, Rome, the Rome Meeting) which resulted in valuable lessons learned, conclusions and recommendations. They are guiding the work of the Secretariat towards the more detailed needs assessment to be provided cluster by cluster and discussed in the upcoming CORMON meetings and within respective Ecosystem Approach Governance Structure.

9. The following issues will be presented for review and in-depth discussion in the upcoming CORMON meetings:

a) Better interlinkages between Activities/Pressure/Impacts and clarification of definition of impacts noting that such a definition should primarily focus on biodiversity;
b) Clarifications of definitions of integration and aggregation rules. In this respect the Rome Meeting requested the Secretariat to make the necessary changes in document UNEP/MED WG. 450/3 opting for giving the priority at this stage of IMAP implementation to the work on geographical aggregation and assessment scaling rather than integration.

10. Consistent with the outcome of the Rome meeting, and acknowledging the achievements, lessons learned, and challenges faced during the current initial phase of IMAP implementation at national level, the following elements will be submitted for discussion at the upcoming CORMON meetings:

a) Efforts for coordinated national IMAP implementation should be enhanced, notably through technical proposals;
b) Tailored capacity-building activities should be established to fill the gaps clearly identified during IMAP national trainings, including on technical capacities, software, monitoring protocols, human resources needed, etc.;
c) Further efforts are necessary by the Contracting Parties to generate more synchronized datasets for assessments (collection of quality assured data in a coherent manner and format and availability of long-time data series to monitor trends);
d) IMAP compatible Pilot Info-system needs to be finalized to accommodate reporting of IMAP compatible data by the Contracting Parties, with clear distinction between mandatory and optional data;
e) Monitoring protocols and assessment methods have to be harmonized and standardized, including region-wide harmonized criteria for reference conditions and threshold/ boundary values per assessment area, as appropriate and feasible;
f) Further development of the risk-based approaches, analytical testing and assessment methodologies, assessment criteria for integrated chemical and biological assessment methods and testing of new

research-proved tools for monitoring the toxic effects, as well as improvement of knowledge on emerging chemicals, are needed;

g) Testing of the Background Assessment Criteria (BACs) and Environmental Assessment Criteria (EACs) and thresholds application should be undertaken on a trial basis and at regional and sub-regional levels;
h) Identification and evaluation of marine litter accumulation (stranding fluxes, loads and linkage with specific sources) and hotspots using GIS and mapping systems and modelling tools should be enhanced, including better understanding of transport dynamics and accumulation zones;
i) Science-Policy Interface should be strengthened, structured and sustained, by supporting the national monitoring programmes, to ensure that ongoing scientific projects can address IMAP national implementation needs;
j) Cooperation at sub-regional level for Common Indicators, as appropriate, to share best practices and addressing specific gaps within national monitoring programmes should be strengthened;
k) A continual exchange of best practices should be encouraged and established among thematic experts possibly through on-line communication tools for all three IMAP clusters.

11. Based on the findings of the 2017 MED QSR and related Decision IG.23/6, as well the recommendations of the Rome Meeting, the Secretariat has concluded a coordinated analysis with the involvement of all relevant components on major achievements and gaps of the 2017 MED QSR, priority needs and specific issues to address for each IMAP cluster. Specific recommendations were also coordinated on procedural (including meetings and coordination) needs, based on lessons learnt from the 2017 QSR process, in order to find realistic ways and means for addressing and filling the 2017 MED QSR identified gaps.

12. The outcome of this specific mapping resulted in:

a) A vision of a better integrated and DPSIR-based Good Environmental Status (GES) assessment of the 2023 MED QSR; and
b) A short list of key priority needs which need to be addressed in order to achieve this vision, accompanied with the necessary main processes and milestones and related outputs.

13. Based on the outcomes of above steps undertaken by the Secretariat, key priority needs to be addressed towards a DPSIR-based GES assessment of the 2023 MED QSR are as follows:

1. Scale(s) of monitoring, assessment and reporting to be agreed on, to enable comparable data sets assessment;
2. Necessary methodological tools and assessment criteria to be agreed on to allow and promote integrated assessment of GES;
3. Full implementation of IMAP to be achieved, with data generation throughout the Mediterranean;
4. Fully operational SEIS-based IMAP Info System to be put in place to enable timely reporting of the Contracting Parties;
5. Monitoring Protocols and Data Quality Assurance and Quality Control for IMAP Common Indicators are to be made available to guide Contracting Parties;
6. National capacity and knowledge gaps are to be addressed to ensure region-wide coherence and data availability;
7. Regional partners, projects to be able to input process in a coordinate manner;
8. Regular, effective (and more frequent) regional coordination with the Contracting Parties to be put in place.

III. Vision and Milestones to be achieved for a successful delivery of the 2023 MED QSR

14. **Vision: An integrated DPSIR-based GES assessment, developed on consolidated and quality-assured monitoring data sets, reported and processed through an effective IMAP Info System that is interoperable with national and other regional monitoring and reporting networks.**

15. The 2023 MED QSR Roadmap is built around the following phases and processes:

1. Timely negotiation and agreement of Contracting Parties through the Ecosystem Approach Governance Structure at regional (and as appropriate at sub-regional) level on the scale(s) of monitoring, assessment and reporting;
2. Development and agreement of Contracting Parties through the Ecosystem Approach Governance Structure on necessary methodological tools and assessment criteria to allow and promote integrated assessment of GES at the level of Ecological Objectives and to the extent possible, across relevant Ecological Objectives;
3. Full implementation of IMAP-based national monitoring programmes throughout the Mediterranean to enable the region to generate quality assured and real time data during 2020-2022 (at least delivery of two sets of data for each IMAP cluster[1]);
4. Delivery and operationalisation of a user-friendly and SEIS-based IMAP Info System to collect and process data produced by IMAP-based national monitoring programmes;
5. Development and implementation of Monitoring Protocols and Data Quality Assurance and Quality Control for IMAP Common Indicators (depending on the nature of Common Indicators, to be developed on regional/sub-regional or national level and discussed, agreed on by the Contracting Parties through the relevant level of the Ecosystem Approach Governance Structure);
6. Continuous support and technical assistance to the Contracting Parties in relation to all the above areas;
7. Outreach to regional partners to provide inputs to the 2023 MED QSR, establishment of solid partnerships and development of a communication and visibility strategy for the 2023 MED QSR;
8. Regular and effective regional cooperation and coordination with the Contracting Parties, through CORMONs, under the guidance of the Ecosystem Approach Coordination Group.

16. Table 1 below details each of the above main processes and milestones of the roadmap, with main outputs and delivery timelines in a table format.

17. The 87th Meeting of the Bureau considered and welcomed the 2023 MED QSR Roadmap and Needs Assessment that was thereafter presented to the EcAp Coordination Group members for written consultation, and consequently concluded by the end of 2018, as requested by COP 20. The CORMON Meetings will follow the recommendations of the Ecosystem Approach Coordination Group in order to further address specific needs and necessary priority actions to deliver the outputs presented in Table 1, specific to their clusters, as provided for by Decision IG.23/6 on the 2017 MED QSR.

[1]Noting that in line with consultations throughout the UNEP/MAP system, it is most likely feasible to have at least two data sets in areas of pollution and marine litter and coast and hydrography, while only one data set can be assured for biodiversity and NIS throughout the Mediterranean

Table 1. 2023 MED QSR Vision, Main Processes, Milestones and Outputs

<table>
<tr><td colspan="5" align="center"><u>2023 MED QSR Vision:</u>
An integrated DSPIR-based GES assessment, developed on consolidated and quality-assured monitoring data sets, reported and processed through a fully operational IMAP Info System that is interoperable with national and other regional monitoring and reporting networks</td></tr>
<tr><td colspan="5">2017 MED QSR features (starting point)
This first regional assessment product, based on 23 IMAP common indicators, includes clear findings, conclusions and key messages related to each indicator. Data sources of the assessment include Contracting Parties’ data sets as part of the MED POL data base, other relevant data provided by MAP components and MAP implemented project, and GFCM and other regional sources of data, including projects.
Data sets are provided to the extent possible for all common indicators but are incomplete and data availability is limited for the whole region. The assessment is limited in relation to integrated GES assessment (provided, if any, only across Common Indicators of specific Ecological Objectives). The assessment recognizes the need to address interlinkages between pressures/impacts and state of marine environment, but it cannot provide it in detail.</td></tr>
<tr><td colspan="5">Decision IG. 23/6 of COP 20 on 2023 MED QSR preparation provides for:
(i) harmonization and standardization of monitoring and assessment methods;
(ii) improvement of availability and ensuring of long time series of quality assured data to monitor the trends in the status of the marine environment;
(iii) improvement of availability of the synchronized datasets for marine environment state assessment, including use of data stored in other databases where some of the Mediterranean countries regularly contribute;
(iv) improvement of data accessibility with the view to improving knowledge on the Mediterranean marine environment and ensuring that IMAP Info System is operational and continuously upgraded, to accommodate data submissions for all the IMAP Common Indicators.</td></tr>
<tr><td colspan="5" align="center">MAIN PROCESSES AND MILESTONES</td></tr>
<tr><td>1. Scales of Monitoring, Assessment and Reporting</td><td>2. Integrated assessment of GES</td><td>3. Implementation of national IMAPs throughout the Mediterranean
6. Technical assistance and support</td><td>4. IMAP Info System
5. Monitoring Protocols and Data Quality Assurance and Quality Control</td><td>7. Outreach and visibility</td></tr>
<tr><td colspan="5" align="center">OUTPUTS</td></tr>
<tr><td>Analysis for each IMAP cluster on knowledge gaps, with focus on scales of monitoring prepared (mid 2019 - end 2020);</td><td>Analysis of interrelations between sectors, activities, pressures, impacts and state of marine environment for each Common Indicators included in the IMAP Pilot Info System prepared (2018-2019);</td><td>State of the national implementation of IMAP reported by the Contracting Parties (2018/2019, 2020/2021, 2021/2022);</td><td>IMAP information and data sharing policy developed (2019);</td><td>Timeline for data-sharing with regional partners defined (2019-2021);</td></tr>
</table>

Approaches on scales of monitoring for IMAP Common Indicators included in the IMAP Pilot Info System defined (2019); Scales of monitoring for all IMAP Common Indicators agreed (2021); Scales of assessment products for all IMAP Common Indicators clustered per Ecological Objectives proposed (2021-2022); Assessment criteria/thresholds/ baseline values proposed/updated for IMAP Common Indicators included in the IMAP Pilot Info System (2020-2021); Assessment criteria/thresholds/ baseline values initiated for all IMAP Common Indicators (2021-2022); Reporting formats adjusted to agreed scales of monitoring and scales of assessment products (2021-2022).	Approaches for mapping the pressures/impacts/status of marine environment for the above IMAP Common Indicators defined (Rome Meeting); (2019-2020); Methodological concept developed and proposed to assess the interrelation of pressures/impacts/status of marine environment (2020); Methodological concept to support better integration of thematic assessment products related to IMAP Common i.e. integration between Ecological Objectives (at national, sub-regional and regional scale) is agreed and tested (2020-2021); Thematic assessment products are prepared (2021-2022); 2023 MED QSR delivered (2023);	Minimum 3 sets of data on IMAP Common Indicators (EO5, EO9, EO10) reported by the Contracting Parties (2019, 2020, 2021/2022); Minimum 1 set of data (EO1 and EO2) reported by Contracting Parties (2021/2022); Minimum 2 sets of data (EO7, EO8) reported by the Contracting Parties (2020, 2021/22); Country capacity building trainings organized in line with their needs (2019-2021); Sub-regional/regional workshops and trainings, in areas of common capacity needs and knowledge gaps, organized (minimum 2 per sub-region), (2019-2021); Joint monitoring pilots designed and implemented (minimum 2 in participating countries), (2019-2021).	IMAP Pilot Info system ready to upload monitoring data (end of 2019); Data dictionaries and data standards finalized for all IMAP Common Indicators (mid 2021); IMAP Pilot Info System updated to cover all IMAP Common Indicators (mid-2022); IMAP Info System fully operational enabling the Contracting Parties to report their monitoring data in 2020, 2021 and 2022. Monitoring Protocols drafted for IMAP Common Indicators included in the IMAP pilot Info System; (2018/2019); Quality Assurance and Quality Control schemes in place for IMAP Common Indicators included in the IMAP Pilot Info System (2019-2020); Quality Assurance and Quality Control schemes expanded to cover all IMAP Common Indicators (2021-2022);	Agreements reached with Regional Partners (2020); Communication and visibility strategy for the 2023 MED QSR developed and agreed (2021); Outreach to key partners is undertaken and relevant meetings held (2019-2020); Communication and visibility strategy for the 2023 MED QSR is implemented (2021-2023); 2023 MED QSR published in 2 languages and on line available and presented at COP 23.

8.Effective Regional Collaboration
• CORMON meetings are held (minimum 1/year/cluster between 2019-2022); • Integrated CORMON meetings are held (minimum 1/biennium 2020, 2022); • Ecosystem Approach Coordination Group meetings are held (minimum 1/year between 2019-2023); • Sub-regional expert groups to address monitoring and assessment sub-regional specifics, including scales of assessment products and their integration, are held (minimum 1/biennium for all 4 sub-regions in integrated manner, for all clusters); • Online expert groups are held for each cluster, to ensure continuous work between CORMON meetings (to be re-established in CORMONs in 2019); • Bilateral meetings on MoU implementation are held, new MoUs are considered and partnerships with key partners are further strengthened; • Progress reports are submitted to the meetings of the Bureau of the Contracting Parties, the meetings of the MAP Focal Points and the COPs (2019-2023) for guidance and approval as appropriate.

Appendix II

UNEP/MED WG.467/7
Cross-Cutting Issues and Common Challenges: The Methodological Approach for Mapping the Interrelations between Sectors, Activities, Pressures, Impacts and State of Marine Environment for EO5 and EO9

UNITED NATIONS

EP

UNEP/MED WG.467/7

UNITED NATIONS ENVIRONMENT PROGRAMME MEDITERRANEAN ACTION PLAN

UNEP

8 August 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Agenda Item 5: The Methodological Approach for Mapping the Interrelations between Sectors, Activities, Pressures, Impacts and State of Marine Environment

Cross-Cutting Issues and Common Challenges: The Methodological Approach for Mapping the Interrelations between Sectors, Activities, Pressures, Impacts and State of Marine Environment for EO5 and EO9

UNEP/MAP
Athens, 2019

Note by the Secretariat

At their 19th Ordinary Meeting (COP 19, Athens, Greece, 9-12 February 2016), the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) adopted a novel and ambitious Integrated Monitoring and Assessment Programme and related Assessment Criteria (IMAP).

The IMAP foresees in its initial phase (2016-2019) of implementation, the following:

- Existing national monitoring and assessment programmes of Contracting Parties to be updated and integrated, in line with the IMAP structure, principles and common indicators;
- Good environmental status (GES) definitions to be updated and the assessment criteria to be further refined;
- Scale of reporting units to be defined, taking into account both ecological considerations and management purposes, following a nested approach;
- An updated and integrated data and information system for UN Environment/Mediterranean Action Plan (MAP)-Barcelona Convention with clearly set rules for data handling and assessment for the various components, and with a user-friendly reporting platform for Contracting Parties to be developed.

At the 20th Ordinary Meeting (COP20, Tirana, Albania, 17-20 December 2017), the Contracting Parties endorsed in Decision IG.23/6 the key findings of the 2017 MED QSR (the QSR Decision); underlined the gaps of the 2017 MED QSR; and requested the Secretariat to make all possible efforts to overcome them. The Contracting Parties recommended as general directions towards a successful 2023 Mediterranean Quality Status Report (2023 MED QSR): (i) harmonization and standardization of monitoring and assessment methods; (ii) improvement and ensuring availability of long time series of quality assured data to monitor the trends in the status of the marine environment; (iii) improvement of availability of synchronized datasets for marine environment state assessment, including 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, ensuring that Info-MAP System is operational and continuously upgraded to accommodate data submissions for all the IMAP Common Indicators.

The Regional Meeting on IMAP Implementation: Best Practices, Gaps and Common Challenges (IMAP Best Practices Meeting, Rome, Italy, 10-12 July 2018) welcomed the work undertaken by the Secretariat and MAP Components to support the implementation of IMAP at regional, sub-regional and national levels, including several cross-cutting issues, as provided in UNEP/MED WG.450/3. The Meeting further requested the Secretariat to present the following issues for review and more in-depth discussion in the upcoming CORMONs:

- Better interlinkages between activities/pressure/impacts and clarification of definition of impacts noting that such a definition should primarily focus on biodiversity;
- Update, based on feedback and inputs received during the Meeting, of Tables 1, 2 and 3 of document UNEP/MED WG.450/3 for further review by the CORMONs; and
- Clarifications of definitions of integration and aggregation rules opting for giving priority at this stage to the work for IMAP implementation on geographical aggregation and assessment scaling rather than integration.

In this context, MED POL further elaborated document UNEP/MED WG.450/3 for consideration of the Meeting of CORMON on Pollution that was held in Podgorica, Montenegro, 2-3 April 2019 with a particular focus on:

a) Simplifying and revising its section 2 related to methodological approaches;

b) Adding a semi-quantitative “Scoreboards” method with a simplified example to support mapping of the interrelation of drivers-pressures-impacts-state-responses in line with DPSIR approach;
c) Providing information on UN Regional Seas Programme approaches to integration and aggregation;
d) Revising and simplifying sections 3 and 4 related to assessment scales and options for the definition of thresholds (Tables 5, 6 and 7 have been revised for EO5 and EO9).

Following the outcome of the Meeting of CORMON on Pollution Monitoring, 2-3 April 2019, Podgorica, Montenegro, this document was updated in line with its conclusions.

The Meeting of the MED POL Focal Points, held in Istanbul, Turkey on 29- 31 May approved the methodologies proposed for GES-integrated assessment based on DPSIR approach and recommended its submission for approval of the 7th Meeting of EcAp Coordination Group. The Meeting recommended testing the proposed methodologies by the Contracting Parties in an integrated manner for Pollution, Biodiversity, and Coast and Hydrography Clusters of IMAP with the aim to present related main findings to the next meetings of respective CORMONs.

Table of Contents

Annexes

1. OVERVIEW OF CROSS-CUTTING ISSUES AND COMMON CHALLENGES OF IMAP IMPLEMENTATION

1. IMAP describes the strategy, themes, and products that the Contracting Parties are aiming to deliver, through collaborative efforts in the framework of the UN Environment/MAP - Barcelona Convention, during the second cycle of the implementation of the Ecosystem Approach Process in 2016-2021. IMAP Decision IG.22/7 provides, during the initial phase of IMAP implementation (2016 -2019), for the review and revision, as appropriate, of the national monitoring and assessment programmes in order to integrate IMAP provisions; the update of GES definitions; as well as the further refinement of assessment criteria.

2. Based on common region-wide agreed Common Indicators (CIs) per Ecological Objectives (EOs), the underlying aim of IMAP is to monitor and assess the status of the marine and coastal environment towards the achievement of Good Environmental Status (GES) of the Mediterranean Sea and Coast. The determination of GES and the assessment on its achievement includes the main elements of the ecosystem and is closely linked to the effects of pressures from human activities (e.g. pressure-based ecological objectives). The evaluation of all IMAP EOs and its consideration as functional units of the marine ecosystem as a whole should allow the definition and assessment of achievement of GES.

3. Further work is required on a number of issues including (i) the harmonization of monitoring and assessment methods; (ii) the definition of links between assessment scales, pressures and cumulative impacts on ecosystem components; (iii) the improvement of long time series of quality assured data to monitor the trends; and (iv) the improvement of data management and data accessibility through the MAP Info-System for all the IMAP Common Indicators (CIs). However, there is a need to address these issues in more detail for the period (2019-2021), and to this respect, criteria for assessments, reference and limit levels (baselines, thresholds, etc.), aggregation rules for the CIs and EOs, assessment scales (spatial/temporal), as well as continuous review of work progresses are considered critical to ensure an effective implementation of IMAP.

1.1. From 2017 Mediterranean QSR towards 2023 Mediterranean QSR: A more integrated approach for GES assessment

4. As indicated above, based on the 2017 MED QSR, the IMAP Guidance (UNEP(DEPI)/MED IG.22/Inf.7) and other UN Environment/MAP documents, as well as findings from ongoing projects and other relevant work, the following issues should be considered as a priority to improve GES assessment:

- Assessment of pressures/impacts/state interactions identifying, where possible, cause-effect relationships;
- Definition of clear and common aggregation (geographical) and integration rules, including in time and space;
- Definition of adequate assessment scales using a nested approach;
- Application of both trends and new/updated IMAP thresholds as appropriate tools for GES assessment.

5. There is a need to ensure better integration and interaction of pressures, impacts and state elements in assessing GES and the interrelation to the extent possible among different relevant Ecological Objectives of the coastal and marine environment in the Mediterranean Sea.

6. Here, the terms pressure is defined as the forces that generate changes in the state of the ecosystem as a result of drivers and thereby the provision of its services (e.g. nutrient load, changes in the salinity regime, fishing effort, oil spills, introduction of invasive species). Impacts

are defined as the consequences for the marine environment caused by the pressures affecting state.

7. Transboundary issues should be also considered, since GES achievement in one Contracting Party may be dependent on actions taken by other Contracting Parties within the region or sub-region, due to different interactions, especially regarding anthropogenic pressures that may have transboundary effects. In this respect, based on existing assessment best practices, a two-step process for assessments may be recommended:

- First, an assessment of the predominant pressures and their impacts on the marine environment, including a mapping of the uses and activities in the marine environment, when appropriate.
- Second, an assessment of the environmental status of marine ecosystems (including species and habitats), informed by the pressure and impact assessments under the first step (e.g. Scorecards).

2. METHODOLOGICAL APPROACHES FOR INTEGRATED MARINE ASSESSMENTS

8. There are some approaches to support the integrated assessment under IMAP of the predominant pressures and their impacts on the marine and coastal environment to assess the state of the marine environment (i.e. DPSIR-based assessments); and as a consequence, build policy responses (e.g. measures and priority actions) to address the drivers (e.g. economic sectors and activities) causing the degradation of the marine ecosystem and its ecosystem services.

9. The following subsections explain some of the most commonly used GES-integrated assessments based on DPSIR approach that have been acknowledged and approved in principle by the Meeting of the CorMon on Pollution Monitoring.

2.1. GRID/Table approach

10. Pressures can be considered in the two following ways: (i) at source, i.e. focusing on the primary and main activities generating the pressure; this aspect is relevant for setting environmental targets and defining measures aiming at reducing the pressures in order to achieve or maintain GES; and (ii) at sea, i.e. the level of pressure in the marine environment to which the different elements of the ecosystem are subjected; this aspect is particularly relevant for determining GES for both IMAP pressure-based and status-based Common Indicators.

11. With its EOs and CIs, IMAP is the multidimensional measurement and assessment system of the Barcelona Convention within the application of the DPSIR approach. Therefore, the elaboration of a table with these two dimensions of the IMAP (i.e. by using the IMAP measurement information through Common Indicators cross-checked along their potential sources and origin) would produce an assessment which should allow elucidating priority actions for natural/anthropogenic drivers and related policy responses.

12. Table 1 provides a tabular representation of interactions between pressures and impacts for EO5 and EO9, as measured by IMAP Common Indicators (left column). A full example of the GRID/Table Approach for the overall interrelationships between the IMAP Common Indicators grouped per related Ecological Objectives (EO) and Pressures to the marine ecosystem can be found in Annex I.

13. Thus, the proposed approach is to cross-map all the anthropogenic activities with significant contribution to pressures with the Common Indicators used for its monitoring and assessment. Following the first step, expert judgment can/may better define/refine specific

interactions, for these activities contributing to pressures at Common Indicator level considering sub-regions, or, if relevant and appropriate, sub-divisions or lower geographical units (using as appropriate the nested approach). Table 2 is an example of pressure/impacts interactions at sub-regional level for key pressures, which is also considering sub-divisions.

14. Table 2 is an example of a GRID/Table template taking into account the relevant geographical scale (i.e. sub-regions and sub-divisions) and is expected to be the starting point to be completed to advance in a future integrated Med QSR 2023, at least for the four sub-regions established in the Mediterranean for assessment purposes in the framework of implementing the Ecosystem Approach Roadmap.

15. Some metrics and sub-divisions are still to be refined to improve the analysis, prior to setting up any management strategy (Table 2). This approach can support the definition of areas/sectors of activities where appropriate pressures reduction and management measures will be needed. It can also support prioritization in terms of specific baselines, thresholds, and finally targets, and support the monitoring of associated measures' efficiency.

16. Finally, the total balance of the reference scales for both environmental state (e.g. healthy ecosystems) and pressures (e.g. anthropogenic impact intensity), could define the selection of geographical scales, starting from both the greatest sensitivity/ecological relevance and highest level of pressures.

Table 1: Natural and anthropogenic pressures (selected based on the main activities in terms of pressures as provided by ICZM Protocol and other Barcelona Convention`s Protocols) affecting the marine ecosystems and the related measurement IMAP Common Indicators for EO5 and EO9. Following the analysis presented in this table that is based on the expert judgment, the members of the EcAp Coordination Group can better define/refine specific interactions, for activities contributing to pressures at Common Indicator level.

Pressures vs. measured IMAP Common Indicators (EO5 and EO9)	**Non-Construction Zone**	**Natural Hazards**	**Natural disasters**	**Climate Change**	**Agric. and forestry runoffs**	**Coastal Urbanization**	**Damming (demand on water)**	**Waste water discharges**	**Industry**	**Tourism frequentation**	**Yachting**	**Marine mining**	**Dredging**	**Desalinization**	**Coastal artificialization.**	**Port operations**	**Offshore structures**	**Cables and pipelines**	**Shipping**	**Oil and gas extraction**	**Renewable energy**	**Fishing (incl. recreational)**	**Sea-based food harvesting**	**Extraction of genetic**	**Aquaculture**	**Solid waste disposal**	**Storage of gases**	**Research and education**	**Defence operations**	**Damping of munitions**
C13. Nutrients																														
C14. Chlorophyll *a*																														
CI17: Key harmful contaminants																														
CI18: Pollution effects																														
CI19: Acute pollution events																														
C20: Contaminants in seafood																														
CI21: Intestinal enterococci																														

Table 2: GRID/Table for IMAP integrated assessments under the nested assessment approach. The four sub-regions have been already defined for practical reasons and for the purpose of the UN Environment/MAP 2011 Initial Integrated Assessment (UNEP(DEPI)/MED WG.363/Inf.21) and the Med QSR 2017, namely the Western Mediterranean, Ionian and Central Mediterranean, Adriatic Sea and Aegean-Levantine Seas. The sub-divisions (i.e. sub-regional seas/basins) have been defined according to availability of database sources for the purpose of development of the assessment criteria for pollution (UNEP(DEPI)/MED WG.427/Inf.3). Sub-divisions might correspond initially to the Contracting Parties` coastal zones and offshore areas. Other sub-divisions may be defined. Downscaling at sub-divisional level is also used under the EU Marine Strategy Framework Directive. Following initiated analysis presented in this table that is based on the expert judgment, the members of the EcAp Coordination Group can better define/refine specific interactions, for activities contributing to pressures at Common Indicator level in Mediterranean sub-regions and sub-division.

Scaled GRID pressures/impact approach	**SUB-REGIONS**	**SUB-DIVISIONS**	**Coastal urbanization**	**Industry**	**Offshore structures**	**…**
Common Indicator 14 (Chl-a) (Ecological Objective 5)	**Western Mediterranean Sea**	North Western (NWMS)				
		Alboran Sea (ALBS)				
		Tyrrhenian Sea (TYRS)				
	Adriatic Sea	North Adriatic (NADR)				
		Middle Adriatic (MADR)				
		South Adriatic (SADR)				
	Central and Ionian Seas	Central (CEN)				
		Ionian Sea (IONS)				
	Aegean and Levantine Seas	Aegean Sea (AEGS)				
		Levantine (LEVS)				
Scaled GRID pressures/impact approach	**SUB-REGIONS**	**SUB-DIVISIONS**	**Coastal urbanization**	**Industry**	**Offshore structures**	**…**
Common Indicator 17 (Contaminants) (Ecological Objective 9)	**Western Mediterranean Sea**	North Western (NWMS)				
		Alboran Sea (ALBS)				
		Tyrrhenian Sea (TYRS)				
	Adriatic Sea	North Adriatic (NADR)				
		Middle Adriatic (MADR)				
		South Adriatic (SADR)				
	Central and Ionian Seas	Central (CEN)				
		Ionian Sea (IONS)				
	Aegean and Levantine Seas	Aegean Sea (AEGS)				
		Levantine (LEVS)				

2.2. SCOREBOARDS METHOD: Quantifying pressures/impacts relationships; risk-based approach

17. Mapping of pressures/impacts relationships can be done using a risk-based approach. Risk-based approach is particularly effective for Ecological Objectives that are spatially patchy and where pressures are applied at specific locations. It is recommended to map the pressures that are most likely to have significant impacts, considering the vulnerability of various elements of the ecosystem.

18. Similarly, to the GRID/Table Approach, a variety of scales are necessary to reflect state-based assessments (i.e. ecologically-relevant scales for the various ecosystem elements: species, habitats, ecosystems), and pressure-based assessments aimed to guide management of human activities to reduce their impacts. The GRID/Table approach and the quantitative risk-based methodological scoreboard approach that rely on the calculation of numeric scores (i.e. criteria which should be based on EOs assessments along the spatial distribution of pressures-impacts and risks to the marine environment) for the IMAP integrated assessments could be seen as tools to support implementation of the DPSIR approach.

19. Scoreboard method is similar to the GRID/Table approach; however, it uses numeric scores (i.e. assignment of a numeric value by categories) rather than colours alone, to allow calculating derived quantitative information. As well, the chosen scales would shape the final results obtained by scorecard methods and these are even more powerful when used with a risk-based approach focus.

20. There are several scoreboard methodological approaches that may be used for the mapping of distribution of pressures and assessment of their impacts over different ecosystem components (e.g. species groups, pelagic or benthic habitats), with defined quality threshold values (i.e. categorizations and values assignment). An example, under the guidance of PAP/RAC-UN Environment/MAP including interrelations between the IMAP Common Indicators, coastal vulnerability assessment and management, as well as Marine Spatial Planning (MSP) was undertaken recently in Boka Kotorska Bay (Montenegro), through the CAMP initiatives. This methodological approach might guide next steps to develop the matrixes for quantifying the spatial distribution of pressures and their impacts over different marine ecosystem components.

21. Following the recommendation of the Meeting of CorMon on Pollution Monitoring, GRID/Table Approach, risk-based and the semi-quantitative approaches should be complemented with the modelling of the monitoring data in order to ensure a more reliable quantification of the magnitude of impacts. The vulnerability assessment and mapping of distribution of pressures and impacts over different ecosystem components (species groups, pelagic or benthic habitats) may be considered to support scientifically-based scoring.

22. In the absence of quantitative assessment criteria, semi-quantitative approaches should be a basis for mapping and quantifying the interrelation of drivers-pressures-impacts-state-responses relying on the best available expert judgment. Given the fact that IMAP implementation is at stage when monitoring and assessment scales are to be updated/agreed and tested, as well as aggregation and integration rules fully defined, at present, the semi-quantitative scoreboards method is useful for mapping the interrelation of drivers-pressures-impacts-state-responses of complex processes, such as those present in the marine environment (e.g. considering in the vertical axis the economic activities and the natural elements that have great relevance according to the ICZM Protocol and other Barcelona Convention`s Protocols, whilst in the horizontal axis the EcAp/IMAP EOs and CIs). Scoreboards method should provide insights on impacts, which are directly relevant to the state-based assessment of the ecosystem with sufficient detail (e.g. impact on non-commercial species by incidental by-catch which would need to be separated into at least the specified species groups of birds, mammals,

reptiles and fish; and preferably at species level, to feed into species-level assessments). The state-based integrated assessments, combining the state-based Common Indicators as a set of ecosystem elements in a holistic manner, should cover the overall pressure-based Common Indicators affecting it (e.g. the state assessment of the benthic ecosystem should evaluate together the impact from the pressures such as physical loss, physical disturbance, non-indigenous species, nutrient enrichment, removal of species and others). Therefore, this level of detail based on the IMAP EOs and CIs should be the primary methodological basis to develop scoreboard, as well as assign scores, while relying on the best available expert judgment.

23. The added value of the combined synthesis of the semi-quantitative approaches and expert judgment is a clear vision on the requirements and responsibilities from both the managerial and measurement systems. Table 3 details the activities (originated by main drivers) which are commonly known and aligned with the current IMAP multidimensional measurement system (with their Ecological Objectives and Common Indicators) to address current scenarios of Pressures-State-Impacts. The Table provided in UNEP/MED WG.463/Inf.9 presents an extension of this interrelation, relating specifically IMAP, as the measurements system of the Barcelona Convention with relevant responses provided through relevant regional policies.

Table 3: Template to frame the activities according to the DPSIR approach and links them to the Barcelona Convention measurements system (IMAP). Below template includes agriculture as an example, while complete template that includes all other relevant interrelations is provided in UNEP/MED WG.463/Inf.9. The list of activities elaborated in this template is not exhaustive and may be further extended and amended in line with specific circumstances related to concrete examples for which determination of the interrelation between pressure/state/impact is needed.

	SEAWARD - LAGOONS - ISLANDS - OFFSHORE					
Economic (Driver)		**Pressure**	**State**	**Impact**	**IMAP EOs CIs**	**Regional policy (Response)**
	Activity type				**Pressure, Impact and State-based indicators**	**UN Barcelona Convention**
8) Maritime activities	Awaiting areas (oil tankers, cargo transport, hazardous substances vessels)	Introduction of pollutants (oil hydrocarbons and related organic compounds)	Water column habitats decline	Healthy coastal water and habitats decline	BIODIVERSITY (EO1): CI1-CI2; SEA FLOOR INTEGRITY (EO6)	Offshore Protocol
		Risk of accidents and spills	Water quality degradation	Coastal and marine environment impacted	CINTAMINATION (EO9): CI19	Offshore Protocol
	Bunkering	Introduction of pollutants (oil hydrocarbons and related organic compounds)	Water column habitats decline	Healthy coastal water and habitats decline	CINTAMINATION (EO9): CI19; BIODIVERSITY (EO1):CI1-CI2	Offshore Protocol
		Risk of accidents and spills	Water quality degradation		CINTAMINATION (EO9): CI19	Offshore Protocol

	SEAWARD - LAGOONS - ISLANDS - OFFSHORE					
Economic (Driver)		**Pressure**	**State**	**Impact**	**IMAP EOs CIs**	**Regional policy (Response)**
	Activity type				**Pressure, Impact and State-based indicators**	**UN Barcelona Convention**
	Offshore platforms (oil and gas exploitation)	Introduction of pollutants (oil hydrocarbons and related organic compounds)	Water column habitats decline	Healthy coastal water and habitats decline	CINTAMINATION (EO9): CI17, CI18, CI20; BIODIVERSITY (EO1):CI1-CI2	Offshore Protocol
		Risk of accidents and spills	Water quality degradation		CINTAMINATION (EO9): CI19	
	Shipping traffic (commercial, ferries, military, cruise liners)	Introduction of pollutants and noise, litter	Water column habitats decline	Healthy coastal water and habitats decline	BIODIVERSITY (EO1): CI1-CI2; CONTAMIANTION (EO9): CI17, CI20; MARINE LITTER (EO10): CI22-cC24; ENERGY (EO11): CI26-CI27	Offshore Protocol
		Risk of accidents or acute spills	Water quality degradation	Healthy coastal water and habitats decline	CINTAMINATION (EO9): CI19	
		Introduction of NIS (ballastwater)	Biodiversity and functions alteration	Healthy coastal water and habitats decline	NON-INDIGENOUS SPECIES (EO2): CI6	
	Dredging (natural environments)	Extraction of soil substrates	Disturbance of sea-floor integrity impaired	Benthic species and habitats deterioration	SEA FLOOR INTEGRITY (EO6); BIODIVERSITY (EO1): CI1-CI2	Offshore Protocol
	Offshore energy (renewable)	Occupation of coastal marine space	Surface and pelagic ecosystems altered	Healthy coastal water and habitats decline	BIODIVERSITY (EO1): CI1-CI2	Offshore Protocol
	Solid waste disposal	Asfixiation of benthic habitats	Habitats and species loss	Healthy coastal benthic habitats decline	SEA FLOOR INTEGRITY (EO6); BIODIVERSITY (EO1): CI1-CI2	Dumping Protocol
	Storage of gases	Subsubstrate storage (seismic risks)	Disturbance of sea-floor integrity impaired	Healthy coastal benthic habitats decline	SEA FLOOR INTEGRITY (EO6); BIODIVERSITY (EO1): CI1-CI2	Offshore Protocol

	SEAWARD - LAGOONS - ISLANDS - OFFSHORE					
Economic (Driver)		**Pressure**	**State**	**Impact**	**IMAP EOs CIs**	**Regional policy (Response)**
	Activity type				**Pressure, Impact and State-based indicators**	**UN Barcelona Convention**
	Defence operations	Noise, contamination and waste material	Coastal and marine environment threatened	Healthy coastal water and habitats decline	SEA FLOOR INTEGRITY (EO6); BIODIVERSITY (EO1): CI1-CI2	Offshore Protocol
	Disposal of munition	Dumping of munitions (including bacteriological)	Disturbance of sea-floor integrity impaired	Healthy coastal benthic habitats decline	SEA FLOOR INTEGRITY (EO6); BIODIVERSITY (EO1): CI1-CI2	Offshore Protocol

24. Moreover, for each chain of elements part of the analysis (Drivers > Activity type > Pressure > State > Impacts (Ecosystem Services, Welfare) > Responses), the table template provides the link to the related Ecological Objective (EOs) and Common Indicators (CIs) of the Barcelona Convention measurement system (i.e. UNEP/IMAP).

25. The above described approach is then complemented by an Excel tool (see Figure 1) which can be used for an expert-based evaluation with different approaches (both item and impact scores). The structure of the Excel file reflects the content of the template provided in Table 3. On the one hand, the Excel tool could allow simply estimating (in %) how many items (i.e. Drivers/Pressures from land-based sources) have the potential to threat the marine ecosystem. Experts involved in such evaluation can provide an assessment for each activity type through a 0/1 score: 1 indicating the presence of the potential risk and 0 its absence. The final score is than expressed in percentage, dividing the sum of all scores for the number of scored items (activity types).

26. The same Excel tool (Figure 1) enables to estimate the magnitude of impacts (in %) by adapting its conceptual objective. Thus, for each Driver/Pressure, experts involved in the evaluation are invited to express a 0 to 3 score: 0 indicating the absence of the impact, while 1, 2 and 3 respectively indicating the presence of an impact with low, moderate and high magnitude. Similarly, to the analysis on the occurrence of potential threats, the final score is expressed in percentage and is obtained by dividing the sum of all scores by the maximum theoretical score (equal to the number of scored items multiplied by 3).

27. The level of detail based on the IMAP Common Indicators and Ecological Objectives should be the primary methodological basis to assign scores.

SCORECARDS: SEMI QUANTITATIVE APPROACH
(choose 0, 1, 2 or 3 to estimate impact)

None (0)	Low (1)	Moderate (2)	High (3)

Overall of Pressure-Impact (Ecosystem Services) (%):

	SEAWARD - LAGOONS - ISLANDS - OFFSHORE				IMPACT SCORE	
Economic (Driver)		**Pressure**	**State**	**Impact (Ecosystem)**	**% of total impacts**	**Regional policy (Response)**
	Activity type					**UN Barcelona Convention**
Maritime activities	Awaiting areas (oil tankers, cargo transport, hazardous substances vessels)	Introduction of pollutants (oil hydrocarbons and related organic compounds)	Water column habitats decline	Healthy coastal water and habitats decline	3	Offshore Protocol
		Risk of accidents and spills	Water quality degradation	Coastal and marine environment impacted	3	Offshore Protocol
	Bunkering	Introduction of pollutants (oil hydrocarbons and related organic compounds)	Water column habitats decline	Healthy coastal water and habitats decline	3	Offshore Protocol
		Risk of accidents and spills	Water quality degradation		3	Offshore Protocol
	Offshore platforms (oil and gas exploitation)	Introduction of pollutants (oil hydrocarbons and related organic compounds)	Water column habitats decline	Healthy coastal water and habitats decline	2	Offshore Protocol
		Risk of accidents and spills	Water quality degradation		1	IMO
	Shipping traffic (commercial, ferries, military, cruise liners)	Introduction of pollutants and noise, litter	Water column habitats decline	Healthy coastal water and habitats decline	0	Offshore Protocol
		Risk of accidents or acute spills	Water quality degradation	Healthy coastal water and habitats decline	0	IMO
		Introduction of NIS (ballast water)	Biodiversity and functions alteration	Healthy coastal water and habitats decline	3	IMO
	Dredging (natural environments)	Extraction of soil substrates	Disturbance of sea-floor integrity impaired	Benthic species and habitats deterioration	3	Offshore Protocol
	Offshore energy (renewable)	Occupation of coastal marine space	Surface and pelagic ecosystems altered	Healthy coastal water and habitats decline	3	Offshore Protocol

	Storage of gases	Sub substrate storage (seismic risks)	Disturbance of sea-floor integrity impaired	Healthy coastal benthic habitats decline	3	Offshore Protocol
	Disposal of munition	Dumping of munitions (including bacteriological)	Disturbance of sea-floor integrity impaired	Healthy coastal benthic habitats decline	3	Offshore Protocol
				TOTAL SEAWARD IMPACT (Ecosystem services)	**30**	

Figure 1. Example of Scoreboard, including semi quantitative assessment and risk-based approach considerations (note: fictional scoring). This tool allows to estimate the magnitude of impacts % of total (of estimated possible) pressures-impacts on the environment and ecosystem services. It also links the Drivers (with detailed forces/activities) with Responses (Action Plans, Protocols, etc. within the Barcelona Convention). The same approach could be used to estimate the item scores (see text).

2.3. The NEAT approach

28. The Nested Environmental Status Assessment Tool (NEAT) (Borja et al., 2016) is a pioneering tool developed specifically to assess the marine environment. It uses a combination of high-level integration of habitats and spatial units; therefore, allowing for specification on structural and spatial levels, applicable to any geographical scale. NEAT is a structured, averaging approach and hierarchical tool (i.e. based on a nested assessment approach) for making marine state assessments (freely available at www.devotes-project.eu/neat). Based on a nested assessment approach, the NEAT has been discussed and applied at various scales in the framework of different projects (Action Med, PERSEUS, DEVOTES).

29. In the study of Pavlidou et al. (2019), the results of assessment were evaluated in relation to the anthropogenic pressures affecting the study area, as well as the management measures taken and compared to the results from previous studies. The NEAT was able to show clear spatial gradients differentiating the impacted and slightly impacted areas and the response of the ecosystem towards some management measures. The application of NEAT tool classified the whole tested area with the pelagic habitat components (fish, water column and phytoplankton ecosystem components), contributing strongly to the global environmental status. Sediment, benthic fauna and vegetation, mammals and aliens NIS were the most impacted ecological components.

30. The NEAT tool is now being further considered at the Mediterranean scale, within the project MEDCIS, and could be considered as a best practice in the context of the second phase of IMAP implementation.

2.4. UN Regional Seas Programme approach

31. There is a need to link the state of the marine ecosystem with other mankind dimensions, namely, ecosystem services (i.e. food provision, tourism activities, coastal livelihoods, natural resources, etc.) and economic activities beyond the marine ecosystem boundaries; but affecting it. There is also a need to better manage and communicate their status and trends to decision-makers. A step forward for the integration and aggregation of the IMAP components with other related mankind interests in the marine environment might relay in the use of composite indicators and indices, namely, ecosystem-based indicators (combining both higher levels of aggregation of state-based and pressure-based indicators). These are powerful communication tools at the science-policy interface.

32. The United Nations Environment Programme (UNEP) Regional Seas Programme (RSP), Global Environment Facility-Large Marine Ecosystem Projects (GEF-LMEs), as well as the SGD 14 (Agenda 2030) are encouraging and promoting the use of these science-based tools, such as the Ocean Health Index (OHI) or the Environmental Vulnerability Index (EVI) (UNEP, 2014).

3. IMAP EOs RELATIONSHIPS TO ASSESS GES

33. The relationships between the UN Environment/MAP Ecological Objectives, the status of the ecosystem elements and pressures, and the IMAP Common Indicators are important to ensure the integrated assessment of GES. Building on the relevant best practices coming from the EU MSFD implementation (European Commission, 2017). Table 4 presents indicative interrelations between Ecological Objectives (EOs), whilst Table 5 further presents a possible framework enabling the integrated assessment of GES taking into account the relationship among different IMAP Ecological Objectives.

Table 4. Indicative interrelations between Ecological Objectives (EOs)

	EO1	EO2	EO3	EO4	EO5	EO6	EO7	EO8	EO9	EO10	EO11
EO1		Extended	Extended	Extended	Extended	Extended	Extended	Significant	Significant	Limited	Significant
EO2			Limited	Extended	Limited	Limited	Significant	No relation	No relation	Significant	No relation
EO3				Extended	Significant	Significant	Significant	No relation	Significant	Limited	Significant
EO4					Extended	Limited	Significant	No relation	Significant	Limited	Limited
EO5						Limited	Significant	Significant	Limited	No relation	No relation
EO6							Significant	Significant	Significant	Limited	No relation
EO7								Significant	Significant	Significant	No relation
EO8									Limited	Significant	No relation
EO9										Limited	No relation
EO10											No relation
EO11											

Green	**No relation**
Yellow	**Limited relations**
Orange	**Significant relations**
Red	**Extended relations**

34. In order to make best use of this integrated framework within a DPSIR-based approach, the following logical sequence of assessments is recommended:

- Map the distribution and intensity of human uses and activities and identify the main areas of activity (Drivers). This can be used as proxy pressure assessment to support later identification of measures (Responses);
- Assess the Pressures in terms of spatial distribution and intensity (including temporal aspects, where necessary). This may be less relevant for the assessment of mobile species (e.g. birds and cetaceans), for which it is more difficult to know the place and time of exposure to particular pressures (pressure-based CIs);
- Assess the environmental Impacts/extent of Impacts in relation to the elements to be used for the state-based and the pressure-based assessments (state-based CIs);
- Assess the State as derived from the assessments of impacts in previous step, to lead to an overall assessment of status.

Table 5: A possible framework for integrated GES assessment, showing IMAP Common Indicators in relation to the predominant pressures. EOs/Cells in Orange concern pressures (P); IMAP Common Indicators in yellow concern impacts (I) and ecosystem elements in grey cells concern state. Some EOs are repeated, as they are applicable to several ecosystem elements (species groups, pelagic and benthic habitats). EOs for which Common Indicators are not defined (EO 6, 7 and 11) are not considered in the table. Cells marked with '?' indicate situations where an impact from the pressure is possible without any possible assessment.

ASSESSMENT OF GOOD ENVIRONMENTAL STATUS (GES)					Assessment of pressures				
					EO 2	EO 3	EO 5	EO 9	E0 10
					Nis	Extraction of wild species	Eutrophication	Contamination	Marine Litter
					Common Indicators of pressure				
					CI 6	CI 8, CI 10, CI 11	CI 3	CI 17, CI 19	CI 22, CI 23
Assessment of state	EO 1, EO 3	Species (birds, turtles, fish etc.)	State indClators	CI 1 to 5, CI7, CI9	CI 3-5, C I7	CI 9, CI 12	?	CI 18, CI 20-21	CI 24
	EO 1, EO 3	Pelagic Habitats		CI 1 to 5, CI7, CI9	CI 3-5, C I7	CI 7, CI 9, CI 12	CI 14	CI 18, CI 20-21	CI 24
	EO 1, EO 3	benthic habitats		CI 1 to 5, CI7, CI9	CI 3-5, C I7	CI 7, CI 9, CI 12	CI 14	CI 18, CI 20-21	CI 24
	EO 1, 2, 3, 4	ecosystems		CI 1 to 5, CI7, CI9	CI 3-5, C I7	CI 7, CI 9, CI 12	CI 14	?	?

35. Table 5 is built on best practices from the EU countries on MSFD implementation, taking also into account IMAP and Mediterranean region specificities.

36. In order to reach a clear conclusion on whether GES is achieved or not for a specific area, there is a need for aggregation and integration across the individual assessments and data sets relating to the 11 Ecological Objectives. Geographical aggregation and integration of the various indicators need to take into consideration the scales for identifying and implementing any necessary management actions.

37. The integration of individual assessments at Common Indicator and Ecological Objectives' level into a unique status assessment entails a number of challenges, including the following:

i) Some Ecological Objectives may aim at mitigating a pressure relevant for other Ecological Objectives (for example, NIS can be a threat to biodiversity and food web);
ii) Not all the Ecological Objectives have an equal weighting when assessing the overall GES;
iii) Some pressure-related Ecological Objectives may affect other Ecological Objectives;
iv) Integration at the Ecological Objectives' level may be based on partly redundant information given by Common Indicators (for example, under EO 10 on marine litter, CI 22 is partly related to CI 23);
v) Assessment integration and scaling up requires Contracting Parties' assessments to be comparable.

38. In line with the above, the following recommendations may be considered:

- The integration across levels of different complexity should accommodate different alternatives, i.e. integration at indicator level (across indicators within EOs) could certainly differ from integration at Ecological Objectives' level;
- Integration across state-based Ecological Objectives (EO1 to 3, EO6) is different than across pressure-based Ecological Objectives (EO 2, 5, 8, 9 to 11);
- There is a different contribution of the two main types of Ecological Objectives to the overall GES evaluation, as GES for pressure-based Ecological Objectives should also be met when GES for state-based Ecological Objectives (EO1, 3, 4, 6) is achieved.

39. Decisions on a 'boundary' between 'in GES' and 'not in GES' are needed at various steps (levels) in this process:

a. There is need to determine appropriate threshold values for each Common Indicator used to assess the elements, enabling a clear distinction on whether GES for an Ecological Objective has been achieved or not. Where several Ecological Objectives are used per ecosystem element, a specified method of aggregation across the Ecological Objectives is needed in order to assess whether the element has achieved GES or not. These rules could include the one-out-all-out principle or other specified approaches. In this sense GES can be defined as having been achieved for specified elements of the marine environment (e.g. related to specific EOs or biodiversity elements) rather than as a whole; this allows for a more step-wise approach to assessments and for a means to communicate that GES has been achieved for certain elements but not yet for others;

b. For multiple elements (e.g. multiple species or contaminants) in a broader functional group (e.g. demersal fish, heavy metals etc.), a way to express overall status of the broader group is needed. In this situation, a minimum list of elements, which 'represent' the broader group, should be specified and then used for assessment of that group. In these cases, all the listed elements within the group should achieve the specified quality levels in order to say that the broader group has achieved GES. Progress towards GES for the group could be expressed as the proportion (percentage) of the minimum list of elements, which have achieved GES.

3.1. Geographical aggregation and integration

40. Integration at a higher geographical scale to achieve consistent conclusions on the extent to which GES is achieved for each of the different topics remains a key step to support assessments.

41. The 2011 Initial Integrated Assessment of the Mediterranean Sea and Coastal Areas undertaken by the UN Environment/MAP Barcelona Convention Secretariat and its Contracting Parties delivered a region-wide assessment report complemented by four sub-regional assessment reports. The 2017 MED QSR followed the regional approach only. Further discussion is needed and should start well in advance to define the level of aggregation of assessments for the 2023 MED QSR.

42. This raises the question of how the assessment of complementary elements is taken into account when presenting the overall extent to which GES is being achieved.

43. A proposed scheme is to base the regional assessment on the geographical aggregation of IMAP-based national indicators and their incorporation into the assessment for each sub-regional/ regional assessment unit. The assessment outputs for presenting the extent to which GES is achieved can take different forms depending on the purpose of the presentation and communication.

44. These options include:

- To combine all assessment results in an integrated scheme for presenting assessment results which provides a concise presentation of GES status in relation to all IMAP Common Indicators at the relevant geographic scales.
- To provide details on the assessment results which are relevant for management. Needs and options are specific for the Ecological Objectives and Common Indicators. In general, possible approaches include:

    - Number or percentage of assessed elements failing/meeting threshold values/good status;
    - Distinction between elements accessible to management and those that are not (e.g. banned legacy contaminants vs. contaminants in use);
    - Distinction between matrices where this helps addressing management;

- o Expression of distance to the threshold value/good status in order to provide an insight into the magnitude of the problem and an indication of progress between IMAP cycles. Options depend on the indicators and may include bar chart presentations of the assessment values against threshold, possibly normalised on a scale 0–1 or differentiated classification on both sides of the good/not good boundary.

45. Consideration will be then given to the envisaged level of integration of Common Indicators and Ecological Objectives; the flow/sequence of assessment and integration steps the possible nodes of integration; and the associated integration rules. Comparable outputs should be agreed to be delivered as part of the assessment process within the UN Environment/MAP - Barcelona Convention, taking into consideration some differences for purposes of the management of pressures in national waters. Contracting Parties are then expected to deliver the assessment of the environmental status at sub-regional level through regional cooperation and common regional assessment frameworks, understanding that some regional indicators may not be ready, or be only of national relevance

3.2. Assessment scale

46. IMAP Decision recognized that further work is necessary during the initial phase of its implementation on assessment scales. A nested system (Figure 2.) provides a flexible approach to defining the scales for assessment (for the different EOs) in a way that also provides consistency and clarity on the scales/areas to be used for assessment. It enables a linkage between state-based and pressure-based assessments, which facilitates linkages to measures. Whilst an outline approach to defining and using such a nested system is presented here, it would be necessary for Contracting Parties, working together on regional level, to develop this into an operational mechanism, by:

a. Assigning the elements (drivers, pressure, state or impacts) to be assessed to the most appropriate scale, taking account of the most appropriate ecological scales for state-based elements and relating these to appropriate scales for pressure-based assessments; an initial generic proposal for this is given in Table 6 below, noting that this needs further discussion and adaptation;
b. Defining suitable boundaries for the areas (sub-region, sub-division or smaller) to be used for each scale within the region;
c. Adjusting the proposal to accommodate practical implementation issues, e.g. the occurrence of national boundaries, the foreseen assessment process, balancing the number of areas for assessment with implementation needs, such as links to measures and management etc.

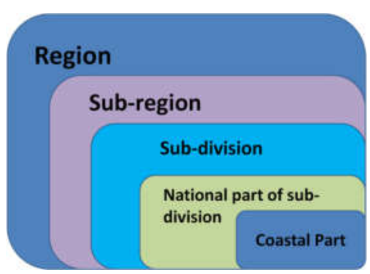

Figure 2. Schematic representation of a nested set of assessment scales to be used to cover all assessment needs for IMAP.

47. In the Mediterranean Sea the sub-regions (as defined in the 2011 Initial Integrated Assessment) provide the basis for assessments and reporting, and thus, the Contracting Parties are required to cooperate to ensure a common and coordinated approach in their monitoring and effectiveness of measures. However, assessments of whether GES has been achieved can be at a finer scale, as deemed appropriate.

48. The broad range of topics to be assessed across the eleven Ecological Objectives and related Common Indicators calls for a variety of scales to be used. For example, wide-ranging species such as sea turtles are more appropriately assessed at the regional scale, whilst nutrient enrichment and contaminant hotspots may be more appropriately assessed at finer scales linked to their land-based sources and management needs. In addition, there may be several populations of particular species (e.g. commercial fish) in the region and in sub-regions, which should be assessed separately.

49. A variety of assessment scales are therefore necessary to reflect ecologically-relevant scales for the various ecosystem elements (species, habitats, ecosystems) and management and administratively-relevant scales for pressure elements. Additionally, the outcome of the assessment is intrinsically linked to the scale of assessment. Assessing pressures and their impacts at too broad a scale can hide significant areas of impact in certain parts of a sub-region. On the other hand, it should be also borne in mind that IMAP must be applied across the entire regional waters and adoption of too fine a scale could lead to burdensome assessment processes.

50. Developing suitable mapping/dissemination tools to show the environmental status of the different Ecological Objectives across the whole region should use a nested scale system, accommodating state and pressure aspects to provide a reference layer for information management at regional level. An initial proposal for assignment to appropriate scales for elements' assessment is provided below (Table 6) building on best practices from MSFD implementation for further development in the framework of IMAP implementation and possible adaptation to sub-regional needs.

Table 6: Initial proposal for assignment to appropriate scales of elements to be assessed (as a basis for discussion and further development during the initial phase of IMAP).

Elements for assessment	Region	Sub-region	Sub-division	National part of sub-division	Coastal waters
State elements					
Species groups (EO1)	Large cetaceans, deep-sea fish	Offshore birds, small cetaceans, turtles, pelagic & demersal fish	Coastal birds, seals, coastal fish		
Water column and seabed habitats (EO1)			Water column habitats, seabed habitats beyond 1nm		Seabed habitats
Ecosystems (EO1 and 7)		Ecosystems			
Pressure elements					
Physical loss and damage, hydrographical changes (EO6, 7)			Linked to seabed habitats		EO7
UW noise (EO11)	Linked to large cetaceans	Linked to small cetaceans			

Eutrophication (EO5)				X	MED POL practice
Contaminants (EO 9)				X	MED POL practice
Litter (EO10)				X	
Removal of species (EO3)	As fish groups/GFCM practice	As fish groups/GFCM practice	As fish groups/GFCM practice		
Non-indigenous species (EO2)				NIS	

51. Working at different spatial scales does not necessary imply that in principle the identified areas should be nested. But such nesting characteristic is of the outmost importance when integration of different spatial scales is required within the same EO or CI or between EOs or CIs in order to produce an assessment at the regional or sub-regional level as IMAP requires. Furthermore, a key benefit of such an agreed approach is that it enables visualization of the outcomes of assessments in a map form at different scales. Nevertheless, agreement among the Contracting Parties is still required on the common criteria and on the borders for delimitation of transnational areas in order to define the smallest entity for each assessment. This may well vary between and within Ecological Objectives, but pragmatic approaches are needed to allow assessment and management at all relevant levels.

Table 7: Proposed assessment scales for IMAP Common Indicators (after 2017 MED QSR and 2017 MEDCIS workshop) to be further reviewed and developed by CORMON meetings. The assessment scales will be further developed taking into account specific elements (e.g. species of bird, mammal, certain habitat type).

EOs	**Common Indicators**	**Region**	**Sub-region**	**Sub-division**	**National part of sub-division**	**Coastal waters**
EO1	CI 1 Distributional range	Diving whales deep sea fish	Birds, small cetaceans, turtles, demersal and pelagic fish	Coastal fish and benthic species		
	CI 2 Condition species	Biogeographically-relevant scales				
	CI 3 Species distribution	Biogeographically-relevant scales				
	CI 4 Population abundance	Diving whales	Small cetaceans, turtles, demersal & pelagic fish	Coastal fish and benthic species		
	CI 5 Population demography	Diving whales	Small cetaceans, turtles, demersal & pelagic fish Coastal fish and benthic species			
EO2	CI 6 Trends in NIS	XX	XX	XX		

EO3	CI 7 Spawning stock Biomass	Ecologically-relevant scales, based on GFCM areas				
	CI 8 Total landings					
	CI 9 Fishing Mortality	Ecologically-relevant scales, based on GFCM areas				
	CI 10 Fishing effort	Ecologically-relevant scales, based on GFCM areas				
	CI 11 CPUE/LPUE					
	CI 12 By-catch	Ecologically-relevant scales, based on GFCM areas				
EO5	CI 13Nutrients	X	X	X	XX	XXX
	CI 14 Chlorophyll-a					
EO7	CI 15 Habitats impacted			X	XX	XXX
EO8	CI 16 Erosion	X	X	XX	XXX	XXX
EO9	CI 17 Key harmful contaminants	X	X	XX	XXX	XXX
	CI 18 Pollution effects	X	X	XX	XXX	XXX
	CI 19 Acute pollution events	X	X	XX	XXX	XXX
	CI 20 Contaminants in seafood	FAO- GFCM areas	FAO-GFCM areas	Catch or Production Area		
	CI 21 Intestinal enterococci			X	X	XXX
	CI 22 Beached litter	Harmonized protocol				
EO10	CI 23 Litter at sea	Surface litter and microplastics				

52. Regarding existing challenges, data may be of limited availability and implementation is still at an early phase, as a number of countries are in the process of revising their national monitoring programs to align them with IMAP. However, previous projects have produced results, outcomes and recommendations for a nested system (Action Med, PERSEUS, DEVOTES, etc.) that can be considered by the Contracting Parties in an easy-to-use format (see indicative proposed scales for IMAP Common Indicators in table 7 above).

53. As stated previously, the nested approach is considered as one of the best-fitted approaches in the view of GES assessment. As a prerequisite, harmonized approaches must be

highlighted, and the best approaches should be further identified for monitoring and assessment scales for some of the Ecological Objectives and/ or Common Indicators. Considering the practical steps for its implementation and given the number of different assessments to be undertaken, it is recommended to first minimise the number of areas defined, using the same areas for several species and habitats, pelagic or benthic, keeping in mind the need for ecologically-relevant scales. Secondly, the areas used for pressure-based and ecosystem-based assessments must be associated with each other (e.g. areas for assessment of physical disturbance are the same as used for the assessment of seabed habitats or nested within the area).

54. The outcomes from the EU-funded project MEDCIS can be also considered. The Project agreed, in line with the new reporting format adopted for the update of Art. 8 - 10 of MSFD in 2018, on the same nested principle, proposing Mediterranean Marine Reporting Units (Med MRU), including the Mediterranean basin as region, the marine sub-regions as defined by the UN Environment/MAP 2011 Initial Integrated Assessment, sub-divisions to be further discussed, national parts of sub-divisions and territorial waters (possibly the WFD zones for the Contracting Parties, which are EU Member States). In this context, the term Reporting rather than Assessment qualifies such units as areas that should cover the all process envisaged by IMAP that is: monitoring, assessment and responses or measures to achieve or maintain GES.

55. All initiatives also recognised that (i) the sub-divisions are still uncertain (nationally and internationally) although information is shared, (ii) the scale of reporting for each Ecological Objective and Common Indicator is not always defined, and (iii) more coordination is foreseen.

56. An indicative set of proposed assessment scales is provided in Table 7 above, building on the initial proposal for assignment to appropriate scales of elements (see Table 6) and considering the key findings of the 2017 MED QSR and work in progress within MEDCIS Project, for further discussion and development by the CORMON meetings.

4. THE CONVERGENCE OF TRENDS AND STATUS ASSESSMENTS: FURTHER IMAP IMPLEMENTATION

57. Across the Mediterranean Sea, most of the reduction targets adopted by CPs are trends, expressed as reduction in percentage over time, in a reasonable and achievable period. The setting of threshold values overcomes this problem by committing to lower pressure or impacts to an agreed and 'acceptable' level in relation to GES. The threshold values should ensure protection of the environment and human health and can be referred to concentration levels as well as impact, pressure or state-indicator levels that should not be exceeded.

58. The Contracting Parties have approved the most recent update of the pollution assessment criteria and thresholds as presented in Annex II of Decision IG 23/6 and encouraged themselves and the Secretariat to test them for indicative purposes in the different contexts that exist in the Mediterranean. This progress is a continuation of many years of MED POL's work on continual introduction and implementation of the assessment criteria and thresholds. The updated criteria have been tested during the preparation of the 2017 MED QSR contaminant factsheets. Because of their satisfactory testing at this initial stage, their future application is recommended for indicative purposes.

59. Further work on assessment criteria refinement and establishment of new quantitative thresholds need to be set at appropriate geographical scales, thereby taking into account the different biotic and abiotic characteristics of regions, sub-regions and sub-divisions (see chapter 2 above). Defining threshold values will require involvement of relevant UN Environment/MAP Components' Focal Points as well as experts from related areas of expertise.

60. Threshold value means a value or range of values that allows for an assessment of the quality level achieved for a particular Common Indicator or Ecological Objective, thereby contributing to the assessment of the extent to which GES is being achieved. While they are expressed as numerical values, it should be kept in mind that they have been derived from underlying data, which often entails uncertainties. Applying ample safety factors to the threshold values in order to take knowledge gaps and uncertainty effect into account is a necessary process as well as an on-going revision to be up-to-date to the state-of-the-art knowledge.

61. Thresholds should ideally meet the following requirements: be based on scientific knowledge and sound and reliable monitoring data programme; consider different harm end points; be expressed in numerical values; be based on comparable reporting units; be set at appropriate geographic scales (see chapter 2 above); be set on the basis of the precautionary principle; be consistent across different Common Indicators and Ecological Objectives and consider pressures/impacts interactions; reflect natural ecosystem dynamics and fit with defined assessment scales.

62. Depending on the Common Indicators and Ecological Objectives, the definition of thresholds can include different level of warnings, such as thresholds of no concern, thresholds of toxicological concern (TTC), end points of effects, or the precautionary principle. If a threshold applies to a pressure, impact or state-indicator also the actual definition of the indicator itself has to be thoroughly explicated in terms of its metric or formulation. Translating this concept into IMAP Common Indicators, it could be summarized as irreversible changes in populations communities, assemblages and ecosystems (EOs 1 & 2); toxicological action mode (EOs 5, 9 & 10), physical damage (EOs 6, 10 & 11), disruption of human activities (EO 9/ CIs 20 & 22) and irreversible changes in habitats, or components of the environment (EOs 1, 5, 6 & 7). This approach may be however complicated by various types of harm for a specific pressure with different end points that must be considered for threshold setting. The *Risk* approach, based on cross-mapping data on pressures and impacts, enables a better definition of areas where interactions occur. It could be used for many indicators through a quantitative risk assessment framework, supporting the prioritization of efforts against specific pressures.

4.1. Options for the definition of thresholds

63. Table 8 presents different options and concepts for the definition of thresholds within IMAP.

64. There are few existing baseline values and targets defined for the IMAP Common Indicators (CIs 13- 14, 17-18, 20-24; see UN Environment, 2017a) with some of them, as defined by experts, based on percentage reduction over time in the pressure or impact level (CIs 22-24). Some will have to be refined, considering sub-regional constraints, when appropriate. Thresholds are still to be defined and/or updated by CORMON meetings including the definition of proportion/percentage to meet GES. While thresholds for some Ecological Objectives in the different compartments of the marine environment (beach/surface/seabed or Pelagic/benthic) may follow the same basic concepts, they may each require specific approaches and the different marine compartments need to be discussed. For sure, the setting of quantitative thresholds requires the possibility for a quantification of the pressure and an appropriate formulation of the threshold unit. Finally, as measures aimed to reduce impacts over marine environment from pressures might be targeted for specific species, contaminants, items (litter) classes, groups, etc. thresholds should be set for single items, types, groups, classes, accordingly. As an example, measures to reduce impacts related to a specific contaminant (e.g. cadmium), or a type of litter (e.g. plastic bags) will need the definition of specific baselines and thresholds to support both monitoring and the evaluation of measures efficiency.

65. It might be advisable to derive "provisional and commonly agreed thresholds" rather than moving towards a situation with many different approaches across regions, sub-regions or Contacting Parties. The contribution by stakeholders with different backgrounds will be then beneficial. Setting priorities, depending on the availability of data, the relevance of metrics, and the most impacted Common Indicators is the proposed scheme prior to the second phase of IMAP implementation (2019-2023).

66. In Table 8, for the threshold category 'Zero option', the Common Indicators 17 and 19 related to contaminants (EO9) have been included. This 'zero option' threshold should be the ideal criteria to evaluate GES in terms of synthetic contaminants (which should not be present in the environment) and oil spills (which should not occur in the sea), respectively. For CI17 (synthetic chemicals) and CI19, the threshold 'zero option' is already the norm to define targets.

67. Nevertheless, the majority of the thresholds for EO5 and EO9 classify in the 'Lowest-end point' option, as shown in Table 8, therefore, the eutrophication processes or environmental toxicity scenarios appear when non-effect concentration levels for these substances are surpassed.

68. Finally, it should be mentioned here, the strong link between the thresholds already set for EO5 and EO9 and the scales of monitoring. The environmental information gathered in the field allows to set and refine continuously the 'threshold' for pollution (namely, assessment criteria); and thus, the monitoring scales should be considered for the use of the derived thresholds information for EO5 and EO9.

Table 8. Options and concepts for the setting of thresholds within IMAP with possible associated Common Indicators

Threshold	**Concept**	**IMAP Common Indicators**	**Comment**
Zero option	Possible option when the pressure does not exist in nature, by definition (litter, synthetic contaminants, man-made noise)	CI 12, CI 21, CI17, CI19	*"zero pressure" appears unreasonable, since impossible to reach when the pressure is a common situation*
Value-of-no-return	Values that alter irreversibly (or through significant effects) the indicator when exceeded/going below	CI 1-5, CI 6, CI 7, CI 14, CI 9, CI 18	*This approach is well adapted to population, communities, assemblages that may be altered beyond recovery.*
Cut-off values	Agreement that the reduction of a pressure can be defined on a concentration/ significant value when scientific evidence of impact is still investigated	CI 1-5, CI 6, CI 7, CI 9, CI 13, CI17, CI 18, CI 21	*Thresholds based on the mapping of areas where concentration/abundance of a particular high impact may support this approach*
Expert judgement	Approach based on the expertise of a wide range of contributors, a subjective opinion based on scientific evidence.	CI 8, CI 15-16	*The setting of low provisional threshold values is a way to initiate provisional thresholds. This couldbe an Expert Judgment*

Threshold	**Concept**	**IMAP Common Indicators**	**Comment**
Public acceptance	Societal agreement to reduce a pressure in the marine ecosystem while research is investigating the impacts. Human well-being disturbance is a component of socioeconomic considerations	CI 8, CI 16, CI 22	*Based on concentration/abundance mapping, areas of particular high impact can be determined and tackled.*
Lowest end point	Lowest concentration causing an adverse effect on one of the specific endpoints (Non-effect Concentration)	CI22, CI23, C13-14, C17-21, CI23	*The lowest concentration approach is relevant when it is impossible to balance different adverse effects of a single pressure (toxicological, physiological effect, socioeconomic impact)*
Hot spot areas	Possible definitions of areas or situations, which are clearly unacceptable from a societal point of view.	CI 1-7, CI 23	
Precautionary principle	No conclusive scientific knowledge but evidence of harm, thresholds may be defined to provide maximum protection against adverse effects	Pressure indicators	
Significant decrease	Relevant when no metric is available to measure the impact	Pressure indicators	
Calculation of reduction	Based on defined target. The threshold is defined as the baseline minus a desired percentage of reduction until deadline.	Pressure indicators	*Thresholds defined through predefined targets, possibly by policy makers*

Annex I
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Appendix III

UNEP/MED WG.467/8
Data Standards and Data Dictionaries for Common Indicators related to Pollution and Marine Litter

UNITED NATIONS

EP

UNEP/MED WG.467/8

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

8 August 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Agenda Item 6: IMAP Pilot Info System and Related Quality Assurance Issues; Data Standards and Data Dictionaries; MAP Data Management Policy

Data Standards and Data Dictionaries for Common Indicators related to Pollution and Marine Litter

Note by the Secretariat

This document includes changes introduced following comments received at the 7th Meeting of the Ecosystem Approach Coordination Group. All changes are indicated in Track Changes mode.

UNEP/MAP
Athens, 2019

Note by the Secretariat

In the framework of the 2018-2019 Programme of Work and Budget of the UN Environment/MAP (Decision IG.23/14), INFO/RAC is leading the work on development of the Info/MAP platform and the platform for implementation of IMAP, fully operative and further developed and connected to MAP components' information systems and other relevant regional knowledge platforms. The purpose of this platform is to facilitate access to knowledge for managers and decision-makers, as well as stakeholders and the general public (output 1.5.1).

The EU-funded EcAp-MED II Project is supporting this output by the development of a Pilot IMAP Compatible Data and Information System [IMAP (Pilot) Info System], that would enable the Contracting Parties to start reporting data as of mid-2019 for selected 10 IMAP Common Indicators, and by laying down the basis for building a fully operational IMAP Info System by the end of the initial phase of IMAP, as provided for by Decision IG.22/7.

The criteria used for selecting the 10 Common Indicators as part of the IMAP (Pilot) Info System are:

a) Maturity of Common Indicators, in terms of monitoring experiences and best practices;
b) Existing data collection and availability representing all IMAP Clusters;
c) Availability of Common Indicators Guidance Factsheets and/or metadata templates.

The proposed data standards (DSs) and data dictionaries (DDs) for IMAP Common Indicators 13, 14 and 17 related to eutrophication (EO5) and contaminants (EO9); as well as for IMAP Common Indicators 22 and 23 related to marine litter (EO 10), were developed considering related IMAP Guidance Factsheets and existing Metadata Reporting Templates, as approved by the Meeting of the MED POL Focal Points, Rome, Italy, 29-31 May 2017 (UNEP(DEPI)/MED WG.439/20). DSs and DDs for Common Indicator 21 related to EO9 were prepared with the support of ENI SEIS II Project.

Data Standards (DSs) and Data Dictionaries (DDs) were developed building on respective relevant experience of INFO/RAC, as well as experience gained in building other relevant databases such as EMODnet Chemistry platform, SeaDataNet and WISE Data Dictionary maintained by EEA and available in EIONET. As such, the IMAP (Pilot) Info System is interrelated with other regional marine databases (e.g. SeaDataNet, SeaDataCloud, EMODNET, etc.), which might contain or require a different number of metadata entries.

Data Standards (DSs) and Data Dictionaries (DDs) are a set of information describing the content, format and structure of a database and relationship between the elements. DSs are prepared in a form of Excel spreadsheets in which every row indicates a field to be filled by the data providers, aligned with the current MED POL Database for the common cases. The DSs are accompanied by DDs provided in a form of a column next to each Data Standard or excel spreadsheet to guide the data provider. It is a crucial component of any relational database, invisible to most database users. For ease of reference, the current document presents updated proposal of Excel spreadsheets of DSs and DDs for Common Indicators 13, 14,17, 22 and 23 in a Word File format. This updated proposal of DSs and DDs provides broader data sets and associated dictionaries than requested as mandatory by the related IMAP Guidance Factsheets and Metadata Templates. In the Data Standards, the mandatory data are represented in black and the non-mandatory data in red. The possibility to fill in also non-mandatory fields is given to allow the Contracting Parties that already have monitoring systems collecting a wider set of data to also report them as the additional data. It is at the discretion of the Contracting Parties to decide on reporting on non-mandatory data sets. The list of CAS Registry Numbers (CAS Number), as the unique numerical identifier assigned by the Chemical Abstract Service (CAS) to every chemical substance described in the open scientific literature, are included as well.

The first drafts of Data Standards and Data Dictionaries for the selected IMAP Common Indicators were reviewed by the Regional Meeting on IMAP Implementation: Best Practices, Gaps and Common Challenges (IMAP Best Practices Meeting), Rome, Italy, 10-12 July 2018. Following its outcome and the bilateral consultations among INFO/RAC and MED POL, the revised version of DSs and DDs for Common Indicators 13, 14, 17, 21, 22 and 23 were presented for review and feedback to the Ecosystem Approach Correspondence Groups on Pollution Monitoring (2-3 April 2019) and Joint Meeting of the Ecosystem Approach Correspondence Group on Marine Litter Monitoring and ENI SEIS II Assessment of Horizon 2020/National Action Plans of Waste Indicators (4-5 April 2019), hereinafter referred as CorMon on Pollution and CorMon on Marine Litter, held back-to-back in Podgorica, Montenegro.

The Meeting of CorMon Pollution approved the proposed Data Standards and Data Dictionaries for IMAP Common Indicators 13, 14 and 17, and recommended their submission to the Meeting of the MED POL Focal Points.

The Meeting of CorMon Marine Litter recommended submission of Data Standards and Data Dictionaries for IMAP Common Indicators 22 and 23 to the present Meeting of the MED POL Focal Points Meeting, after addressing several comments related to the refinement of the "Titles" and "Description" of the fields, as well as avoiding duplication of fields between the different tables. It should be noted that the DSs and DDs for Common Indicator 22 take into consideration the list of beach marine litter items as revised by the Meeting of CorMon Marine Litter.

In order to ensure finalization of the IMAP (Pilot) Info-System, the Meetings of CorMon Pollution and Marine Litter recommended to the Secretariat and INFO/RAC implementation of the following actions:

a) Upload finalized DSs and DDs to IMAP (Pilot) Info System whilst providing the consequent changes to the data base structure;
b) Ensure IMAP (Pilot) Info-System is enabled to receive in 2020 new datasets related to IMAP Common Indicators 13, 14, 17, 21, 22 and 23;
c) Inform the Meeting of the MED POL Focal Points on the document related to MAP "Data Management Policy" developed by INFO/RAC and submitted for the consideration of the INFO/RAC Focal Points;
d) Prepare by the end of next biennium (2020-2021) DSs and DDs for other IMAP Common Indicators related to Pollution cluster; and
e) Request the Secretariat, in consultations with MED POL Focal Points, to designate national experts that would actively contribute to the finalization of DSs and DDs for other IMAP Common Indicators related to Pollution cluster.

The final version of DSs and DDs are uploaded in the IMAP (Pilot) Info System, and the consequent changes to the database structure is provided This will be followed by a testing phase of the IMAP (Pilot) Info System that will be realized with the voluntary participation of interested countries to be invited to start providing data flow for the selected Common Indicators supported by the IMAP (Pilot) Info System. After the testing and reflection of its findings, it is expected to have the IMAP (Pilot) Info System fully operational to receive uploaded data for 10 selected IMAP Common Indicators.

It must also be noted that the data already reported through the MED POL Metadata Templates, as confirmed by the Meeting of the MED POL Focal Points, Rome, Italy, 29-31 May 2017, will be migrated to the new IMAP (Pilot) Info System, whilst it will be enabled to receive the monitoring data for Common Indicators 13, 14, 17 and 21 generated in 2019 onward.

Following the work undertaken by the Meetings of CorMon on Pollution Monitoring and CorMon on Marine Litter, the Meeting of MED POL Focal Points amended the Data Standards and Data Dictionaries with regards to deletion of some fields related to Common Indicator 17 (i.e. fields related to TON, TIN, extractable lipid, lipid weight), contribution of the aquaculture on marine litter generation, as well as to reflect on the updated list of beach marine litter items. The Meeting recommended submission of the Data Standards and Data Dictionaries related to IMAP Common Indicators 13, 14, 17, 21, 22 and 23 for approval of the 7th Meeting of EcAp Coordination Group.

List of Abbreviations / Acronyms

CI	Common Indicator
CORMON	Correspondence Group on Monitoring
DDs	Data Dictionaries
DSs	Data Standards
EcAp	Ecosystem Approach
EEA	European Environmental Agency
EO	Ecological Objective
IMAP	Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria
INFO/RAC	Regional Activity Centre for Information and Communication
MAP	Mediterranean Action Plan
MED POL	Programme for the Assessment and Control of Marine Pollution in the Mediterranean Sea
MED QSR	Mediterranean Quality Status Report
MSFD	Marine Strategy Framework Directive
PoW	Programme of Work
QA	Quality Assurance
QC	Quality Control

Table of Contents

1. DATA STANDARDS AND DATA DICTIONARIES FOR IMAP COMMON INDICATORS 13, 14, 17, 21, 22 AND 23

1. The Data Standards and Data Dictionaries (DSs and DDs) are presented in tabular forms in the next sections and should guide the data providers into filling the future Metadata Templates, the formats to be developed in accordance with this basic information on data reporting. The Data Standards (DDs for Stations and DDs for characteristic parameters and the List of reference under each Common Indicator) are taken from related Excel files prepared by INFO/RAC, in close consultations with MED POL. Further extended instructions and in-depth details will be provided to facilitate the submission of the datasets by the Contracting Parties when the IMAP (Pilot) Info System will be launched.

2. The current MED POL Metadata Templates (excel spreadsheet formats), were designed for a relational database (SQL) containing metadata (e.g. station, year, coordinates, country, dates, QA/QC, etc.) associated to the data (namely, parameter) to be measured and reported (i.e. Chlorophyll-a, nutrients, contaminants, etc.). To this regard, the alignment of new IMAP Metadata Templates for the IMAP (Pilot) Info System with the current MED POL Metadata Template formats, will be provided through Data Standards and Data Dictionaries presented in this document. Even more, new IMAP Metadata Templates will offer enlarged possibilities for the Contracting Parties that are measuring additional parameters to report those to the IMAP (Pilot) Info System, as well.

3. Specifically, regarding Common Indicators 13 and 14, as a variety of methods (e.g. Chlorophyll *a* concentration - spectrophotometer, fluorometer, HPLC, in situ.) used for measurements with different underlying variability exists, an alignment of the initial proposal of Data Dictionaries by INFO/RAC was proposed. A coding list for the used Analytical Methods corresponding to a combination of analyte, matrix and method in the general case is suggested. This list was obtained through a harvesting data tool from the SeaDataNet Project, which reference vocabulary is currently maintained by the BODC (British Oceanographic Data Center). The list is provided in an Excel file (List_P01) presented at the IMAP Best Practices Meeting.

4. The list of reference for the Common Indicator 17 on chemicals is also in use by the European Environmental Agency (EEA, WISE-Marine) and includes either the CAS numbers (Chemical Abstract Service reference number) or the EEA reference number (for particular EEA requirements). The IMAP Guidance Factsheets related to Common Indicator 17 (EO9) contain the agreed chemical compounds and those can be found in the EEA list (with its CAS number). Similarly, for eutrophication (EO 5) there is a list of parameters (as Data Dictionaries) aligned with the parameters for Common Indicators 13 and 14 provided in Guidance Factsheets for respective Common Indicators. The mandatory reporting is foreseen only for the biota and sediment matrices as agreed under IMAP Guidance Factsheets and for specific compounds under each Common Indicator, despite any other substance and matrix can be reported by applying then harmonized CAS number.

5. For Common Indicator 17, a list of biota matrices (e.g. species) is the major difference with the reference list for species from MED POL. However, this MED POL`s list has also been checked against the EEA reference list. Finally, the List _Dictionary P01 (in accordance with EMODNET data policy) is also provided to include, if available, the pertinent code corresponding to a combination of analyte, matrix and method in the general case. This list is created similarly as for Common Indicators 13 and 14. However, this requirement is on a voluntary basis.

6. In line with the Guidance Fact Sheet for IMAP Common Indicator 21, related DDs establish reporting of required data i.e. CFU (Intestinal enterococci per 100 mL) / Number of Colony-formation-unit per analysis.

8. For Common Indicators 22 and 23, the proposed DDs reflect the elements included in the Metadata Reporting Templates to facilitate the population of corresponding data in the IMAP (Pilot) Info System. For beach marine litter (i.e. Common Indicator 22), the DDs are structured based on the

approved Beach ID Form and Beach Survey Form providing information and metadata on the beach profile, link to the potential sources, recorded marine litter items, effect to biota etc. For seafloor marine litter, the DDs include a number of information related to the vessel/trawling characteristics as well as the list of marine litter items. For floating microplastics, the DDs provide information about the methodological approach for monitoring floating microplastics (i.e. manta net), and the list and types of microplastics that may be found in the marine environment.

ECOLOGICAL OBJECTIVE 5

9. In close consultations with MED POL, INFO/RAC developed the Data Standards and Data Dictionaries for Common Indicators 13 and 14 for EO5 within the Pollution cluster of the IMAP, as explained above. Below are the characteristics of the proposed Data Dictionaries which create the basis for the data reporting on these Common Indicators.

1.1 Common Indicators 13 and 14

Table 1: Data Dictionaries (stations information) for CI13 and CI14.

Field	Description	List of values
Country Code	Enter member country code as ISO two digits, for example "IT" for Italy.	
National Station ID	Station code	
National Station Name	Station name	
Region	Administrative first level subdivision to which the station belongs to	
Latitude	Latitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).	
Longitude	Longitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use positive values without '+' before numbers (for ex. 13.98078) for coordinates east of the of the Greenwich Meridian (0°) and negative values with '-' for coordinates west of the Greenwich Meridian (0°) (for ex. -2.6893).	
Closest Coast	Station distance from the coast in km	
TCM Matrix	Measure of seawater at the station	W = Sea water column
Sea Depth	Sea depth in meters	
Area Typology	Typology of the monitored area enter one of the values in the list	R = Reference C = Coastal HS = Hot spot O = Other
Pressure Type	If the monitoring station id dedicated to monitor pressure, indicate the typology of pressure monitored, enter one of the values in the list	AP = Aquaculture plant RP = River Plume UWWTP = Urban Waste Water Treatment Plant IP = Industrial Plant O = Others
Remarks		

*non-mandatory under IMAP Guidance Factsheets

Table 2: Data Dictionaries (physicochemical information) for EO5 Common Indicator 13 and 14.

Field	Description	List of values
Country Code	Enter member country code as ISO two digits, for example "IT" for Italy.	
National Station ID	Station code	
Year	Year of sampling in AAAA format	
Month	Month of sampling in 1-12 format	
Day	Day of sampling in 1-31 format	
Time	Hour-minutes-seconds of sampling in HH:MM:SS format	
Sample ID	Sample Code if multiple replies are made with the same value as Year, Month, Day and Time	
Determin_Nutrients	Name of the physico-chemical parameter or of the nutrient, enter one of the values in the list in the "List_PhysicoChemical"	
Nutrients Seawater_unit	Unit of measurement of the physiochemical parameter or nutrient, enter one of the values in the list	% = Oxygen saturation m = Secchi disks depth pH = pH °C = Temperature µg/L = Chlorophyll *a* µmol/L = Ammonium, Nitrate, Nitrite, Total Nitrogen µmol/L = Dissolved Oxygen µmol/L = Orthophosphate, Total Phosphorus µmol/L= Orthosilicate µS/cm = Conductivity
LOD_LOQ_Flag	Enter the value LOQ in case the concentration value is less than the quantification limit or the value LOD in case the concentration value is less than the detection limit. In the other cases, leave the field empty.	"LOQ = Concentration value below the quantification limit LOD = Concentration value below detection limit
Concentration	Concentration measure	
Sample Depth	Sampling depth in meters	
Analytical Method	Analytical method List of analytical methods, in line with IMAP, will be completed. Suggestion to use code from List_P01 provided in an Excel file	
Remarks		

Table 3: List of physicochemical parameters under IMAP Guidance Factsheets EO5 and provided as mandatory in Data Dictionaries for Common Indicators 13 and 14.

Field	Description	Remarks
Temperature (water)	Water Temperature (°C)	
Salinity	Salinity (psu)	
Conductivity	Conductivity (µS/cm)	
Dissolved oxygen	Dissolved Oxygen (µmol/L)	
Oxygen saturation	Dissolved Oxygen - saturation percentage (%)	
pH	pH	
Chlorophyll *a*	Chlorophyll-*a* (µg/L)	
Secchi disk depth	Secchi disk (m)	
Nitrate	Nitrate (µmol/L)	
Nitrite	Nitrite (µmol/L)	
Ammonium	Ammonium (µmol/L)	
Total phosphorus	Total Phosphorus (µmol/l)	
Orthophosphate	Orthophosphate (µmol/L)	
Total nitrogen	Total Nitrogen (µmol/L)	
Orthosilicate	Reactive silicate (µmol/L)	

ECOLOGICAL OBJECTIVE 9

10. The INFO/RAC in close consultations with MED POL has developed the Data Standards and Data Dictionaries for Common Indicator 17 for EO9 within the Pollution cluster of the IMAP, as explained above. Below the characteristics of the proposed Data Dictionaries are shown which create the basis for the data reporting on this Common Indicator. In addition, Data Dictionaries for Common Indicator 21 are shown.

1.2 Common Indicator 17

Table 4: Data Dictionaries (Stations Information) for Common Indicator 17 within EO9.

Field	Description	List of values
Country Code	Enter member country code as ISO two digits, for example "IT" for Italy.	
National Station ID	Sation code	
National Station Name	Station name	
*Region	Adminstrative subdivision after country which the station belongs to (according to the country subdivision)	
Latitude	Latitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).	
Longitude	Longiitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use positive values without '+' before numbers (for ex. 13.98078) for coordinates east of the of the Greenwich Meridian (0°) and negative values with '-' for	

	coordinates west of the Greenwich Meridian (0°) (for ex. -2.6893).	
*Closest Coast	Station distance from the coast in km	
TCM Matrix	Environmental matrix measured in the station, enter one value of the list	B = Biota BS = Biota and sediment BSW = Biota, sediment and sea water column BW = Biota and sea water column S = Sediment SW = Sediment and sea water column W = Sea water column
Sea Depth	Sea depth in meters	
Area Tipology	Indicate the typology of the monitored area, enter one of the values in the list	R = Reference C = Coastal HS = Hot spot O = Others
PressureType	If the monitoring station id dedicated to monitor pressure, indicate the typology of pressure monitored, enter one of the values in the list	IP = Industrial Plants MT = Maritime Traffic

*non-mandatory under IMAP Guidance Factsheets

Table 5: Data Dictionaries (contaminants information)

Field	Description	List of values
Country Code	Enter member country code as ISO two digits, for example "IT" for Italy.	
National Station ID	Station code	
Year	Year of sampling in YYYY format	
Month	Month of sampling in 1-12 format	
Day	Day of sampling in 1-31 format	
Time	Hours-minutes-seconds of sampling in HH:MM:SS format	
Sample ID	Sample Code if multiple replies are made with the same value as Year, Month, Day and Time	
Matrix	Sample matrix, enter one value of the list	W = Water S = Sediments B = Biota
Determin Haz Subs Name	Name of the contaminant, enter one value of the column 'Label' of the list 'List contaminants'	
Determin Haz Subs ID	ID of the contaminant, enter one value of the column 'ID_Contaminant' of the list 'List_contaminants'	

CAS Number	CAS number of contaminant, enter one value of the column CAS Number of list 'List_contaminants'	
Haz Subs_unit	Unit of measurement for the contaminant, enter one value of the list	µg/l = water matrix µg/kg = sediments and biota matrices
Haz Subs_WD	For sediment or biota, specify dry or wet weight, enter one value of the list	WW = Wet weight DW = Dry weight
LOD_LOQ_Flag	Enter the value '<' in case the concentration value is less than the quantification limit or the value '[' in case the concentration value is less than the detection limit. In the other cases, leave the field empty.	<= Concentration value below the quantification limit [= Concentration value below detection limit
Concentration	Concentration value. In the case of analytes sums in which at least one is not less than the LOQ, use the Concentration field with the sum of solely quantifiable analytes (i.e. not lower than the LOQ). In case the concentration value of the single analyte or all the analytes constituent the sum is less than the LOQ, the LOD_LOQ_Flag field and the Concentration field should be used as follows: in the case of a single analyte enter the value of LOQ/2; in the case of analytical additions, enter the zero value taking into account that the individual substances below the quantification limit do not contribute to the value of the sum.	
Sample Depth	Sampling depth in meters	
Salinity	For water matrix: Salinity (psu)	
Temperature	For water matrix: Temperature (°C)	
Dissolved oxygen	For water matrix: dissolved oxygen (µmol O2/l)	
*Grain Type	For sediment matrix: tipology of sediment, enter one value of the list	CS = Coarse Sand FS = Fine Sand G = Gravel M = Mud MS = Middle Sand
Fraction	Per sediment matrix: maximum size of sediment particles in µm	

Sediment Depth	For the sediment matrix: Depth of the collected sample of sediment, measured as a range, in centimeters, starting at the seafloor surface. The range would start by zero if the top of the sediment sample is the seafloor surface. For ex. insert '0-10' if 10 cm of sediments have been sampled starting from seafloor surface or insert '5-15' if 10 cm of sediments have been sampled starting from 5 cm from the seafloor surface.	
*TC	For sediment matrix: Total carbon content in % unit	
*TOC	For sediment matrix: Total organic carbon in % unit	
*TIC	For sediment matrix: Total inorganic carbon in % unit	
*TN	For sediment matrix: Total nitrogen content in % unit	
Species ID	For the biota matrix: monitored species. Enter one value of the column 'ID_Species' of the list 'List_species'	
Species Name	For the biota matrix: monitored species. Enter one value of the column 'Label' of the list 'List_species'	
Specimen_lenght	For the biota matrix: length of specimen in cm. In case of pooling, indicate mean length	
Specimen_length_sd	For the biota matrix: Standard deviation of average length of specimens in a pool in cm.	
Specimen_weight	For the biota matrix: weight of specimen in g. In case of pooling, indicate mean weight.	
Specimen_weight_sd	For the biota matrix: Standard deviation of average weight of specimens in a pool in g.	
Pooling	In case of pooling, describe the content of pooling as number of specimens and other methodological issues	
Extractable Organic Matter	Extractable Organic Matter in mg/g	

Tissue	For biota matrix: tissue element of the monitored species, enter one of the list values	**BL =** Fluids - Blood. Includes haemolymph, erythrocytes, haemocytes, serum (blood component without cells and clotting factors) and plasma (serum including clotting factors) **EG =** Eggs. Includes bird eggs and fish eggs (roe). Use the remarks field to provide additional information, if necessary. **FA =** Tissues - Fat. Any type of adipose tissue or organ. Includes the form code BB for "Blubber". GO = Organs - Gonads. Includes female gonads (ovaries) and male gonads (testes). Use the remarks field to provide additional information, if necessary. **KI =** Organs - Kidney. Use the remarks field to provide additional information, if necessary. **LI** = Organs - Liver. Includes hepatopancreas. Use the remarks field to provide additional information, if necessary. **MU =** Tissues - Muscle. Any type of muscle tissue or organ. Includes the former code TM for "Tail muscle". **OT =** Other. Use the remarks field to provide additional information, if necessary. **ST =** Tissues **-** Soft tissue. Includes any body tissue except mineralized tissue (hard tissue)
Fat Content	Fat content as percentage of total wet matter	
Analytical Method	Analytical method	
LOQ	Limit of quantification	
EmodnetCodeP01	Code of the parameter/ EMODNet method according to the dictionary P01,enter one value of the list "List_dictionary_P01"	
Remarks	Notes	

*non-mandatory under IMAP Guidance Factsheets

Table 6: Example of the List of physicochemical parameters under IMAP Guidance Factsheets EO9, that are also available in the EEA reference list of contaminants (Code list), showing compounds provided as mandatory in the Data Dictionaries for Common Indicator 17 (PAHs not shown). The full list is provided with related Excel files presented at the IMAP Best Practices Meeting.

ID_Contaminant	Label	CAS Number	Matrix	Mandatory	Additional
CAS_309-00-2	Aldrin	309-00-2	Sediments	Y	
CAS_7429-90-5	Aluminium and its compounds	7429-90-5	Sediments	Y	
CAS_7440-43-9	Cadmium and its compounds	7440-43-9	Biota, Sediments	Y	
CAS_60-57-1	Dieldrin	60-57-1	Sediments	Y	
CAS_58-89-9	Gamma-HCH (Lindane)	58-89-9	Biota, Sediments	Y	
CAS_118-74-1	Hexachlorobenzene	118-74-1	Biota, Sediments	Y	
CAS_7439-92-1	Lead and its compounds	7439-92-1	Biota, Sediments	Y	
CAS_7439-97-6	Mercury and its compounds	7439-97-6	Biota, Sediments	Y	
CAS_37680-73-2	PCB 101 2,2’,4,5,5’-pentachlorobiphenyl)	37680-73-2	Biota, Sediments	Y	
CAS_32598-14-4	PCB 105 (2,3,3’,4,4’-pentachlorobiphenyl)	32598-14-4	Biota, Sediments	Y	
CAS_31508-00-6	PCB 118 (2,3’,4,4’,5-pentachlorobiphenyl)	31508-00-6	Biota, Sediments	Y	
CAS_35065-28-2	PCB 138 (2,2’,3,4,4’,5’-hexachlorobiphenyl)	35065-28-2	Biota, Sediments	Y	
CAS_35065-27-1	PCB 153 (2,2’,4,4’,5,5’-hexachlorobiphenyl)	35065-27-1	Biota, Sediments	Y	
CAS_38380-08-4	PCB 156 (2,3,3’,4,4’,5-hexachlorobiphenyl)	38380-08-4	Biota, Sediments	Y	
CAS_35065-29-3	PCB 180 (2,2’,3,4,4’,5,5’-heptachlorobiphenyl)	35065-29-3	Biota, Sediments	Y	
CAS_7012-37-5	PCB 28 (2,4,4’-trichlorobiphenyl)	7012-37-5	Biota, Sediments	Y	
CAS_35693-99-3	PCB 52 (2,2’,5,5’-tetrachlorobiphenyl)	35693-99-3	Biota, Sediments	Y	
EEA_33-38-5	Polychlorinated biphenyls(7 PCB: 28,52,101,118,138,153,180)		Biota, Sediments	Y	
EEA_32-03-1	Total DDT (DDT, p,p' + DDT, o,p' + DDE, p,p' + DDD, p,p')		Biota, Sediments	Y	
CAS_7440-66-6	Zinc and its compounds	7440-66-6	Biota, Sediments		Y

Table 7: Example of the List of available reference species (Code list) for Data Dictionaries and Data Standards of the IMAP (Pilot) Info System for EO9 (CI17 and CI20).

Species code	Species
2279156	Holothuria tubulosa
2357093	Hoplostethus atlanticus
2481126	Larus
2481156	Larus glaucoides
2481127	Larus hyperboreus
2409391	Lepidorhombus whiffiagonis
2419875	Leucoraja naevus
5213960	Limanda limanda
2301117	Littorina littorea
2415070	Lophius budegassa
2415075	Lophius piscatorius
2291262	Lymnaea palustris
2286995	Macoma balthica
5214420	Mallotus villosus
2415822	Melanogrammus aeglefinus
2415788	Merlangius merlangus
2415643	Merluccius merluccius
2415777	Micromesistius poutassou
5214022	Microstomus kitt
5214883	Molva dypterygia
5214880	Molva molva
5220008	Monodon monoceros
4284897	Mullus barbatus
7791733	Mya arenaria
7865139	Mya truncata
2333785	Myoxocephalus scorpius
8288896	Mytilus edulis
2285683	Mytilus galloprovincialis
2303019	Nassarius reticulatus
2226962	Nephrops norvegicus
5193449	Nucella lapillus
2286060	Ostrea edulis

1.3 Common Indicator 21

Table 8: Data Dictionaries (stations information)

Field	Description	List of values
Country Code	Enter member country code as ISO two digits, for example "IT" for Italy.	
National StationID	Station code	
National Station Name	Station name	
*Region	Administrative subdivision after country which the station belongs to	
Latitude	Latitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).	
Longitude	Longitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use positive values without '+' before numbers (for ex. 13.98078) for coordinates east of the of the Greenwich Meridian (0°) and negative values with '-' for coordinates west of the Greenwich Meridian (0°) (for ex. -2.6893).	
*Closest Coast	Station distance from the coast in km	
Matrix	Environmental matrix measured in the station, enter one value of the list	W = Water column
Beach name	Name of the beach or coastal area	
Sea Depth	Sea depth in meters	
Mixing	Mixing property of the water column at the station point, enter one of the values in the list	FM = Fully mixed PM = Partially mixed VS = Vertically stratified

*non-mandatory under IMAP Guidance Factsheets

Table 9: Data Dictionaries for Microbiological parameters.

CFU (Intestinal Enterococci per 100 mL)	Number Colony-Formation-Unit per analysis	

DATA STANDARDS AND DATA DICTIONARIES FOR IMAP EO10 COMMON INDICATORS 22 AND 23

11. The characteristics of the proposed DSs and DDs are hereunder presented which create the basis for the data reporting on the two IMAP Common Indicators for Marine Litter.

1.4 IMAP EO10 Common Indicator 22

12. For IMAP EO10 Common Indicator 22, the following Tables 10 to 12 are proposed. Table 10 is aimed to be completed only at the beginning of the program, when the station (i.e. the selected beach) is incorporated and simultaneously with the first survey data. Table 10 should be renewed once every year, or if/when a new development is altering the beach characteristics. In contrast, Tables 11 and 12 should be filled for each individual survey.

Table 10: Data Dictionaries (Beach ID Form) for IMAP Common Indicator 22

Field	Description	List of values
Country Code	Enter country (contracting Party) code as ISO two digits, for example "IT" for Italy.	
National Station ID	Station code	
Beach National ID	Beach Code	
Beach Name	Beach Name	
Region	First level administrative subdivision to which the station belongs to	
Municipality	Indicate the township which the beach belongs to	
Beach Width	Average beach width (m)	
Beach Width Low Tide	Beach width at mean low spring tide (m)	
Beach Width High Tide	Beach width at mean high spring tide (m)	
Beach Length	Total length of the beach (m)	
Back of Beach	What kind/type exists at the back of the beach? e.g. sand dune	
Latitude Start 100m	Latitude of the starting point of 100m transect of the beach in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).	
Longitude Start 100m	Longitude of the starting point of 100m transect of the beach in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use negative values for coordinates west of the Greenwich Meridian (0°).	
Latitude End 100m	Latitude of the ending point of 100m transect of the beach in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).	
Longitude End 100m	Longitude of the ending point of 100m transect of the beach in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use negative values for coordinates west of the Greenwich Meridian (0°).	
Prevailing Currents	Prevailing currents off the beach	N = North E = East S = South W = West

Field	Description	List of values
Prevailing Winds	Prevailing winds	N = North E = East S = South W = West
Beach Orientation	When you look from the beach to the sea, what direction is the beach facing?	N = North E = East S = South W = West
Sand	Percentage of beach coverage with sand (0-100)	
Pebbles	Percentage of beach coverage with pebbles (0-100)	
Rocky Coast	Percentage of beach coverage with rocky coastline (0-100)	
Slope	Slope of the beach in percentage (0-100)	
Currents Influencer	Are there any objects in the sea (e.g. a pier) that influence the currents?	Y =Yes N = No
Currents Influencer Spec	In case Currents Influence = Y, specify which currents influencer	
Local People Use	Is it used by local people?	Y =Yes N = No
Local People Use Season	In case of Yes, enter one value of the list	S = Seasonal WY= Whole Year Round
Sun Bathing Use	Is it used by people (e.g. beach goers, tourists etc.)	Y =Yes N = No
Sun Bathing Use Season	In case of Yes, enter one value of the list	S = Seasonal WY= Whole Year Round
Fishing Use	Is the beach used for recreational fishing?	Y =Yes N = No
Fishing Use Season	In case of Yes, enter one value of the list	S = Seasonal WY= Whole Year Round
Surfing Use	Is it used for surfing?	Y =Yes N = No
Surfing Use Season	In case of Yes, enter one value of the list	S = Seasonal WY= Whole Year Round
Sailing Use	Is it used for sailing?	Y =Yes N = No
Sailing Use Season	In case of Yes, enter one value of the list	S = Seasonal WY= Whole Year Round
Other Use	Specify which other use	
Other Use Season	In case of Yes, enter one value of the list	S = Seasonal WY= Whole Year Round
Pedestrian Access	Beach accessible to pedestrians (Yes / No), enter one of the values in the list	Y = Yes N = No
Boat Access	Beach accessible by boat (Yes / No), enter one of the values in the list	Y =Yes N = No
Vehicle Access	Beach accessible by vehicle (Yes / No), enter one of the values in the list	Y =Yes N = No

Field	Description	List of values
Nearest Town close to the beach	Beach adjacent (< 5 km) to urban areas (Yes / No), enter one of the values in the list	Y = Yes N = No
Nearest Town Name close to the beach	Enter the name of the nearest town or village	
Nearest Town Location close to the beach	Describe the location of the nearest town with regards to the beach (i.e. north, south, east or west)	North South East West
Nearest Town Distance close to the beach	Distance of the nearest town from the beach (km)	
Nearest Town Population close to the beach	Population of the nearest urbanized area	
Nearest Aquaculture site close to the beach	Beach adjacent (< 5 km) to aquaculture site , enter one of the values in the list	Y = Yes N = No
Nearest Aquaculture site close to the beach	Describe the location of the aquaculture site with regards to the beach (north, south, east or west)	
Nearest Aquaculture site Distance close to the beach	Distance of the aquaculture site from the beach (km)	
Developments Behind Beach	Is there any development behind the beach?	Y =Yes N = No
Developments Behind Beach Spec		
Outlets Beach	Are there food and/or drink outlets on the beach?	Y = Yes N = No
Outlets Distance	Distance of the outlets from the survey area (m)	
Outlets Year Presence	Number of months during food and drink outlets are on the beach	
Outlets Position	Position of food and drink outlets in relation to the survey area	N = North E = East S = South W = West
Shipping Lane Distance	Distance of the beach to the nearest shipping lane in km	
Shipping Lane Position	Position of the shipping lane in relation to survey area	N = North E = East S = South W = West
Traffic Density	What is the estimated traffic density: number of ships/year passing from the area of interest	
Traffic Type	Is it mainly used from which type of vessels?	Merchant ships Fishing vessels All kinds
Harbour	Is the beach located near a harbour, a port or a marina (Yes/NO)? Enter one of the values in the list and further specify	Y = Yes N = No Specify:
Harbour Name	Enter the name of the nearest harbour, port or marina	Specify: Harbour, Port, Marina[4]

Field	Description	List of values
Harbour Distance	Distance between the sampling area and the harbour in km	
Harbour Entrance	Is the harbour entrance facing the survey area?	Y = Yes N = No
Harbour Position	Position of harbour in relation to survey area	N = North E = East S = South W = West
Harbour Type	What is the main type of vessels using the harbour? e.g. passenger ships, merchant/cargo ships, fishing vessels?	
Harbour Size	Number of ships/vessels using the harbour every day	
River Mouth	Beach adjacent to river mouths or drains of water (Yes / No), enter one of the values in the list	Y = Yes N = No n/a
River Mouth Name	Enter the name of the nearest rivers / drains	
River Mouth Distance	Distance between the sampling area and nearest river mouths / drains of water in km	n/a
River Mouth Position	What is the position of nearest river mouth in relation to survey area?	N = North E = East S = South W = West n/a
Waste Water Discharge Distance	Distance between sampling area and industrial sites / landfills in km	
Waste Water Discharge Position	Position of discharge points in relation to survey area	N = North E = East S = South W = West
Clean Up Frequency	Cleaning frequency during all year round	D = Daily W = Weekly M = Monthly O = Other
Clean Up Seasonal	Seasonal Cleaning: please specify in months	
Clean Up Method	Main method that was used for Clean-up	Manual Mechanical
Clean Up Responsible	Who is responsible for the cleaning	
Amendment	Is this an amendment of an existing Beach ID form already submitted in the system?	Y = Yes N = No
Additional Comments	Please include any additional comments that you find important and of relevance	
Beach Map ID	Naming the shapefile associated with the map, e.g. "12202005.shp". Specify the following information in the map: Nearest town Nearest harbour Nearest river mouth Nearest shipping lane	

Field	Description	List of values
	Food/drink outlets Discharge or waste water Discharges	
Regional Map ID	Naming the shapefile associated with the map, e.g. "12202005.shp"	

Table 11: Data Dictionaries (Beach Survey Form) for IMAP Common Indicator 22

Field	Description	List of values
Country Code	Enter country (contracting Party) code as ISO two digits, for example "IT" for Italy.	
Beach National ID	Beach Code	
Beach Name	Beach Name	
ID Survey	Survey code	
Latitude Start 100m[1]	Latitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Put new value if you diverted from the predetermined 100 m.	
Longitude Start 100m[1]	Longitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use negative values for coordinates west of the Greenwich Meridian (0°).	
Latitude End 100m[1]	Latitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).	
Longitude End 100m[1]	Longitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use negative values for coordinates west of the Greenwich Meridian (0°).	
Year	Year of sampling in YYYY format	
Month	Month of sampling in 1-12 format	
Day	Day of sampling in 1-31 format	
Time	Time of sampling in HH:MM:SS format	
Surveyors Num	Number of surveyors	
Surveyor Contact Info	Please indicate the contact details of the surveyor (e.g. institute, mail, telephone)[9]	
Weather Conditions	Did any of the following weather conditions affect the data of the survey?	Wind Rain Sand storm Fog Snow Exceptionally high tide Exceptionally low tide Storm surge
Animals	Did you find stranded or dead animals?	Y = Yes N = No
Animals Species	If Animal = Yes, describe the animals, or note the species name if known	
Animals Number	If Animals is = Yes put the number of animals for each species	
Animals State	If Animal = Yes, Describe the stranded animal state, enter a value of the list	Dead Alive

[1] Put new value if you diverted from the predetermined 100 m

Field	Description	List of values
Entangled Animals	Is the animal entangled in litter?	Y = Yes N = No
Entangled Animals Litter	If Yes enter one value of the List_Beach_Litter_Categories	
Special Circumstances	Were there any circumstances that influenced the survey? For example, tracks on the beach, recent replenishment of the beach or other	Y = Yes N = No
Special Circumstances Type	If no, enter a value of the list	tracks on the beach, recent replenishment of the beach description of the new circumstance
Unusual Items	Were there any unusual marine litter items and/or marine litter loads?	Y = Yes N = No
Unusual Items Description	If Yes enter description of the unusual item	
Last Cleaning Date[9]	Last beach cleaning date in DD / MM / YYYY format[9]	
Photo ID	Naming the file associated with the photo, e.g. "12202005.jpg"	

Table 12: Data Dictionaries (Beach Litter Items) for IMAP Common Indicator 22

Value	Description	MacroCategory
G1	4/6-pack yokes, six-pack rings	Plastic/Polystyrene
G3	Shopping bags incl. pieces	Plastic/Polystyrene
G4	Small plastic bags, e.g. freezer bags incl. pieces	Plastic/Polystyrene
G5	The part that remains from rip-off plastic bags	Plastic/Polystyrene
G7/G8	Drink bottles	Plastic/Polystyrene
G9	Cleaner bottles & containers	Plastic/Polystyrene
G10	Food containers incl. fast food containers	Plastic/Polystyrene
G11	Beach use related cosmetic bottles and containers, e.g. Sunblocks	Plastic/Polystyrene
G13	Other bottles, drums and containers	Plastic/Polystyrene
G14	Engine oil bottles & containers <50 cm	Plastic/Polystyrene
G15	Engine oil bottles & containers >50 cm	Plastic/Polystyrene
G16	Jerry cans (square plastic containers with handle)	Plastic/Polystyrene
G17	Injection gun containers (including nozzles)	Plastic/Polystyrene
G18	Crates and containers / baskets (excluding fish boxes)	Plastic/Polystyrene
G19	Vehicle parts (made of artificial polymer or fiber glass	Plastic/Polystyrene
G21/24	Plastic caps and lids (including rings from bottle caps/lids)	Plastic/Polystyrene
G26	Cigarette lighters	Plastic/Polystyrene
G27	Cigarette butts and filters	Plastic/Polystyrene
G28	Pens and pen lids	Plastic/Polystyrene
G29	Combs/hair brushes/sunglasses	Plastic/Polystyrene
G30/31	Crisps packets/sweets wrappers/Lolly sticks	Plastic/Polystyrene
G32	Toys and party poppers	Plastic/Polystyrene
G33	Cups and cup lids	Plastic/Polystyrene
G34	Cutlery, plates and trays	Plastic/Polystyrene
G35	Straws and stirrers	Plastic/Polystyrene

Value	Description	MacroCategory
G36	Heavy duty sacks (e.g. fertilizer or animal feed sacks	Plastic/Polystyrene
G37	Mesh bags (e.g. vegetables, fruits and other products) excluding aquaculture mesh bags	Plastic/Polystyrene
G40	Gloves (washing up)	Plastic/Polystyrene
G41	Gloves (industrial/professional rubber gloves)	Plastic/Polystyrene
G42	Crab/lobster pots and tops	Plastic/Polystyrene
G43	Tags (fishing and industry)	Plastic/Polystyrene
G44	Octopus pots	Plastic/Polystyrene
G45	Mesh bags (e.g. mussels nets, net sacks, oyster nets including pieces and plastic stoppers from mussel lines	Plastic/Polystyrene
G46	Oyster trays (round from oyster cultures)	Plastic/Polystyrene
G47	Plastic sheeting from mussel culture (Tahitians)	Plastic/Polystyrene
G49	Rope (diameter more than 1cm)	Plastic/Polystyrene
G50	String and cord (diameter less than 1 cm)	Plastic/Polystyrene
G53	Nets and pieces of net < 50 cm	Plastic/Polystyrene
G54	Nets and pieces of net > 50 cm	Plastic/Polystyrene
G56	Tangled nets/cord	Plastic/Polystyrene
G57/G58	Fish boxes	Plastic/Polystyrene
G59	Fishing line/ (tangled and not tangled)	Plastic/Polystyrene
G60	Light sticks (tubes with fluid) incl. Packaging	Plastic/Polystyrene
G62/G63	Buoys (e.g. marking fishing gear, shipping routes, mooring boats etc.)	Plastic/Polystyrene
G65	Buckets	Plastic/Polystyrene
G66	Strapping bands	Plastic/Polystyrene
G67	Sheets, industrial packaging, plastic sheeting (i.e. non-food packaging/transport packaging) excluding agriculture and greenhouse sheeting[2]	Plastic/Polystyrene
G68	Fibre glass items and fragments	Plastic/Polystyrene
G69	Hard hats/Helmets	Plastic/Polystyrene
G70	Shotgun cartridges	Plastic/Polystyrene
G71	Shoes and sandals made of artificial polymeric material	Plastic/Polystyrene
G73	Foam sponge items (i.e. matrices, sponge, etc.)	Plastic/Polystyrene
G75	Plastic/polystyrene pieces 0 - 2.5 cm	Plastic/Polystyrene
G76	Plastic/polystyrene pieces 2.5 cm > < 50 cm	Plastic/Polystyrene
G77	Plastic/polystyrene pieces > 50 cm	Plastic/Polystyrene
G91	Biomass holder from sewage treatment plants and aquaculture	Plastic/Polystyrene
G124	Other plastic/polystyrene items (identifiable) including fragments	Plastic/Polystyrene
	Please specify the items included in G124	Plastic/Polystyrene
G125	Balloons, balloon ribbons, strings, plastic valves and balloon sticks	Rubber
G127	Rubber boots	Rubber

[2] Meeting of MED POOL Focal Points requested to consider defining separate categories for greenhouse for agriculture and greenhouse sheeting; polystyrene and irrigation pipes The 7th Meeting of EcAp Coordination Group agreed to define separate categories for agriculture (i.e. greenhouse sheeting; expanded polystyrene trays/seedlings; and irrigation pipes), which will be brought as a proposal to the next Meeting of CORMON on Marine Litter.

Value	Description	MacroCategory
G128	Tyres and belts	Rubber
G134	Other rubber pieces	Rubber
	Please specify the items included in G134	Rubber
G137	Clothing / rags (clothing, hats, towels)	Cloth
G138	Shoes and sandals (e.g. Leather, cloth)	Cloth
G141	Carpet & Furnishing	Cloth
G140	Sacking (hessian)	Cloth
G145	Other textiles (including pieces of cloths, rags, etc.)	Cloth
	Please specify the items included in G145	Cloth
G147	Paper bags	Paper/Cardboard
G148	Cardboard (boxes & fragments)	Paper/Cardboard
G150	Cartons/Tetrapack Milk	Paper/Cardboard
G151	Cartons/Tetrapack (non-milk)	Paper/Cardboard
G152	Cigarette packets (including transparent covering of the cigarette packet)	Paper/Cardboard
G153	Cups, food trays, food wrappers, drink containers	Paper/Cardboard
G154	Newspapers & magazines	Paper/Cardboard
G158	Other paper items (including non-recognizable fragments)	Paper/Cardboard
	Please specify the items included in G158	Paper/Cardboard
G159	Corks	Paper/Cardboard
G160/161	Pallets / Processed timber	Processed/Worked Wood
G162	Crates and containers / baskets (not fish boxes)	Processed/Worked Wood
G163	Crab/lobster pots	Processed/Worked Wood
G164	Fish boxes	Processed/Worked Wood
G165	Ice-cream sticks, chip forks, chopsticks, toothpicks	Processed/Worked Wood
G166	Paint brushes	Processed/Worked Wood
G171	Other wood < 50 cm	Processed/Worked Wood
	Please specify the items included in G171	Processed/Worked Wood
G172	Other wood > 50 cm	Processed/Worked Wood
	Please specify the items included in G172	Processed/Worked Wood
G174	Aerosol/Spray cans industry	Metal
G175	Cans (beverage)	Metal
G176	Cans (food)	Metal
G177	Foil wrappers, aluminium foil	Metal
G178	Bottle caps, lids & pull tabs	Metal
G179	Disposable BBQ's	Metal
G180	Appliances (refrigerators, washers, etc.)	Metal
G182	Fishing related (weights, sinkers, lures, hooks)	Metal
G184	Lobster/crab pots	Metal
G186	Industrial scrap	Metal
G187	Drums and barrels (e.g. oil, chemicals)	Metal
G190	Paint tins	Metal
G191	Wire, wire mesh, barbed wire	Metal
G198	Other metal pieces < 50 cm	Metal
	Please specify the items included in G198	Metal
G199	Other metal pieces > 50 cm	Metal
	Please specify the items included in G199	Metal
G200	Bottles (including identifiable fragments)	Glass
G202	Light bulbs	Glass

Value	**Description**	**MacroCategory**
G208a	Glass fragments >2.5cm	Glass
G210a	Other glass items	Glass
	Please specify the items included in G210a	Glass
G204	Construction material (brick, cement, pipes)	Ceramics
G207	Octopus pots	Ceramics
G208b	Ceramic fragments >2.5cm	Ceramics
G210b	Other ceramic/pottery items	Ceramics
	Please specify the items included in G210b	Ceramics
G95	Cotton bud sticks	Sanitary Waste
G96	Sanitary towels/panty liners/backing strips	Sanitary Waste
G97	Toilet fresheners	Sanitary Waste
G98	Diapers/nappies	Sanitary Waste
G133	Condoms (incl. packaging)	Sanitary Waste
G144	Tampons and tampon applicators	Sanitary Waste
G--	Other sanitary waste	Sanitary Waste
	Please specify the other sanitary items	Sanitary Waste
G99	Syringes/needles	Medical Waste
G100	Medical/Pharmaceuticals containers/tubes	Medical Waste
G211	Other medical items (swabs, bandaging, adhesive plaster etc.)	Medical Waste
	Please specify the items included in G211	Medical Waste
G101	Dog faeces bag	Faeces
G213	Paraffin/Wax	Paraffin/Wax
Presence of pellets	Please say Y or N	
Presence of oil tars	Please say Y or N	
Number Items	Number of items in the category expressed as number of objects / 100m	

1.5 IMAP EO10 Common Indicator 23

1.5.1 Seafloor Marine Litter

Table 13: Data Dictionaries (Station Information) for IMAP Common Indicator 23 (Seafloor Marine Litter)

Field	Description	List of values
Country Code	Enter member country code as ISO two digits, for example "IT" for Italy.	
National Station ID	Station Code	
National Station Name	Station Name	
Area	Administrative subdivision/sea compartment where the sampling station is located and also reference to EcAp Subdivision Code"	
Closest Coast	Distance station from the coast in km	
Additional Comments	Please include any additional comments that you find important and of relevance	

Table 14: Data Dictionaries (Sampled Seafloor) for IMAP Common Indicator 23 (Seafloor Marine Litter) (Fields in red are not mandatory).

Field	**Description**	**List of values**
Country Code	Enter member country code as ISO two digits, for example "IT" for Italy.	
National Station ID	Station code	
Year	Year of sampling in YYYY format	
Month	Month of sampling in 1-12 format	
Day	Day of sampling in 1-31 format	
Time	Hours-minutes-seconds of sampling in HH:MM:SS format	
Haul Number ID	Sample Code if multiple replies are made with the same value as Year, Month, Day and Time	
Sampled Surface	Sampled surface of seafloor (km2)	
Latitude Start	Latitude of the Seafloor area in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).	
Longitude Start	Longitude of the Seafloor area in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use negative values for coordinates west of the Greenwich Meridian (0°).	
Latitude End	Latitude of the Seafloor area in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).	
Longitude End	Longitude of the Seafloor area in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use negative values for coordinates west of the Greenwich Meridian (0°).	
Depth Start	Depth in metres (m)	

Field	Description	List of values
Depth End	Depth in metres (m)	
Haul Duration	Indicate the total duration of the haul (start till end) in minutes	
Covered Distance	Indicate the total length of the haul in km	
Objects Number	Indicate the number of objects per square kilometers of seafloor (items/km^2). See Seafloor_ML_List	
Object Weight	Indicate the weight for each object per square kilometers of seafloor (weight/km^2). See Seafloor_ML_List	
Gear	Type of gear (e.g. bottom trawl, etc.9	
Speed	Indicate the constant speed of the vessel during the haul duration in knots	
Net Opening	Opening of the net in metres or use the figure obtained from the trawl sensors (e.g. SCANMAR, SIMRAD) if available	
Cod-end mesh size	Cod-end mesh size (mm) measured as stretched mesh (diamond shap)	
Surveyor Contact Info	Add surveyor's name and contact details (name, e-mail, etc.)	Non-Mandatory
Campaign Name	Add the name of the mission/cruise/project with which the survey is linked to	Non-Mandatory
Vessel Name	Add the name of the vessel	Non-Mandatory
Vessel Length	Add the length of the Vessel (m)	Non-Mandatory
Vessel Engine Power	Add the engine power of the Vessels (KW of HP)	Non-Mandatory
IMO Number	Add the International Maritime Organization (IMO) number of the Vessel	Non-Mandatory
Additional Comments	Please include any additional comments that you find important and of relevance	

Table 15: Data Dictionaries (Sampled Seafloor) for IMAP Common Indicator 23 (Seafloor Marine Litter)

Value	Description	Macro Category
L0	**No Litter**	Yes, no litter found No, go to other items)
L1a	Plastic bags	Plastic
L1b	Plastic bottles	Plastic
L1c	Plastic food wrappers	Plastic
L1d	Plastic sheets	Plastic
L1e	Hard plastic objects	Plastic
L1f	Fishing nets (polymers)	Plastic
L1g	Fishing lines (polymers)	Plastic
L1h	Other synthetic fishing related	Plastic

Value	Description	Macro Category
L1i	Synthetic ropes/strapping bands	Plastic
L1j	Other plastic	Plastic
L1	Total Plastic	Plastic
L2a	Tyres	Rubber
L2b	Other Rubber (gloves, floats, etc.)	Rubber
L2	Total Rubber	Rubber
L3a	Beverage cans (metal)	Metal
L3b	Other food cans/wrappers	Metal
L3c	Middle size containers (paint, etc.)	Metal
L3d	Large metallic objects	Metal
L3e	Cables	Metal
L3f	Fishing related (hooks, spears, etc.)	Metal
L3g	Remnants from war	Metal
L3	Total metal	Metal
L4a	Glass/ceramic bottles	Glass/Ceramic
L4b	Piece of glass	Glass/Ceramic
L4c	Ceramic jars	Glass/Ceramic
L4d	Large objects	Glass/Ceramic
L4	Total Glass/Ceramic	Glass/Ceramic
L5a	Clothing (other than polymers)	Textils / Natural fibers
L5b	Large pieces (carpets, etc.)	Textils / Natural fibers
L5c	Natural fishing ropes	Textils / Natural fibers
L5d	Sanitaries (non-polymers)	Textils / Natural fibers
L5	Total textils / Natural fibers	Textils / Natural fibers
L6	Total processed wood	Processed wood
L7	Total paper and cardboard	Paper and cardboard
L8	Total other	Other
L9	Total unspecified	Unspecified
	Total litter	Total litter
	Total fishing gears (sum of L1f to L1i, L3f, L5c)	Fishing gears

1.5.2 Floating Microplastics

1. All tables and relevant information which are presented hereunder are presented to the Contracting Parties to the Barcelona Convention for first time and thus should be considered as totally new.

Table 16: Data Dictionaries (Station Information) for IMAP Common Indicator 23 (Floating Microplastics) (Fields in red are not mandatory).

Field	Description	List of values	Remarks
Country Code	Enter member country code as ISO two digits, for example "IT" for Italy.		
National Station ID	Station Code		
National Station Name	Station Name		
Region	Administrative subdivision after country which the station belongs to		
Data Owner	Name of Institution carrying out the monitoring surveys		
Latitude	Latitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).		Latitude of the station is essential for the GIS representation and joined to the monitoring network. It is independent from the sampling point.
Longitude	Longitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use negative values for coordinates west of the Greenwich Meridian (0°).		Longitude of the station is essential for the GIS representation and joined to the monitoring network. It is independent from the sampling point.
Closest Coast	Distance station from the coast in km		
TCM Matrix	Floating microplastics with the use of Manta Net are only referred to water column (**W**). If other measures of other environmental matrix are performed in the same station enter one of the values in the list (information not related to floating microplastic monitoring but useful to characterize the station)	B = Biota BS = Biota and sediment BSW = Biota, sediment and water column BW = Biota and water column S = Sediment SW = Sediment and water column W = Water column	Values in the list in red are not mandatory
Sea Depth	Sea depth of the station in meters (information not related to floating microplastic monitoring but useful to characterize the station)		Not mandatory

Field	Description	List of values	Remarks
Mixing	Mixing property of the water column at the station point, enter one of the values in the list	FM = Fully mixed PM = Partially mixed VS = Vertically stratified	Not mandatory Reference method to be added
Area Typology	Typology of the monitored area enter one of the values in the list	RP = River Plume PF = Port Facility US = Urban Settlement IS = Industrial Settlement	RP = Turbid freshwater flowing from land and generally in the distal part of a river (mouth) outside the bounds of an estuary or river channel.
Remarks	Notes		

Table 17: Data Dictionaries (Microplastic Mesh) for IMAP Common Indicator 23 (Floating Microplastics) (Fields in red are not mandatory).

Field	Description	List of values	Remarks
National Station ID	Station code		
Year	Year of sampling in YYYY format		
Month	Month of sampling in 1-12 format		
Day	Day of sampling in 1-31 format		
Time	Hours-minutes-seconds of sampling in HH:MM:SS format		Start time of sampling (duration not less than 20 minutes)
Sample ID	Sample Code if multiple replies are made with the same value as Year, Month, Day and Time		
Latitude START	Latitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).		
Longitude START	Longitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use negative values for coordinates west of the Greenwich Meridian (0°).		
Latitude END	Latitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx).		
Longitude END	Longiitude of the station in the WGS84 decimal degrees reference system with at least 5 digits (xx.xxxxx). Use negative values for coordinates west of the Greenwich Meridian (0°).		
Sea Depth	Sea depth of the station in meters		
Temp	Temperature (°C)		Not Mandatory
Salinity	Salinity (psu)		Not Mandatory

Field	Description	List of values	Remarks
Transparency	Indicate the depth of shallows in meters (m)		Not Mandatory
DO	Dissolved oxygen - percentage of saturation (%)		Not Mandatory
pH	pH		Not Mandatory
Sea State	State of the sea according to Douglas scale (from 0 to 9 degrees)		
Wind Intensity	Intensity of the wind according to Beaufort scale (from 0 to 12 degrees)		
Wind Direction	Wind direction measured in degrees (angle unit) regard to the magnetic north, as reported on the compass		
Boat Speed	Average speed held by the boat during the sampling operations expressed in nodes		
Length Way	Length of the sampled linear way (m)		
Width Manta Trawl	Width of manta trawl (m)		
Surface Sampled	Surface sampled of seawater (m2)		
Remarks	Note		

Table 18: Data Dictionaries (Sampled Microplastics) for IMAP Common Indicator 23 (Floating Microplastics)

Field	Description	List of values
National Station ID	Station code	
Year	Year of sampling in YYYY format	
Month	Month of sampling in 1-12 format	
Day	Day of sampling in 1-31 format	
Time	Hours-minutes-seconds of sampling in HH:MM:SS format	
Sample ID	Sample Code if multiple replies are made with the same value as Year, Month, Day and Time	
Microplastic Morph Type	Indicate the type of morphology of the microplastics, enter one of the values in the list	Foam Filament Fragment Granule Pellet Sheet

Field	Description	List of values
Color	Indicate the color of microplastics, enter one value of the list	White Black Red Blue Green Other colors
Transparency	Indicate if the object is transparent or opaque, enter one value of the list	T = Transparent O = Opaque
Number of objects	Indicate the number of objects (sampled according to color and form indicated) per square meter of seawater	
Remarks	Notes	

Appendix IV

UNEP/MED WG.467/9
Data Standards and Data Dictionaries for Common Indicators related to Biodiversity and Non-Indigenous Species

UNITED NATIONS

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UNEP/MED WG.467/9

UNEP

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

8 August 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Agenda Item 6: IMAP Pilot Info System and Related Quality Assurance Issues; Data Standards and Data Dictionaries; MAP Data Management Policy

Data Standards and Data Dictionaries for Common Indicators related to Biodiversity and Non-Indigenous Species

UNEP/MAP
Athens, 2019

Note by the Secretariat

In the framework of the Programme of Work and Budget for 2018–2019 of UN Environment/MAP (Decision IG.23/14), INFO/RAC is leading the work on the development of the "*Info/MAP platform and platform for the implementation of IMAP fully operative and further developed, connected to MAP components' information systems and other relevant regional knowledge platforms, to facilitate access to knowledge for managers and decision-makers, as well as stakeholders and the general public*" (output 1.5.1).

The EU funded EcAp-MED II Project has contributed to the delivery of this output by developing a Pilot IMAP Compatible Data and Information System (IMAP (Pilot) Info System), that would enable the Contracting Parties to start reporting data as of mid-2019 for selected 11 IMAP Common Indicators (1, 2, 6, 13 ,14, 15, 16, 17, 21, 22, 23). The IMAP (Pilot) Info System lay down the basis for building a fully operational IMAP Info System, by the end of the initial phase of IMAP, as provided for by Decision IG.22/7.

The criteria used for selecting the 11 Common Indicators as part of the IMAP (Pilot) Info System are: a) maturity of Common Indicators as of 2017, in terms of monitoring experiences and best practices; b) existing data collection and availability representing all IMAP clusters; c) availability of Common Indicators Guidance Factsheets and/or metadata templates.

The preparation process of Data Standards and Data Dictionaries for Common Indicators related to Biodiversity and Non-Indigenous Species has followed a close consultation process between INFO RAC and SPA RAC. As well as with the Contracting Parties.

The Regional Meeting on IMAP Implementation: Best Practices, Gaps and Common Challenges (IMAP Best Practices Meeting, Rome, Italy, 10-12 July 2018) reviewed the first drafts of Data Standards and Data Dictionaries for the selected IMAP Common Indicators. Following its outcome and the bilateral consultations between INFO/RAC and SPA/RAC, the revised version of DSs and DDs for CI 1,2 and 6 has been presented to the CORMON Biodiversity and Fisheries (Marseille, 12-13 February 2019) for review and feedback.

The present proposal of DSs and DDs for IMAP Common Indicators 1,2 and 6 related to Biodiversity (EO1) and Non-indigenous species (EO2) has been further developed considering also the outputs of the CorMon Biodiversity and Fisheries (Rome, Italy, 21 May 2019) and has been presented at the 14th SPA/BD Thematic Focal Points Meeting (Portorož, Slovenia, 18-21 June 2019).

Table of contents

I. IMAP (Pilot) Info System, Data standards and Data dictionaries

1. The draft **IMAP (Pilot) Info System has** been developed by INFO/RAC in close consultations with UN Environment/MAP Components. The IMAP (Pilot) Info System will be able to receive and process data according to the proposed Data Standards and Data Dictionaries (DSs and DDs) that set the basic information on data reporting within IMAP.

2. It should be noted that proposed DSs and DDs also build on the respective relevant experience of INFO/RAC, as well as the experience gained in building other relevant databases such as EMODnet Chemistry platform, SeaDataNet and WISE Data Dictionary maintained by EEA and available in EIONET. In such a way the IMAP (Pilot) Info System is interrelated with other regional marine databases (e.g. SeaDataNet, SeaDataCloud, EMODNET, etc.), essential to avoid duplication of data transmissions for the Contracting Parties.

3. **Data Standards (DSs)** are prepared in the form of Excel spreadsheets in which every column indicates a field to be filled by the data providers. **Data Dictionaries (DDs)** are prepared in the form of Excel spreadsheets in which every row provides information to guide the data provider. DSs & DDs are spreadsheets included in the **same Excel file**, downloadable from the IMAP (Pilot) info system. The data uploaded using the Data Standards will be suitable for the inclusion in the database.

4. The Regional Meeting on IMAP Implementation (**Best Practices, Gaps and Common Challenges (IMAP Best Practices Meeting), Rome, Italy, 10-12 July 2018**) reviewed the first drafts of Data Standards and Data Dictionaries for the selected IMAP Common Indicators. Following its outcome and the bilateral consultations between INFO/RAC and SPA/RAC, the revised version of DSs and DDs for CI 1,2 and 6 has been presented to the **CorMon Biodiversity and Fisheries (Marseille, 12-13 February 2019)** for review and feedback.

5. The present proposal of DSs and DDs for **IMAP Common Indicators 1,2 and 6 related to Biodiversity (EO1) and Non-indigenous species (EO2)** has been further developed considering also the outputs of the CorMon Biodiversity and Fisheries (Rome, Italy, 21 May 2019) and has been presented at the 14th SPA/BD Thematic Focal Points Meeting (Portorož, Slovenia, 18-21 June 2019).

6. The updated proposal of DSs and DDs provides broader data sets and associated dictionaries than requested as mandatory by the related IMAP Guidance Factsheets and Metadata Templates. In the Data Standards the mandatory data are represented in black and the **non-mandatory** ones in red. The possibility to fill in also **non mandatory** fields is given to allow the Contracting Parties that already have monitoring systems collecting a wider set of data also to report them as the additional data. It is at the discretion of the Contracting Parties to decide on reporting on non-mandatory data sets.

7. Following the outcome of CORMON Biodiversity, the finalized DSs and DDs have been uploaded in the IMAP (Pilot) Info System and the consequent changes to the data base structure have been provided. In other words, once all the parameters and measurement units have been defined, the correspondent data flow have been activated. A **testing phase** of the IMAP (Pilot) Info System will be realized with the **voluntary participation of interested countries**. They will be invited to start providing data flows for the selected Common Indicators supported by the IMAP (Pilot) Info System. After the testing and reflection of its findings, it is expected to have the IMAP (Pilot) Info System fully operational to receive uploaded data for 11 selected IMAP Common Indicators.

8. Starting from the middle of 2019, after the conclusion of the EcAp MED II Project, further modules will be discussed and agreed with the thematic MAP Components for each already

selected Common Indicator and for the remaining ones in view of the completion of the IMAP 27 Common Indicator set, according to the available resources specifically allocated.

9. Apart from the 17 remaining Common Indicators, the selected 11 will also go through a process of enlargement and development. INFO/RAC, is currently proposing a series of modules for each Common Indicator covering the main monitoring issues but in the next period they will be integrated with **new modules** that are in discussion or in development.

10. The aim of the current document is to present the "final" version of DSs & DDs relative to the phase I of development of the IMAP (pilot) Info System, available for data collection since the end of June 2019 (Conclusion of EcAp MED II project).

11. Contracting Parties are requested to provide **guidance, inputs and further reflections** on the "final" DSs &DDs for the selected common indicators. On this basis, a continuous process of harmonization with IMAP guidance factsheets and common indicators monitoring protocols will be assured for next future (Phase II) starting from July 2019. Consequently, also the structure of the Data Standards and Data Dictionaries could be revised and harmonized based on the final result of the IMAP developing process.

12. The "final" DSs & DDs have to be intended as first agreed version useful to allow the starting of the pilot phase of the information system. Interactive work will be needed to refine these Data Standards and Data Dictionaries gradually.

13. As stated by the **CORMON Biodiversity and Fisheries (Marseille 12-13 February 2019)** monitoring protocols should guide data standards development that is carried out in parallel with discussions on the agreed common methodologies. Information systems are a major tool to collect and transfer data. Given that the development of indicators, monitoring methods and data standards are progressing in parallel, close and continuous dialogue and collaboration are needed among the bodies responsible for these developments to ensure their proper alignment and coherence.

14. The appointment of on-line network of designate qualified experts, supporting INFO/RAC on finalization of DSs and DDs for the cluster Biodiversity and Fisheries, as requested during the CorMon of Marseille (12-13 February 2019) and Rome (21 May 2019), could usefully ensure this coherence.

15. IMAP (Pilot) Info System will take in consideration the monitoring guidelines of common indicators discussed during the CorMon meetings (Marseille, France, 12-13 February 2019 and Rome, Italy,
21 May 2019) and endorsed during the Meeting of SPA/BD Thematic Focal Points, as presented under agenda item 7.1. "Implementation of the first phase (2016-2019) of the Integrated Monitoring and Assessment Programme (IMAP - Biodiversity and nonindigenous species) in the framework of the EcAp Roadmap".

II. Data Standards and Data Dictionaries for IMAP Common Indicators 1,2 & 6

1. Biodiversity (EO1):

16. The DSs & DDs for Biodiversity CI 1&2 were developed for habitats expressly reported in the IMAP guidance factsheets. At moment, in the framework of the EcAp-MED II project, the following habitats were taken into account:

➢ **Coralligenous habitat**,

➢ **Maerl-Rhodolith beds habitat**,

➢ **Marine vegetation habitat,** *Posidonia oceanica* meadows. The reference document for the habitats to be monitored is:

- Draft Updated Reference List of Marine Habitat Types for the Selection of Sites to be included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean.

17. In order to draw up the updated Reference List of Marine Habitat Types for the Mediterranean Region, an updated and more comprehensive draft classification of benthic marine habitat types for the Mediterranean region (UNEP/MED WG.457/3) and Draft Updated Reference List of Marine Habitat Types for the Mediterranean region (UNEP/MED WG.457/4) were discussed (Rome, Italy 22-23 January 2019), and elaborated based on:

• Classification of benthic marine habitat types for the Mediterranean region of the Barcelona Convention (1998),

• the schemes of the new EUNIS classification system (Table 1),

• the List of French Mediterranean habitats (Michez et al, 2014),

• the Spanish inventory of marine habitats (Templado et al., 2012),

• the Croatian List of Marine Habitats (Bakran-Petricioli, 2011), and

• new habitats based on the experts' inputs.

Furthermore, the following lists were taken into account:

• the European Red list of marine Habitats in the Mediterranean

• the list compiled by OCEANA, with the contribution of experts on Mediterranean deep-sea habitats, in order to implement the UNGA Resolutions for the protection of Vulnerable Marine Ecosystems (VMEs) in the GFCM context.

18. The proposed Reference List in the IMAP (Pilot) Info System will be periodically reviewed, remaining dynamic to ensure adequate harmonization with other classifications defined in relevant frameworks, such as EUNIS, and according to the implementation inputs of the IMAP. For each module, the relative habitats are extracted from the updated list (Maerl/Rodolith beds and Coralligenous Habitats) and reported as reference. The list of habitats showed in the Data Dictionaries will be updated according to the new IMAP decisions.

19. The Data Dictionaries will present also a List of species to be monitored for each habitat type. The list will be the sum of the list of species agreed at national level and part of the national IMAP. At moment this list is not available and will be updated in light of the adopted national IMAP and the Reference List of Marine Habitat Types for the Mediterranean region discussed and endorsed

during the Fourteenth Meeting of SPA/BD Thematic Focal Points under agenda item 5.3 "Updating of the Action Plan for the Conservation of Marine Vegetation in the Mediterranean Sea and the Reference List of Marine Habitat Types for the Selection of Sites to be included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean".

20. To avoid typing errors, two main databases for consultation are proposed as reference:

• WORMS World Register of Marine Species
(http://www.marinespecies.org/)

• ALGAEBASE
(http://www.algaebase.org)

Coralligenous habitat

21. The Methodological Document on "Data Dictionary on IMAP C.I. 1&2 related to Coralligenous Habitat" is mainly referred to ROV monitoring technique and provides detailed information to set up this activity.

22. As this device is currently used for monitoring Coralligenous habitat but is not exclusive and not so widespread in the Mediterranean basin (on the basis of CPs comments), in the final version of DSs & DDs the section about Diver has been updated and enlarged.

23. The choice of the monitoring approach will be made by the country on the basis of its national monitoring plan and as a function of depth and nature of the monitored area.

24. It is to be highlighted that Contracting Parties can use one of the two methods (ROV and Diver) included in the DSs and DDs. **Excel spreadsheets corresponding to a method not used by the CP can be left empty**.

25. Although a common decision at regional level on the appropriate software for image analysis and a discussion on it should be open, at present in the methodological document on Coralligenous it is not proposed a specific one. Data collected, using different software can be equally supported by the pilot info system.

26. According to inputs received by Countries, a repository of photos will be available in IMAP (Pilot) Info System and the field “Photo ID” is included into Data Standards to link the file of the photos to the associated information. Such photo files can be transferred to IMAP Pilot Info System as attached to the excel file filled with monitoring data and compliant with data standards.

27. Other relevant issues have been raised by some countries and deserve a further in-depth discussion among the designated experts on the identification of monitoring methodologies in the framework of IMAP process, counting on the full support of INFO/RAC in including such as inputs in the IMAP Pilot Info System.

Maerl-Rhodolith beds habitat

28. In Phase II other parameters useful to characterize the habitats (i.e Organic Matter etc.) could be added after a further discussion with Countries.

29. The fields referred to granulometry were modified into non mandatory (in this phase I) to collect observations from some countries but it has to be highlighted that granulometry is a

relevant parameter to characterize the habitat conditions as asked by C.I. 2. In addition, reference methods related to granulometry analysis need to be identified by thematic component of MAP and CPs.

30. The updated Data Standards will give the possibility to collect also information about associated macrofauna species.

Marine vegetation habitat, *Posidonia oceanica* meadows

31. The updated DSs, compared to the previous version, provides a minor number of mandatory fields as requested by some country.

2. Non – indigenous species (EO2):

32. The draft Metadata and Data Dictionaries for NIS (Common Indicator 6) were developed based on the Common Indicator guidance Factsheets (UNEP(DEPI)/MED WG.430/3), and will take in consideration the guidelines for monitoring non indigenous species (UNEP/MED WG.458/4) discussed during the CorMon meetings on biodiversity and fisheries (Marseille, France, 12-13 February 2019 and Rome, Italy, 21 May 2019).

33. The draft metadata include the list of species endorsed by countries during the validation of their national IMAP. Further updating of this list will be reported into the DDs.

34. Further update of DSs and DDs on invertebrates and fishes have been proposed, including comments collected during and after CorMon Biodiversity and Fisheries (Marseille, France, 12-13 February, and Rome, Italy, 21 May 2019). This list will take in consideration the outputs of the joint GFCM- UN Environment/MAP sub-regional pilot study for the Eastern Mediterranean on non-indigenous species in relation with fisheries

3. Conclusions

35. INFO/RAC recalls that the present document is provided as update of DSs & DDs and considers the inputs received by Contracting Parties during the CorMon meetings organised during the biennial exercise of 2018-2019 including the written comments sent afterwards.

36. INFO/RAC has worked to include most part of the collected inputs, according to the acknowledgements of the scientific community, IMAP reference documents and in close collaboration with SPA/RAC.

37. In order to reach the broader consensus at level of Contracting Parties on the finalization of DSs & DDs, it is needed an in-depth discussion on the proposed changes, followed by a final agreement with the support of the on-line group of national experts to be appointed in due time.

38. In the meantime, part of accepted comments is provided as non-mandatory fields to be confirmed, the remaining ones will be addressed in specific bilateral meetings with countries in Phase II, starting in July 2019.

Appendix V

UNEP/MED WG.467/10
Data Standards and Data Dictionaries for Common Indicators related to Coast and Hydrography

UNITED NATIONS

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UNEP/MED WG.467/10

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ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

8 August 2019
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Data Standards and Data Dictionaries for Common Indicators related to Coast and Hydrography

Note by the Secretariat

This document includes changes introduced following comments received at the 7th Meeting of the Ecosystem Approach Coordination Group. All changes are indicated in Track Changes mode.

UNEP/MAP
Athens, 2019

Note by the Secretariat

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The preparation process of Data Standards and Data Dictionaries for Common Indicators related to Coast and Hydrography has followed a close consultation process between INFO RAC and SPA RAC. As well as with the Contracting Parties.

The Regional Meeting on IMAP Implementation (Best Practices, Gaps and Common Challenges (IMAP Best Practices Meeting), Rome, Italy, 10-12 July 2018) reviewed the first drafts of Data Standards and Data Dictionaries for the selected IMAP Common Indicators. Following its outcome and the bilateral consultations between INFO/RAC and PAP/RAC, the revised version of DSs and DDs for CI 15 and 16 has been presented to the CorMon Coast and Hydrography (Rome, 21-22 May 2019) for review and feedback.

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6. It should be noted that proposed DSs and DDs also build on the respective relevant experience of INFO/RAC, as well as the experience gained in building other relevant databases such as EMODnet Chemistry platform, SeaDataNet and WISE Data Dictionary maintained by EEA and available in EIONET. In such a way the IMAP (Pilot) Info System is interrelated with other regional marine databases (e.g. SeaDataNet, SeaDataCloud, EMODNET, etc.), essential to avoid duplication of data transmissions for the Contracting Parties.

7. **Data Standards (DSs)** are prepared in the form of Excel spreadsheets in which every column indicates a field to be filled by the data providers. **Data Dictionaries (DDs)** are prepared in the form of Excel spreadsheets in which every row provides information to guide the data provider. DSs & DDs are spreadsheets included in the **same Excel file**, downloadable from the IMAP (Pilot) Info System. The data uploaded using the Data Standards will be suitable for the inclusion in the database.

8. The Regional Meeting on IMAP Implementation (**Best Practices, Gaps and Common Challenges (IMAP Best Practices Meeting), Rome, Italy, 10-12 July 2018**) reviewed the first drafts of Data Standards and Data Dictionaries for the selected IMAP Common Indicators. Following its outcome and the bilateral consultations between INFO/RAC and PAP/RAC, the revised version of DSs and DDs for CI 15 and 16 has been presented to the **CorMon Coast and Hydrography (Rome, 21-22 May 2019)** for review and feedback.

9. Starting from the middle of 2019, after the conclusion of the EcAp MED II Project, further modules will be discussed and agreed with the thematic MAP Components for each already selected Common Indicator and for the remaining ones in view of the completion of the IMAP 27 Common Indicator set, according to the available resources specifically allocated.

10. Apart from the 17 remaining Common Indicators, the selected 11 will also go through a process of enlargement and development. INFO/RAC, is currently proposing a series of modules for each Common Indicator covering the main monitoring issues but in the next period they will be integrated with **new modules** that are in discussion or in development.

11. The aim of the current document is to present the “final” version of DSs & DDs relative to the phase I of development of the IMAP (pilot) Info System, available for data collection since the end of June 2019 (Conclusion of EcAp MED II project).

12. Contracting Parties are requested to provide **guidance, inputs and further reflections** on the “final” DSs &DDs for the selected common indicators. On this basis, a continuous process of harmonization with IMAP guidance factsheets and common indicators monitoring protocols will be assured for next future (Phase II) starting from July 2019. Consequently, also the structure of the Data Standards and Data Dictionaries could be revised and harmonized based on the final result of the IMAP developing process.

13. The “final” DSs & DDs have to be intended as first agreed version useful to allow the starting of the pilot phase of the information system. Interactive work will be needed to refine these Data Standards and Data Dictionaries gradually.

14. INFO/RAC recalls that the present document is provided as update of DSs & DDs and considers the inputs received by Contracting Parties during the CorMon meeting organised during the biennial exercise of 2018-2019.

II. Information Standards for the Common Indicator 15

Content	Description
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Location and extend of coastal or offshore infrastructures**
Attribute table	Specify the following information in the attribute table associated with the GIS information layer: • CPCODE: Two-letter code of Country • LOCALITY: Specify the location of the infrastructure • ID_STRUCT: ID of the infrastructure, the ID must be unique to identify the infrastructure. It could be a number or alphanumeric obtained combining CPCODE with LOCALITY • ASDES: Description of coastal or offshore infrastructure • ROLE: Specify the role of the infrastructure, for ex. harbour, coastal defense, marine energy, etc.. • TYPE: Specify the type of infrastructure, for ex. quay, groynes, wind farm, etc… • MATERIALS: Specify the materials used to build the infrastructure: concrete, rockfill, etc… • AREA_SF: Area of the structure on sea floor in Km2 • EXT: In case the coastal or offshore infrastructure is an extension of a pre-existing one, it is necessary to specify if the polyline corresponds to such extension - Use the following codes: ○ 1=Yes, it is the extension; ○ 0=No, it is part of the pre-existing infrastructure
Variables	Border on the sea side of the coastal or offshore infrastructure
Spatial resolution	5 mt or higher as produced by CAD (Computer Aided Design) software
Vertical coverage	At least 2 levels, one at sea surface and one at the sea bottom
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	Every 6 years
Data format	GIS Layer: polyline or polygons
Type of layer	Mandatory
Content	**Description**
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Location and extend of hydrographical changes**

Attribute table	Specify the following information in the attribute table associated with the GIS information layer:
	• CPCODE: Two-letter code of Country
	• LOCALITY: Specify the location of the infrastructure
	• ID_STRUCT: ID of the infrastructure, the ID must be unique to identify the infrastructure.
	• PAR: Parameter that is significantly and permanently changed due to coastal or offshore infrastructure. Choose one from the following list:
	    ○ current velocity
	    ○ temperature
	    ○ salinity
	    ○ sea surface height
	    ○ turbidity
	    ○ wave
	    ○ other
	• PAR_OTH: In case the PAR field is 'other' specify the hydrographical Parameter
	• OCCUR: Specify if the alteration of the parameter is occurring or expected to occur. Use the following codes:
	    ○ 1=It is occurring;
	    ○ 0=It is expected to occur
	• DATA: Data used, for ex. data provided by EIA, dredging/disposal scheme, etc…
	• METHOD: Method of alterations assessment, for ex. modeling, expert judgment, analogy with similar and close site, etc…
	• CONF: Level of assessment confidence, Use the following codes:
	    ○ L=Low confidence
	    ○ M=Medium confidence
	    ○ G=Good confidence
	• AREA: Extend of hydrographical alteration in Km2

Variables	Border on the sea side of the area where the specified hydrographical parameter is significantly and permanently changed due to coastal or offshore infrastructure
Spatial resolution	25 mt or higher as produced by numerical model assimilated and validated with in-situ monitoring data and preferably nested in Copernicus CMEMS products for boundary conditions (0.063degree x 0.063degree)
Vertical coverage	At least 2 levels, one at sea surface and one at the sea bottom
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	Every 6 years
Data format	GIS Layer: polygons
Type of layer	Mandatory

Content	**Description**
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Current Velocity**

Geographical coverage	Specify the geographical bounding box that includes the sea area that is covered by the data representation. Such area should be large enough to capture permanent and significant hydrographical changes due to coastal or offshore infrastructures. The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals in WGS 84 or ETRS 89 geographical reference systems. The four data to provide are: • North Bound Latitude • East Bound Longitude • South Bound Latitude • West Bound Longitude
Observations/ Models	Numerical model assimilated and validated with in-situ monitoring data and preferably nested in Copernicus CMEMS current velocity products for boundary conditions (0.063degree x 0.063degree)
Data assimilation	In-situ monitored data provided by acoustic or mechanical current meter
Variables	Eastward sea water velocity (UV) Northward sea water velocity (UV)
Spatial resolution	25 mt or higher nested in Copernicus CMEMS current velocity grids products (0.063degree x 0.063degree)
Vertical coverage	10 or more levels from surface to sea floor. Copernicus CMEMS current velocity product provide 72 levels
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	5 years or more
Temporal resolution	Monthly mean
Data format	NetCDF or raster grid
Type of layer	Non-Mandatory
Content	**Description**
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Temperature**
Geographical coverage	Specify the geographical bounding box that includes the sea area that is covered by the data representation. Such area should be large enough to capture permanent and significant hydrographical changes due to coastal or offshore infrastructures. The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals in WGS 84 or ETRS 89 geographical reference systems. The four data to provide are: • North Bound Latitude • East Bound Longitude • South Bound Latitude • West Bound Longitude
Observations/ Models	Numerical model assimilated and validated with satellite and in-situ monitoring data and preferably nested in Copernicus CMEMS temperature products for boundary conditions (0.063degree x 0.063degree)
Data assimilation	In-situ monitored data provided by CTD probe and satellite sea surface temperature (SST)
Variables	Sea water potential temperature. Potential temperature is the temperature a parcel of water would have if it were moved adiabatically (i.e. without loss of heat) to a reference pressure. The reference pressure used for the ocean is the ocean surface (water pressure = 0 dbar).
Spatial resolution	25 mt or higher nested in Copernicus CMEMS temperature grids products (0.063degree x 0.063degree)

Vertical coverage	10 or more levels from surface to sea floor. Copernicus CMEMS temperature product provide 72 levels
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	5 years or more
Temporal resolution	Monthly mean and daily mean
Data format	NetCDF or raster grid
Type of layer	Non-Mandatory
Content	**Description**
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Salinity**
Geographical coverage	Specify the geographical bounding box that includes the sea area that is covered by the data representation. Such area should be large enough to capture permanent and significant hydrographical changes due to coastal or offshore infrastructures. The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals in WGS 84 or ETRS 89 geographical reference systems. The four data to provide are: - North Bound Latitude - East Bound Longitude - South Bound Latitude - West Bound Longitude
Observations/ Models	Numerical model assimilated and validated with in-situ monitoring data and preferably nested in Copernicus CMEMS salinity products for boundary conditions (0.063degree x 0.063degree)
Data assimilation	In-situ monitored data provided by CTD probe
Variables	Sea water salinity
Spatial resolution	25 mt or higher nested in Copernicus CMEMS salinity grids products (0.063degree x 0.063degree)
Vertical coverage	10 or more levels from surface to sea floor. Copernicus CMEMS salinity product provide 72 levels
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	5 years or more
Temporal resolution	Monthly mean and daily mean
Data format	NetCDF or raster grid
Type of layer	Non-Mandatory
Content	**Description**
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Sea Surface Height**
Geographical coverage	Specify the geographical bounding box that includes the sea area that is covered by the data representation. Such area should be large enough to capture permanent and significant hydrographical changes due to coastal or offshore infrastructures. The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals in WGS 84 or ETRS 89 geographical reference systems. The four data to provide are: - North Bound Latitude - East Bound Longitude - South Bound Latitude - West Bound Longitude

Observations/ Models	Numerical model assimilated and validated with satellite and in-situ monitoring data and preferably nested in Copernicus CMEMS Sea Surface Height products for boundary conditions (0.063degree x 0.063degree)
Data assimilation	Satellite and In-situ monitored data provided by tide gauge observations
Variables	Sea surface height above sea level
Spatial resolution	25 mt or higher nested in Copernicus CMEMS Sea Surface Height grids products (0.063degree x 0.063degree)
Vertical coverage	1 level
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	5 years or more
Temporal resolution	Monthly mean and daily mean
Data format	NetCDF or raster grid
Type of layer	Non-Mandatory
Content	**Description**
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Turbidity**
Geographical coverage	Specify the geographical bounding box that includes the sea area that is covered by the data representation. Such area should be large enough to capture permanent and significant hydrographical changes due to coastal or offshore infrastructures. The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals in WGS 84 or ETRS 89 geographical reference systems. The four data to provide are: - North Bound Latitude - East Bound Longitude - South Bound Latitude - West Bound Longitude
Observations/ Models	Satellite or in-situ observations
Data assimilation	
Variables	Satellite: - Surface ratio of upwelling radiance emerging from sea water to downwelling radiative flux in air (RRS) - Volume attenuation coefficient of downwelling radiative flux in sea water (KD) - Volume absorption coefficient of radiative flux in sea water due to dissolved organic matter and non algal particles (CDM) - Volume absorption coefficient of radiative flux in sea water due to phytoplankton (APHY) - Volume backwards scattering coefficient of radiative flux in sea water due to particles (BBP) In-situ observations: - Turbidity sensor probe - Secchi disk
Spatial resolution	25 mt or higher
Vertical coverage	Satellite: 1 level; In-situ observations turbidity sensor probe: 3 or more levels, at least one on the sea floor, one on sea subsurface (1mt depth) and one in the middle
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	5 years or more
Temporal resolution	Satellite: Daily mean; In-situ observations: at least monthly
Data format	NetCDF or raster grid
Type of layer	Non-Mandatory

Content	Description
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Bathymetry**
Geographical coverage	Specify the geographical bounding box that includes the sea area that is covered by the data representation. Such area should be large enough to capture permanent and significant hydrographical changes due to coastal or offshore infrastructures. The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals in WGS 84 or ETRS 89 geographical reference systems. The four data to provide are: - North Bound Latitude - East Bound Longitude - South Bound Latitude - West Bound Longitude
Observations/ Models	Digital Terrain Model from in-situ observations by multibeam
Data assimilation	
Variables	Digital Terrain Model elaborated from multibeam survey
Spatial resolution	25 mt or higher resolution
Vertical coverage	1 level
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	Every 5 years or more
Temporal resolution	
Data format	raster grid
Type of layer	Non-Mandatory
Content	**Description**
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Wave**
Geographical coverage	Specify the geographical bounding box that includes the sea area that is covered by the data representation. Such area should be large enough to capture permanent and significant hydrographical changes due to coastal or offshore infrastructures. The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals in WGS 84 or ETRS 89 geographical reference systems. The four data to provide are: - North Bound Latitude - East Bound Longitude - South Bound Latitude - West Bound Longitude
Observations/ Models	Numerical model assimilated and validated with in-situ monitoring data and preferably nested in Copernicus CMEMS wave products for boundary conditions (0.042degree x 0.042degree)
Data assimilation	In-situ monitored data provided by accelerometer mounted on buoy

Variables	Sea surface wave significant height (SWH) Sea surface wave mean period from variance spectral density inverse frequency moment (MWP) Sea surface wave mean period from variance spectral density second frequency moment (MWP) Sea surface wave from direction (VMDR) Sea surface wave stokes drift x velocity (VSDXY) Sea surface wave stokes drift y velocity (VSDXY) Sea surface wind wave significant height (WW) Sea surface wind wave mean period (WW) Sea surface wind wave from direction (WW) Sea surface primary swell wave significant height (SW1) Sea surface primary swell wave mean period (SW1) Sea surface primary swell wave from direction (SW1) Sea surface secondary swell wave significant height (SW2) Sea surface secondary swell wave mean period (SW2) Sea surface secondary swell wave from direction (SW2) Sea surface wave period at variance spectral density maximum () Sea surface wave from direction at variance spectral density maximum ()
Spatial resolution	25 mt or higher nested in Copernicus CMEMS wave grids products (0.042degree x 0.042degree)
Vertical coverage	1 level
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	5 years or more
Temporal resolution	hourly-instantaneous
Data format	NetCDF or raster grid
Type of layer	Non-Mandatory
Content	**Description**
Ecological Objective	**EO7. Alteration of hydrographical conditions**
IMAP Common Indicator	**CI15. Location and extent of the habitats impacted directly by hydrographic alterations**
Parameter	**Benthic habitat**
Geographical coverage	Specify the geographical bounding box that is covered by the data representation. The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals in WGS 84 or ETRS 89 geographical reference systems. The four data to provide are: - North Bound Latitude - East Bound Longitude - South Bound Latitude - West Bound Longitude
Observations/ Models	In-situ monitoring observations
Data assimilation	
Variables	Type of habitat according to the 'Reference List of Marine and Coastal Habitat Types in the Mediterranean' – Annex I of the CI15 Guidance Fact Sheet. Use the highest level of identification, for example 'MA1.531 Association with encrusting Corallinales creating belts (e.g. Lithophyllum bissoides, Neogoniolithon spp.)' for Littoral rock/Upper mediolittoral rock.
Spatial resolution	100 mt or higher for separation length between in-situ monitoring sampling station
Vertical coverage	1 level
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	5 years or more

Temporal resolution	Every 3 years
Data format	GIS polygon with attribute table with the following fields beyond unique identifier of the GIS polygon: • CPCODE: Two-letter code of Country • LOCALITY: Specify the location of the infrastructure • ID_STRUCT: ID of the infrastructure, the ID must be unique to identify the infrastructure. • MHT-MED – code of habitat type as reported in Annex I of the CI15 • Guidance Fact Sheet. For example, 'MA1.531'. If not present in the list use the code '9999' • DESC – Description of the habitat as reported in Annex I of the CI15 • Guidance Fact Sheet. For example, 'Association with encrusting Corallinales creating belts (e.g. Lithophyllum bissoides, Neogoniolithon spp.)' • DESC_OTH – Description of the habitat if not present in Annex I of the • CI15 Guidance Fact Sheet. • IMPACT: Specify if the habitat is potentially impacted. Use the following codes: o 1=Yes, it is potentially impacted; o 0=No, it is not potentially impacted If an habitat has an area where it is potentially impacted and an area where it is not potentially impacted, different polygons will be needed to delimitate the two areas
Type of layer	Mandatory

III. Information standards for the Common Indicator 16

GIS information standards:

- Artificial structures
- Coastline artificial/natural

Name of GIS layer: Artificial_structures

Type of GIS Layer: polyline

Geographical Reference Systems: WGS 84 decimal degree

Attribute table:

Content	**Description**
Ecological Objective	**EO8. Coastal ecosystem and landscape**
IMAP Common Indicator	**CI16. Length of coastline subject to physical disturbance due to the influence of manmade structures**
Parameter	**Location and extend of artificial structures**
Attribute table	Specify the following information in the attribute table associated with the GIS information layer: • CPCODE: Two-letter code of Country • ASCODE: Mandatory. Integer. Code of type of artificial structure. The following code list should be used: o 1 Breakwaters o 2 Seawater/Revetments/Sea dike o 3 Groins o 4 Jetties o 5 River mouth structures

Content	Description
Ecological Objective	**EO8. Coastal ecosystem and landscape**
IMAP Common Indicator	**CI16. Length of coastline subject to physical disturbance due to the influence of manmade structures**
	○ 12 Port and marinas • ASDES: Optional. Text. Description of type of artificial structures • Municipal: Optional. Text. Name of municipality or local administrative region where the polygon of artificial structure is located • Year: Mandatory. Text. Year of production of the information layer
Variables	Border on the sea side of coastal artificial structures
Spatial resolution	10 m or higher as produced by photo digitalization or CAD (Computer Aided Design) software
Vertical coverage	1 level at sea surface
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	Every 6 years
Data format	GIS Layer: polyline or polygon

Name of GIS layer: Coastline_AN
Type of GIS Layer: polyline

Geographical Reference Systems: WGS 84 decimal degree

Attribute table:

Content	Description
Ecological Objective	**EO8. Coastal ecosystem and landscape**
IMAP Common Indicator	**CI16. Length of coastline subject to physical disturbance due to the influence of manmade structures**
Parameter	**Artificial/Natural coastline**
Attribute table	Specify the following information in the attribute table associated with the GIS information layer: • CPCODE: Two-letter code of Country • ART_NAT: Mandatory. Integer. Code for type of segment of coastline. Use the following code list: ○ 0 Natural coastline ○ 1 Artificial coastline • Municipal: Optional. Text. Name of municipality or local administrative region where the polygon/polyline of segment of coastline is located • Year: Mandatory. Text. Year of production of the information layer • Ref_Year: Mandatory. Year of the reference coastline used to represent natural and artificial segments
Variables	Segment of artificial/natural of coastline

Content	**Description**
Ecological Objective	**EO8. Coastal ecosystem and landscape**
IMAP Common Indicator	**CI16. Length of coastline subject to physical disturbance due to the influence of manmade structures**
Spatial resolution	10 m or higher as produced by photo digitalization and interpretation
Vertical coverage	1 level at sea surface
Coordinate Reference System	WGS 84 or ETRS 89 decimal degrees
Temporal coverage	Every 6 years
Data format	GIS Layer: polyline

Appendix VI

UNEP/MED WG.467/5
IMAP Guidance Factsheets: Update for Common Indicators 13, 14, 17, 18, 20 and 21;
New proposal for Candidate Indicators 26 and 27

UNITED NATIONS

EP

UNEP/MED WG.467/5

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

8 August 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Agenda Item 7: Updated IMAP Guidance Factsheets for Common Indicators 13, 14, 15, 16, 17, 18, 20 and 21; New proposal for Candidate Indicators 25, 26 and 27

IMAP Guidance Factsheets: Update for Common Indicators 13, 14, 17, 18, 20 and 21; New proposal for Candidate Indicators 26 and 27

Note by the Secretariat

This document includes changes introduced following comments received at the 7th Meeting of the Ecosystem Approach Coordination Group. All changes are indicated in Track Changes mode.

UNEP/MAP
Athens, 2019

Note by the Secretariat

The 19th Meeting of the Contracting Parties (COP 19), held in February 2016, adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria (Decision IG. 22/7), with a list of regionally agreed good environmental status descriptions, common indicators and targets, with principles and clear timeline for its implementation.

The UN Environment/MAP Programme of Work (PoW) adopted at COP 19, included under Output 1.4.3: "Implementation of IMAP (the EcAp-based integrated monitoring and assessment programme) coordinated, including GES common indicators factsheets".

In line with IMAP, Guidance Factsheets for the Common Indicators were developed, reviewed and agreed by the Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring (CorMon on Pollution Monitoring) held in Marseille, France, 19-21 October 2016 and the Meeting of the MED POL Focal Points, held in Rome, Italy, 29-31 May 2017. The Guidance Factsheets provide concrete guidance to the Contracting Parties in support of implementation of their respective national monitoring programmes aligned with IMAP.

The comments received by the Contracting Parties were considered and approved by the 6th Meeting of the Ecosystem Approach Coordination Group, held in Athens, Greece, 11th September 2017. It must be noted that the Guidance Factsheets were used during the elaboration of the Mediterranean Quality Status Report 2017 (Med QSR 2017).

Taking into account the evolving needs to fill the gaps, in particular those related to the assessment component of the Guidance Factsheets, the UN Environment/MAP Programme of Work (PoW) adopted at COP 20, under Output 2.4.1 on national pollution and litter monitoring programmes, measures that provide for undertaking important monitoring activities supported by data quality assurance and control, including further development of the IMAP Guidance Factsheets.

The present document outlines the revision of the Guidance Factsheets for Common Indicators 13, 14, 17, 18, 20 and 21 related to Ecological Objective 5 (Eutrophication) and Ecological Objective 9 (Contaminants) and proposes for the first time Guidance Factsheets for Candidate Indicators 26 and 27 related to Ecological Objective 11 (Energy including underwater noise). These revisions were reviewed and welcomed by the Ecosystem Approach Correspondence Group on Pollution Monitoring (CorMon on Pollution Monitoring) held in Podgorica, Montenegro on 2-3 April 2019.

Following the work undertaken by the Meeting of CorMon on Pollution Monitoring, the Meeting of the MED POL Focal Points, held in Istanbul, Turkey on 29- 31 May 2019 approved the proposed revisions of the Guidance Factsheets for Common Indicators 13, 14, 17, 18, 20 and 21 related to EO5 (Eutrophication) and EO9 (Contaminants), as well as the proposal of the Guidance Fact Sheets for Candidate Indicators 26 and 27 related to EO11 (Energy including underwater noise), and recommended their submission for approval of the 7th Meeting of EcAp Coordination Group. The Meeting took note on the reservation expressed by Morocco with regards to the elaborated example for sampling frequency definition through the discriminant limit of two adjacent mean values for Common Indicators 13 and 14 included within subsection related to temporal scope guidance. The Meeting also pointed out the need for further work to gather relevant knowledge, including through the testing of the Guidance Factsheets for Candidate Indicators 26 and 27 on an indicative basis as appropriate, prior to incorporating them into IMAP upon completion of its initial phase.

List of Abbreviations / Acronyms

ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
CI	Common Indicator
COP	Conference of the Parties
CORMON	Correspondence Group on Monitoring
DDs	Data Dictionaries
DSs	Data Standards
EcAp	Ecosystem Approach
EEA	European Environmental Agency
EO	Ecological Objective
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GES	Good Environmental Status
HELCOM	Baltic Marine Environment Protection Commission - Helsinki Commission
ICES	International Council for the Exploration of the Sea
IMAP	Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria
INFO/RAC	Regional Activity Centre for Information and Communication
MAP	Mediterranean Action Plan
MED POL	Programme for the Assessment and Control of Marine Pollution in the Mediterranean Sea
MED QSR	Mediterranean Quality Status Report
MSFD	Marine Strategy Framework Directive
OSPAR	Convention for the Protection of the Marine Environment for the North-East Atlantic
PoW	Programme of Work
SoED 2019	2019 State of Environment and Development Report
US EPA	United States Environmental Protection Agency
WFD	Water Framework Directive

Table of Contents

1. INTRODUCTION

1. The update of the Guidance Factsheets for Common Indicators 13,14,17,18, 20 and 21 strictly follows the structure of the IMAP Common Indicator Guidance Factsheets as approved by the 6th Meeting of the Ecosystem Approach Coordination Group. This update also considers the assessment maps prepared in 2019 for the purpose of preparation of the SoED 2019. The update is consistent with the Data Standards (DSs) and Data Dictionaries (DDs) of the IMAP (Pilot) Info System developed by INFO/RAC with the overall coordination of the Secretariat.

2. The updated IMAP Guidance Factsheets for Common Indicators 13, 14, 17, 18, 20 and 21 were considered and welcomed by the Meetings of CorMon on Pollution Monitoring and MED POL Focal Points. They are provided in Annex I of this document.

3. In line with Decision IG.22/7, the Secretariat and ACCOBAMS prepared a proposal of the Guidance Factsheets for Common Indicators 26 and 27 of Ecological Objective 11 that was considered and welcomed by the Meetings of CorMon on Pollution Monitoring and MED POL Focal Points. It is presented in the following section.

2. THE GUIDANCE FACTSHEET FOR THE CANDIDATE INDICATOR 26

4.. The Guidance Factsheet for **Common Indicator 26 (EO11): "**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" is presented in the following tabular form.

Indicator Title	Common indicator 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 animals	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Noise from human activities causes no significant impact on marine and coastal ecosystems.	Energy inputs into the marine environment, especially noise from human activities, are minimized	Number of days with impulsive sounds sources, their distribution within the year and spatially within the assessment area, are below thresholds
Rational		
Justification for indicator selection Anthropogenic energy introduced by human activities into the marine environment includes sound, light and other electromagnetic fields, heat and radioactive energy. The most widespread and pervasive is underwater sound (Dekeling et al., 2013a). Sound energy input can occur at varying spatial and temporal scales. Anthropogenic sounds may be of short duration (i.e. impulsive) or be long lasting (i.e. continuous). Lower frequency sounds can be transmitted far (tens to thousands of kilometres), whereas higher frequency sounds transmit less well in the marine environment (hundreds of meters to few kilometres (Urick, 1996). Most common sources of marine noise pollution include ship traffic, geophysical exploration and oil and gas exploitation, military sonar use and underwater detonations, telemetry devices and acoustic modems, scientific research involving the use of active acoustic sources, and offshore and inshore industrial construction works. Such activities are growing throughout the Mediterranean Sea (e.g. DeMicco; OWEMES, 2012; US Energy Information administration, 2013). Marine organisms can be adversely affected both on short and long timescales (and include acute or chronic impact and temporary or permanent effects (Richardson et al, 1995). Adverse effects can be subtle (e.g. temporary reduction in hearing sensitivity, stress effects causing reduced immunity, reproduction success or survival), or more obvious (e.g. injury, death). The former may be difficult to observe and evaluate while the latter may in some circumstances be related to acute short-range noise exposures. Concerning noise source-specific impact, it has been demonstrated that naval exercises involving the use of mid-frequency active sonars		

caused several mass stranding events of Cuvier's beaked whales along the coasts of the Mediterranean Sea and in other sea areas at least during the last 20 years (e.g. Frantzis, 1998; Fernandez et al., 2004; Martin et al., 2004; Agardy et al., 2007; Filadelfo et al., 2009). Further, this correlation is suspected also for the case of geophysical surveys (e.g. Southall et al., 2013; Castellote and Llorens 2013), although definite results are not available yet. Further, displacement and/or acoustic behavioural disruption may occur for Mediterranean fin whales in response to low frequency impulsive noise at very long ranges, reaching more than 200 km (Borsani et al., 2008; Castellote et al., 2012). Finally, sperm whales and beaked whales have been identified to be highly sensitive to mid-frequency impulsive sounds (e.g. Aguilar de Soto et al., 2006; Weir, 2008).

Management concern is primarily associated to the negative effects of noise on sensitive protected species, such as some species of marine mammals.

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Policy Context and targets

Policy context description

Generalities:

In the marine environment, the term pollution is defined in several legal frameworks by the following statement: "the introduction by man, directly or indirectly, of substances or energy into the marine environment […]". This definition includes anthropogenic noise as a form energy caused by human activities. As such, underwater noise pollution is addressed by Regional Seas Conventions, where the following initiatives are considered the most relevant for the management of activities generating noise, and the mitigation of their adverse effects on the marine environment:

- For the Barcelona Convention, the Ecosystem Approach process (EcAp), started in 2008;
- For the OSPAR and HELCOM Conventions, the adoption for their respective monitoring and assessment processes of the indicators related to underwater noise as proposed in the framework of the MSFD (2011 and 2012).

In parallel, the European Union adopted the same definition of pollution given in the paragraph above in the text of the Marine Strategy Framework Directive (MSFD, 2008/56/EC, adopted in 2008). The MSFD gave a considerable impulse to the undertaking of actions, programs, measures, as well as scientific research to cover the knowledge gaps on underwater noise, and hence develop appropriate guidance on the management of man-made noise in the marine environment.
With regards to the MSFD, underwater noise is addressed by Descriptor 11, and two criteria were selected for monitoring and assessment purposes, one addressing loud impulsive signals produced by several coastal and offshore works (pile driving, explosions, seismic pulses, etc.), the other targeting the contribution of anthropogenic sources, especially shipping, to ambient noise levels. Since the adoption of the MSFD (2008), the European Commission issued two Decisions addressing methodological standards for the monitoring and assessment of underwater noise: Commission Decision 2010/477/EU on criteria and methodological standards on good environmental status of marine waters, and Commission Decision 2017/848/EU 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.

Concerning the EcAp process, among the eleven Ecological Objectives (EOs), and respective operational objectives and indicators agreed through Decision 20/4 (17th Meeting of Contracting Parties, COP 17), EO11 addresses underwater noise produced by human activities. However, during the COP 18 (Istanbul, 2013), Decision 21/3 provided a specific list of descriptions of good environmental status and targets for the other EOs, contrary to EO11, considered not yet sufficiently understood to allow a proper definition of good environmental status. Therefore, in 2014-2015 ACCOBAMS in cooperation with the UNEP/MAP Secretariat developed the "Basin-wide Strategy for underwater noise monitoring in the Mediterranean" thanks to its working group on noise (Joint ASCOBANS/ACCOBAMS/CMS Noise Working Group).This strategy proposed to address two types of noise for the monitoring and assessment purposes, as for the MSFD process: loud impulsive signals produced by several coastal and offshore works (pile driving, explosions, seismic pulses, etc.), and the contribution of anthropogenic sources, especially shipping, to ambient noise levels. The strategy was included in the Integrated Monitoring and Assessment Programme (IMAP) during the CORMON Meeting in Athens (March 30 – April 01, 2015), which was finally adopted by Parties during the COP19.Finally, during the COP19, ACCOBAMS and the UNEP/MAP signed an MoU covering the issue of underwater noise.

Several other legal frameworks have addressed anthropogenic underwater noise and its impact on the marine environment and wildlife: The International Whaling Commission (IWC), the Convention on Biological Diversity (CBD), the Convention on Migratory Species (CMS), ACCOBAMS and ASCOBANS, as well as the European Parliament, and more. Almost all the initiatives undertaken by such legal frameworks deal with the impact of noise on some environmental element (usually sensitive marine fauna such as cetaceans and fish, turtles, crustaceans, etc.), while in the MSFD and EcAp processes emphasis is put on the human activities generating noise. This is likely due to the fact that managing human activities in the sea is theoretically easier than managing impact. However, the effectiveness of such an approach rely on a good understanding of the relationship between noise and impact, which is very often not the case.

With specific regards to impulsive noise:

In EU Member States, human activities producing loud impulsive signals into the marine environment are managed nationally through licensing systems, and the consideration of the impact of noise in such management processes is especially due to the European Directive on the Environmental Impact Assessment (EIA Directive). However, the EIA Directive is "project-bases", contrarily to the MSFD and EcAp, which are "ecosystem-based". The main difference between project-based and ecosytem-based approach is that in the case of an EIA, the project developer (e.g. an industry) is responsible for assessing and mitigating the impact of its own activities, while in the case of the EcAp and MSFD processes, country's governments are responsible for the achievement and/or maintenance t of the good environmental status, which include addressing and managing the potential adverse impact of all pressures in the marine environment.

The transposition in national legislation of the EIA Directive resulted in different national management systems. For instance, in the UK a standard mitigation framework applies to a list of well-defined activities; in Germany, impulsive sound signals are allowed as far as they do not exceed legal thresholds (a certain received noise level at 750 m from the source); in Italy the project developer need to implement 60 days monitoring before and after the activity to understand whether or not the activity caused any impact.

Again, while the EIA Directive gave considerable results in managing the impact of single activities introducing noise into the sea, a framework addressing the ecosystem scale has been in need of development in the past decade. This Factsheet addressed exactly this point and provides elements for the implementation of the ecosystem approach to the management of activities producing impulsive noise.

Targets

The primary activity under common indicator 26 should be the setting up by countries of a database ("a noise register[1]") for the registration of "noise events", where a noise event is the occurrence of loud impulsive signals (in low and mid frequency bands) on a given day and in a given place. Once the register is built, it is possible to obtain an overview of the spatial and temporal distribution of noise-producing activities, as well as set the specific thresholds to achieve defined targets. During the QUIETMED project (DG ENV/MSFD Second Cycle/2016) an interim list was drawn of possible targets addressing especially regulatory and management aspects of underwater noise. Possible target shall deal indeed with (not exhaustive list): increasing the number of mitigation measures applied to activities potentially causing impact, decreasing the number of activities generating loud noise in habitats of sensitive cetacean species, applying time-space closures (set on biological and ecological bases) to the occurrence of activities with the highest potential of causing impact to mention few.

Policy documents

Report of the following Meetings: COP17-18-19

- http://www.unepmap.org/index.php?module=events&action=detail&id=65

- http://rac-spa.org/nfp12/documents/reference/13ig21_9_eng.pdf

- http://195.97.36.231/dbases/MEETING_DOCUMENTS/12IG20_8_Eng.pdf

Reports of the 4th and 5thEcAp Coordination Unit meeting:
http://195.97.36.231/dbases/MEETING_DOCUMENTS/14WG401_8_ENG.pdf
Report of the Meeting of the CORMONs, Athens 30 March – 01 April 2015

Report of the Meeting of MED POL and joint-session MED POL/REMPEC, Malta 16-19, June 2015.
http://195.97.36.231/dbases/MEETING_DOCUMENTS/15WG417_17_ENG.pdf

[1] See for example: http://underwaternoise.ices.dk/map.aspx ; http://accobams.noiseregister.org/

DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCILof 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (2010/477/EU) Commission Decision 2017/848/EU of 17 May 2017 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) Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment; and successive amendments in 1997 (97/11/EC), 2003 (2003/35/EC), and 2009 (2009/31/EC). This Directive was repealed and replaced by the following: Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment; also amended in 2014 (2014/52/EU).
Indicator analysis methods
Indicator Definition The indicator is defined by the number of days with impulsive sound sources in an assessment area and over a defined period. Such areas may be the cells of a spatial grid, or larger scale areas such as the subdivision, sub regional and regional scales. Not all impulsive noise sources are to be accounted for, only those exceeding thresholds considered as having a significant impact on populations of sensitive wildlife. The impact is considered significant when severe displacement of animals from their habitats occurs due to noise. Thresholds for the onset of significant impact are defined in the “Basin-wide Strategy for underwater noise monitoring in the Mediterranean” (ACCOBAMS, 2015).
Methodology for indicator calculation The calculation is given by the sum of all days where noise events occurs over a defined period (one year or temporal window such as month or trimester), and for an assessment unit. As described above, a noise event is the occurrence of loud impulsive signals (in low and mid frequency bands) on a given day and in a given place. A spatial grid with a regular cell size is proposed to compute the number of days with impulsive sound sources. The calculation is done for each grid cell using common GIS software or more sophisticated web applications. Also, the calculation may be done in assessment areas as a whole: sub-regions, the whole region, or subdivisions decided at the country level. The “Basin-wide Strategy for underwater noise monitoring in the Mediterranean” (ACCOBAMS, 2015) proposed to use a 20x20 km spatial grid. However, recent developments (especially thanks to the QUIETMED project) led to propose different options, including: the spatial grid already used by the General Fisheries Commission for the Mediterranean (GFCM statistical rectangles), which is has a dimension of 30 min in latitude and longitude, or the adoption for all noise sources of spatial grids already used by countries to manage human activities nationally (e.g. Oil&Gas licenced areas).
Indicator units The indicator unit is called ***pulse-block days*** (PBDs), meaning the number of days of occurrence of impulsive noise events in an area (block), in a given period.
List of Guidance documents and protocols available ACCOBAMS, 2015. A basin-wide strategy for underwater noise monitoring in the Mediterranean. Report prepared by Alessio Maglio, Manuel Castellote and Gianni Pavan. Dekeling, R.P.A., Tasker, M.L., Van der Graaf, A.J., Ainslie, M.A, Andersson, M.H., André, M., Borsani, J.F., Brensing, K., Castellote, M., Cronin, D., Dalen, J., Folegot, T., Leaper, R., Pajala, J., Redman, P., Robinson, S.P., Sigray, P., Sutton, G., Thomsen, F., Werner, S., Wittekind, D., Young, J.V., 2014. Monitoring Guidance

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Recommendations to Member States to set up the national registers of impulsive noise according to criterion D11C1 of the Commission Decision 2017/848/EU and ACCOBAMS premises, and generalisation for the EcAp process. Deliverable 3.4, QUIETMED project. DG ENV/MSFD Second Cycle/2016.

Data Confidence and uncertainties

Data confidence is expected to be high due to the simplicity of the data themselves. To meet minimum objectives of monitoring Common Indicator 26, only the location (geographical coordinates or area), the period (dates) and intensity of noise sources used are necessary. All such information, including the intensity of the noise source, should be obtained from declarative data, i.e. it is not necessary to measure the real noise level with any equipment, or to carry out fieldwork to locate noise-producing activities.

Declarative data can be sought in the national institutes already centralising data on marine activities (e.g. institutions managing Oli & Gas licensing procedures; or environmental impact assessment procedures; etc.). This system, on the one hand result in very low costs for obtaining data, while in the other hand add some uncertainty.

Uncertainty is mainly due to the fact that declarative data maybe not available (e.g. sensitive data such as data on military activities), not well specified or with important gaps, or not completely suitable for impulsive noise monitoring as described in this Factsheet. There is little chance that no data be available at all, or with important gaps, concerning the position and the period of marine activities, while this may be the case concerning information on the intensity of noise sources. Therefore, this fact may be overcome by setting conservative thresholds for up taking marine activities in the noise register.

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

Monitoring Methodology: A register of the use of noise sources is the necessary tool enabling a monitoring programme. The register is a database fed with data on the use of underwater noise sources (noise events).

Tools for monitoring impulsive noise sources (i.e. tool for setting the noise register): the joint use of a spreadsheet (MS Excel or similar) and common GIS software is considered as the recommendation to meet the minimum requirements of Common Indicator 26, where the spreadsheet is used to record noise events, and the GIS software to perform spatial analysis of these areas (e.g. to compute the number of pulse-block days).

What noise sources should be registered:

- **Pile driving**. Pile driving is a conventional technique employed in many coastal and offshore constructions, such as wind farms, offshore platforms, harbour extensions etc. The growth of the wind energy sector caused a great increase in the use of this technique both in coastal and offshore environments.
- **Airgun**. The airgun is presently the most employed technology for carrying out marine seismic exploration. Such surveys are pervasive worldwide, in shallow and deep water as well as in coastal or offshore environments
- **Explosives**. Underwater detonations may occur for the disposal of explosives or may be planned during maritime construction, e.g. to fragment rock prior to dredging. This is the loudest source of underwater noise and need to be treated with particular care.
- **Sonar**. Low-, mid- and high frequency active sonars (LFAS, MFAS, HFAS) are employed during military exercises as well as during academic and industrial surveys, such as fish stock estimations and bathymetric surveys. Especially, low- and mid- frequency naval sonars are of great concern given the mass stranding events of cetaceans linked in space and time with military exercises and need to be addressed with particular care.
- **Acoustic Deterrents**. High-powered devices designed to keep marine mammals away from fish farms by causing them pain. Frequencies range from 5-20KHz for repelling pinipeds and 30-160KHz for delphinids (Carretta et al, 2008, Lepper et al, 2004, Lurton, 2010, OSPAR, 2009).

What information to collect to enter into the register:

Data	Units and/or comments	Priority
Position	geographic position (lat/long) or pre-defined block/area which can be identified through a coding system (single identifier for each block used)	Required
Dates	Start and end day	Required
Source intensity	Source level or proxy, unique levels or in bins (see Annex 5.3 for corresponding tables of values in bins)	Required
Source spectra	Frequency range	Additional
Duty cycle		Additional
Duration of transmission	Actual time/time period	Additional
Directivity		Additional
Source depth		Additional
Platform speed	For moving sources like seismic surveys	Additional

Minimum thresholds (Source intensity) for including a noise event in the register:

- For low frequency sources: no thresholds, i.e. all sources to be registered
- For mid-frequency sources, table hereafter:

Noise source type	Thresholds for inclusion of noise events in the register
Explosive	mTNTeq> 8 g
Airgun	SLz-p > 209 dB re 1 µPa m
Low/mid freq sonar	176 dB re 1 µPa m
Low/mid freq acoustic deterrent	176 dB re 1 µPa m
Other pulse	186 dB re 1 µPa² m² s

Again, **there is no need to measure on the field** and data are to be sought in institutions centralising data (Ministries, national regulatory bodies, etc.).

Monitoring Protocol: Data on the use of impulsive noise sources (location, period, and intensity at least) are entered in the register on a regular basis (once, twice or more times per year). This is done by a selected contact person in each country.

Available data sources

ACCOBAMS Noise Register (currently developed but not yet operational, expected to be on-line in 2019).

National data repositories available for some countries for specific activities (e.g. licensing areas for seismic exploration). Some examples:
http://www.minetur.gob.es
http://www.ifremer.fr/sismer
http://bo.ismar.cnr.it
http://unmig.mise.gov.it/;
http://unmig.sviluppoeconomico.gov.it
http://energy.gov.il
http://www.sigetap.tn
http://www.ypeka.gr
http://www.beph.net

Further data repositories are open data platform developed by different organisations, where the most relevant appear to be the following: EmodNet (EU funded platform). From EmodNet it is possible to access data gates for marine activities, including marine renewable energy plants, platforms, cables and others.

For military activities, as a first approach, the *notice to mariners*[2] can be monitored to gather information on possible military activities. Notice to mariners are indeed freely available information for navigation.
Spatial scope guidance and selection of monitoring stations No monitoring stations needed, only declarative data are required to fill up the noise register. Concerning the spatial scope at large: the monitoring methodology is based on the use of a regular spatial grid to compute pulse-block days. In this sense, a block is a unit of area of a spatial management system, for example a cell of the regular spatial grid. If a noise event lasts several days in the same block (ca. area), the pulse-block day is equal to the number of days of duration of that noise event. Based on the calculation of PBDs, it is possible to derive other quantities such as: - the extent in km², or the proportion (%) of the assessed area, with impulsive sound sources. Here a country may decide to apply a minimum number of PBDs to account an area (e.g. a grid cell or blocks) in the calculation of the extent or proportion. Example: A conservative choice (ca. risk prevention) would be the proportion (% of grid cells) of the assessed area (total number of grid cell) with at least 1 PBDs.
Temporal Scope guidance Data on noise events can be entered in the register by the responsible institution several times in a year, for example whenever data become available. Based on the calculation of pulse-block days, it is possible to derive time-based quantities such as: - the number of PBDs calculated monthly, quarterly, and/or yearly; - the % of days over a time window with impulsive sound sources (noise events). Here again, a country may decide to apply a minimum # of PBDs to account an area (e.g. a grid cell) in the calculation of the extent or proportion. A conservative version of this indicator would be the following: the proportion (% of days) with at least 1 PBDs in the assessed time window (e.g. 1 month) and area (e.g. a subregion).
Data analysis and assessment outputs
Statistical analysis and basis for aggregation Basic descriptive statistics are needed to compute the indicator: - the number of pulse-block days over a time window; - the % of an assessment area with impulsive sound sources. Further statistics are the trend analysis that maybe applied on different aggregated periods, for example: year to year; summer to summer, month of year N to month of year N+1 (and N+3, …) or others. From a regional and sub regional perspective, once the noise register is established by a all countries, such data may be transferred to the ACCOBAMS Nosie Register. This is proposed as the basis for regional and sub regional aggregation of data which can feed regional assessment (QSR) as well as supporting countries in reporting to EcAp EO11.
Expected assessments outputs The assessment outputs are the following: - GIS maps showing the spatial and temporal distribution of noise sources over a year, or calculated monthly or quarterly; the value associated to each grid cell (block) in such maps is the total number of *pulse-block days* for a month, a quarter, or a year; - Noise source coverage values: number of grid cells and % of the total cell number, or extent in km²with number of *pulse-block days*> 0; - Trend analysis is possible across aggregated time periods (year, seasons, months, etc.).
Known gaps and uncertainties in the Mediterranean

[2] Notice to mariners are information issued by country's military authorities. Such notices inform on sailing in a given area about the occurrence of some military exercise or other activity that may be dangerous for boats sailing in the area. For example, notice to mariners may be used for collecting data about military activities to be included in the noise register

As a relatively new Common Indicator within the context of marine environmental protection policy, its applicability beyond usual management of marine activities needs to be determined. The main uncertainties lie in the availability of declarative data (location, period and intensity of noise sources), although experience from the implementation of the MSFD in the last 10 years are encouraging.

Another important issue is the perception that underwater acoustics is too complex and noise monitoring generally too expensive. However, if this might be true if we talk about the science of acoustics (the physics of sound, the engineering behind the hydrophones and recording systems, in-situ recordings, software for analysing measurements, etc.), this Common Indicator was conceived to cut out most of this complexity, and this not only simplifies extremely the way of monitoring, but also minimizes the costs of implementation. Therefore, an emphasis should be put on correctly disseminating the information on how this indicator is built.

Contacts and version Date

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Version No	Date	Author
V.1	10/07/2016	ACCOBAMS
V.2	25/01/2019	ACCOBAMS in consultations with UN Environment/MAP
V3~~Final version~~	31/05/2019	Approved by the Meeting of MED POL FPs
Final version	09/09/2019	Approved by the 7th Meeting of EcAp Coordination Group

3. THE GUIDANCE FACTSHEET FOR THE CANDIDATE INDICATOR 27

5. The Guidance Factsheet for **Common Indicator 27 (EO11): "**Levels of continuous low frequency sound with the use of models as appropriate" is presented in the following tabular form.

Indicator Title	Common Indicator 27. Levels of continuous low frequency sound with the use of models as appropriate	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Noise from human activities causes no significant impact on marine and coastal ecosystems.	Energy inputs into the marine environment, especially noise from human activities, are minimized	Noise levels at monitoring stations are below thresholds; The extent (% or km²) of the assessment area which is above levels causing disturbance to sensitive marine animal is below limits, or such limits are exceeded for a limited amount of time

Rational

Justification for indicator selector

Anthropogenic energy introduced by human activities into the marine environment includes sources of sound, light, heat and others among the electromagnetic field spectrum. The most widespread and pervasive is underwater sound (Dekeling et al., 2013a). Sound energy input can occur at varying spatial and temporal scales. Anthropogenic sounds may be of short duration (i.e. impulsive) or be long lasting (i.e. continuous). Lower frequency sounds can be transmitted far (tens to thousands of kilometres), whereas higher frequency sounds transmit less well in the marine environment (hundreds of meters to few kilometres (Urick, 1996). Most common sources of marine noise pollution include ship traffic, geophysical exploration and oil and gas exploitation, military sonar use and underwater detonations, telemetry devices and acoustic modems, scientific research involving the use of active acoustic sources, and offshore and inshore industrial construction works. Such activities are growing throughout the Mediterranean Sea (e.g. DeMicco; OWEMES, 2012; US Energy Information administration, 2013).

Marine organisms can be adversely affected both on short and long timescales and include acute or chronic impact and temporary or permanent effects (Richardson et al, 1995). Adverse effects can be subtle (e.g. temporary reduction in hearing sensitivity, stress effects causing reduced immunity, reproduction success or survival), or more obvious (e.g. injury, death). The former may be difficult to observe and evaluate while the latter may in some circumstances be related to acute short-range noise exposures.

This indicator addresses, particularly, the continuous (ca. chronic) low-frequency sound produced by marine activities. The major contributor to this type of ambient ocean noise is produced by maritime traffic. For this reason, it has been pointed as an important factor potentially reducing the acoustic space of marine animals, and particularly cetaceans which are known to communicate over very long ranges through acoustic signals. Many studies also shown negative effects on fish. The potential masking of biological signal due to ship noise is considered indeed as a big issue risk as it may be the cause of many other indirect impacts, such as reduced reproduction, reduced foraging success, and hence a long term degradation of the survival rate of populations(e.g. Blair et al. 2016; Tennessen & Parks 2015; Putland et al. 2017; Aguilar de Soto et al. 2006; Pirotta et al. 2012; Wysocki et al. 2006)

Scientific References

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Indicator Title	Common Indicator 27. Levels of continuous low frequency sound with the use of models as appropriate

Guidance for Underwater Noise in European Seas, Part I: Executive Summary, JRC Scientific and Policy Report EUR 26557 EN, Publications Office of the European Union, Luxembourg, 2014, doi: 10.2788/29293

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Policy Context and targets

Policy context description

Shipping activities are regulated by the IMO, the United Nations agency with responsibility for many aspects of shipping, including safety, maritime security, environmental concerns, legal and technical matters and efficiency. IMO is the source of several legal instruments, and among these the MARPOL Convention was signed with the aim of minimising pollution in oceans and seas. MARPOL includes 6 Annexes, each one addressing a category of pollution produced by ships: oil emissions, noxious liquids, packaged harmful substances, sewage, garbage, air pollution. Unfortunately, MARPOL defines pollution as substance, not energy, contrary to many other regulation bodies including other UN-related bodies such as the UN Convention on the Law of the Sea (UNCLOS). Underwater noise is therefore not addressed by MARPOL. However, in recent years the Marine Environment Protection Committee (MEPC) of the IMO addressed underwater noise produced by shipping. As a result, guidelines were issues on the reduction of noise emission from ships. (IMO 2014; IMO 2013b; IMO 2013a). However, it is worth noting that such guidelines address noise radiated from single ships and the way to mitigate the emissions, while the general rising in ambient ocean noise due to increased shipping (i.e. an ecosystem approach) is not addressed.

Given the lack of global regulation of ship radiated noise, the MSFD and EcAp processes provide the first legal instrument for monitoring, assessing and setting targets, at least for their competence areas (the European Union and the Mediterranean region, respectively). All the policy document developed in the framework of such initiatives are therefore a novelty concerning the regulation of emissions of pollutant related to shipping. A closer cooperation with such global regulatory bodies as the IMO and MARPOL is certainly a major asset for the success of initiatives aimed at reducing ship radiated noise, the associated impacts, and therefore deliver good environmental status.

Beyond large scale regulation, many interesting initiatives are being proposed to strengthen the implementation of mitigation measures applied to shipping at a local scale. For example, some ports authorities are setting specific rules to foster ships complying with increasingly high environmental standards, including low noise emissions through reduced speed or displacement of ship lanes. One of the most known

Indicator Title	Common Indicator 27. Levels of continuous low frequency sound with the use of models as appropriate
initiatives appears to be the port authority of Vancouver. Of course, the sum and synergy of increasing numbers of local initiatives has the potential to create a network big enough to produce positive effects at the ecosystem scale.	
Targets The early proposition contained in MSFD-related document was to adopt a decreasing trend in average noise levels. However, this appeared hard to implement as a trend could takes decades to be detected by robust statistical analysis, while actions may be taken already today to reduce noise radiated from ships, the contribution of shipping to marine noise, and finally the adverse effects on marine wildlife. An interim list of targets was developed in the framework of the QUIETMED project, subject to further discussion and validation, or adjustments. This list includes operational and environmental targets. The difference between such two types of targets are that operational targets address actions that can be already implemented and for which we are confident that this will help moving towards (or maintaining) GES. On the other hand, environmental targets rather describe the sought characteristics of the environment with respect to the pressure factor (continuous noise from shipping in the case of Common Indicator 27). Therefore, environmental targets are more related to the units of measurements of the indicator (noise levels, spatial extents, etc.). Operational and environmental targets included in QUIETMED Deliverable 2.3 are the following: (operational) promoting the adoption of IMO guidelines on the reduction of ship radiated noise, and promoting other initiatives aimed fostering the emergence of low-noise ships (e.g. labelling, promoting the role of harbour authorities in regulating noise from ships, etc.); (environmental) threshold levels not exceeded > XX days/year; or (environmental) area with levels exceeding thresholds does not exceed XX% of the assessment area.	
Policy documents IMO, 2014. GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE FROM COMMERCIAL SHIPPING TO ADDRESS ADVERSE IMPACTS ON MARINE LIFE. 44(April). IMO, 2013a. Noise from commercial shipping and its adverse impacts on marine life.66(March). IMO, 2013b. PROVISIONS FOR REDUCTION OF NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE. International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78). Report of the following Meetings: COP17-18-19: – http://www.unepmap.org/index.php?module=events&action=detail&id=65 – http://rac-spa.org/nfp12/documents/reference/13ig21_9_eng.pdf – http://195.97.36.231/dbases/MEETING_DOCUMENTS/12IG20_8_Eng.pdf – Reports of the 4th and 5thEcAp Coordination Unit meeting – http://195.97.36.231/dbases/MEETING_DOCUMENTS/14WG401_8_ENG.pdf – Report of the Meeting of the CORMONs, Athens 30 March – 01 April 2015 – Report of the Meeting of MED POL and joint-session MED POL/REMPEC, Malta 16-19, June 2015. – http://195.97.36.231/dbases/MEETING_DOCUMENTS/15WG417_17_ENG.pdf DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (2010/477/EU). Commission Decision 2017/848/EU of 17 May 2017 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)	
Indicator analysis methods	
Indicator Definition	

Indicator Title	Common Indicator 27. Levels of continuous low frequency sound with the use of models as appropriate

Exceedance level was thought to detect such phenomenon, as an additional indicator for GES assessment.

Annual average of sound pressure level (SPL) and 33% Exceedance Level in selected frequency bands (third-octave bands centred at 20, 63, 125, 250, 500, 2000), where:

- SPL means Sound Pressure Level in dB (re 1μPa
- The term “Exceedance Level” is defined by the international standard ISO 1996-1:2003(E) as the level exceeded during 33% of the analysed time window

Average SPL gives an overview of average noise conditions in the assessed time window (1 year); while the 33% Exceedance Level provides a view of the highest noise levels for about one third of a year, corresponding to roughly 4 months. The use of 33% Exceedance Level is based on the assumption that in the Mediterranean Sea marine traffic noise increases substantially in the Summer season (June to September) mainly due to leisure craft, but also to increased numbers of navigating ships due to better weather conditions. The 33% Exceedance level was thought to detect such phenomenon, as an additional indicator for GES assessment.

Concerning frequencies, they were chosen as follows:

- 20Hz, based on fin whale biological significance. 20 Hz is indeed the peak frequency of the vocalizations of fin whales and monitoring the 1/3 octave band centred at this frequency may help assessing the masking effect from anthropogenic noise sources
- 63 Hz, based on the frequency bands where noise from shipping is most likely to dominate over other sources (consistent with MSFD ambient noise criterion)
- 125 Hz, based on frequency bands where noise from shipping is most likely to dominate over other sources (consistent with MSFD ambient noise criterion)
- 250 Hz, based on frequency bands where noise from shipping is most likely to dominate over other sources according to Mediterranean data (e.g. Pulvirenti et al. 2014)
- 500 Hz, based on frequency bands where noise from shipping is most likely to dominate over other sources according to Mediterranean data (e.g. Pulvirenti et al. 2014)
- 2000 Hz, based sperm whale biological significance. Although sperm whale click peak frequency has been identified in 5000 Hz (Madsen et al., 2002; Watkins et al. 1980), its lower peak frequency limit has been defined in 2000 Hz. It seems more relevant to use the lower peak frequency limit because it is more likely to be affected by anthropogenic noise and it requires lower sampling rates to be recorded, reducing the cost of monitoring equipment and data archiving volume.

Methodology for indicator calculation

The calculation of the indicator requires to perform the following tasks:

- Analysing recordings from deployed acoustic equipment and computing graphs of sound levels against time, sound levels against frequency, or similar;
- Modelling the propagation of noise from continuous sources (ships) for estimating levels at large scales and for mapping the indicators in the assessment areas.

The metrics to employ are the following:

- Average Sound Pressure Level (arithmetic mean) over a year, calculated either from SPL samples obtained from the field or from a modelling process;
- 33% Exceedance level over a year, meaning the level corresponding to the 77th percentile of the distribution of SPL values obtained either from the fields or from a modelling process.

In practice, two simple statistics should be calculated: the arithmetic mean, and the 77th percentile. In the case of recordings, the samples to be used for statistical analysis are short cuts of sound recordings of fixed duration, where the number and duration of each sample is to be determined. Guidance for MSFD-Ambient Noise criterion says samples should not exceed 1 minute. For models, different approaches exist to obtain the required statistics: temporal approaches and probabilistic approaches. Regardless of the approach used for models, if any, it is recommended to consider available guidance on the use of models, such as: *Impacts of noise and use of propagation models to predict the recipient side of noise*(Borsani et al. 2015); *Review of underwater acoustic propagation models* (Wang et al. 2014); and the guidelines on noise modelling and mapping developed in the framework of the QUIETMED project (Deliverable 3.3), where practical

Indicator Title	Common Indicator 27. Levels of continuous low frequency sound with the use of models as appropriate
implementation in a Mediterranean context is described.	
Indicator units Sound Pressure Levels expressed in **dB re 1µPa**	
List of Guidance documents and protocols available Dekeling, R.P.A., Tasker, M.L., Van der Graaf, A.J., Ainslie, M.A, Andersson, M.H., André, M., Borsani, J.F., Brensing, K., Castellote, M., Cronin, D., Dalen, J., Folegot, T., Leaper, R., Pajala, J., Redman, P., Robinson, S.P., Sigray, P., Sutton, G., Thomsen, F., Werner, S., Wittekind, D., Young, J.V., 2014. Monitoring Guidance for Underwater Noise in European Seas, Part I: Executive Summary, JRC Scientific and Policy Report EUR 26557 EN, Publications Office of the European Union, Luxembourg, 2014, doi: 10.2788/29293. Best practice guidelines on acoustic modelling and mapping. 2017/848/EU and ACCOBAMS premises, and generalisation for the EcAp process. Deliverable 3.3, QUIETMED project. DG ENV/MSFD Second Cycle/2016. Best practices guidelines on signal processing algorithms for the preprocessing of the data and for obtaining the noise indicator. Deliverable 3.2, QUIETMED project. DG ENV/MSFD Second Cycle/2016. ACCOBAMS, 2015. A basin-wide strategy for underwater noise monitoring in the Mediterranean. Report prepared by Alessio Maglio, Manuel Castellote and Gianni Pavan. Borsani, J.F., Faulkner, R.C. & Merchant, N.D., 2015. Impacts of noise and use of propagation models to predict the recipient side of noise. Report prepared under contract ENV.D.2/FRA/2012/0025 for the European Commission. Centre for Environment, Fisheries & Aquaculture Science, UK. , (July), p.27. Available at: http://mcc.jrc.ec.europa.eu/document.py?code=201601081529. Verfuß, U.K., Andersson, M., Folegot, T., Laanearu, J., Matuschek, R., Pajala, J., Sigray, P., Tegowski, J., Tougaard, J. BIAS Standards for noise measurements. Background information, Guidelines and Quality Assurance. Amended version. 2015. Wang, L.S. et al., 2014. Review of underwater acoustic propagation models (April 2016), p.35.	
Data Confidence and uncertainties Many sources of uncertainty exist concerning both measurements and models: the characteristics of the sound recorder used, the calibration, the mooring conditions and on the location of deployment (near or far from shipping lanes, in shadow areas, etc.), as well as many steps and settings of the data processing. Also, modelling methods contemplate a large number of variability factors often hindering meaningful comparisons among different monitoring programs. Such uncertainty results in well-known shortcomings in the understanding of how anthropogenic noise may affect the environment. However, despite these sources of uncertainty, many steps forward have been done since the beginning of the implementation of the EcAp process, and considerable effort was done to develop guidance and best practices. Many of these efforts were focussed in northern European waters and the North Atlantic, but recent QUIETMED project produced valuable work in the direction of laying down common methods and shared understanding of the several technical aspects.	
Methodology for monitoring, temporal and spatial scope	
Available Methodologies for Monitoring and Monitoring Protocols <u>General monitoring methodology</u>: the combined use of measurements and modelling is recommended. Continuous sound recording should be done at fixed sites through sound recording stations. Acoustic modelling and mapping through appropriate analytical procedures producing estimations to be validated from field measures. The use of in-situ acoustic measurements is essential for: - Gathering fundamental field data to establish information on the ambient noise in a given location - Reducing uncertainty on source levels to be used as the input for modelling; - Increasing evidence base to improve management decisions.	

Indicator Title	Common Indicator 27. Levels of continuous low frequency sound with the use of models as appropriate

The use of models is essential for:

- Reducing the time required to establish a trend (the expected trend in shipping noise, based on observations in deep water, is of the order of 0.1 dB/year; and therefore, it takes many years, possibly decades, to reveal such small trends without the help of spatial averaging);
- Reducing the number of stations required to establish a trend over a fixed amount of time (similar reasoning to above), therefore reducing the cost of monitoring;
- Helping with the choice of monitoring positions and equipment (selecting locations where the shipping noise is dominant as opposed to explosions or seismic surveys being dominant);
- Producing noise maps, which are a valuable tool to quickly understand the ensonification levels over large areas, and a fundamental tool to calculate the extent of potentially impacted (non-GES) areas;
- Predicting future scenarios and therefore testing different noise reduction strategies, e.g. by answering simple questions such as what happens if we reduce by XX dB the noise of 1% (or 20% etc.) of the circulating ships? Will this be a significant reduction?

Monitoring Protocol: recordings are stored in a storage facility (server) during the year. These can be retrieved manually or automatically transmitted through appropriate networks (wi-fi, GPRS, Satellite) from the station to the server. Cabled sound recorders, directly connected to land, can also be used. Fieldwork is limited to deployment and maintenance of sound recorders. Data can be analysed once a year over the whole acoustic dataset obtained or periodically during the year. Models and mapping are computed through appropriate software once a year or with other suitable periodicity.

Contracting Parties within a subregion are recommended to work together to establish an ambient noise monitoring system. When defining such monitoring system, a number of aspects should be addressed (not exhaustive list): measuring equipment quality, calibration, deployment depth, mooring configuration.

Available data sources

It is expected that the European platform EmodNet shall include in the next future a section dedicated to under water noise data made available from monitoring stations placed in waters surrounding the EU (thus with some good coverage of the Mediterranean Sea).

Input environmental data for acoustic modelling (depth, seafloor, temperature and salinity profiles, etc.) are available at many freely available data repositories (EmodNet, Copernicus, NOAA, etc.).

Input ship data (AIS databases) for acoustic modelling (ship positions, speed, vessel type, etc.) can be accessed through AIS networks (marine traffic, AIShub, etc.).

Spatial scope guidance and selection of monitoring stations

Spatial scope: Contracting Parties should consider the whole maritime space under their jurisdiction for locating the acoustic devices, following the guidelines hereafter for selecting the location. Further, noise mapping based on sound propagation modelling provides an effective way of covering the whole maritime space of a country with limited costs.
Location of sampling sites:

- Monitoring in both high traffic and low traffic areas, also searching and including spots where the noise is supposed to be the lowest;
- Monitoring may be more cost effective if existing oceanographic stations included noise monitoring along with the other oceanographic variables already being monitored, such as European Multidisciplinary Seafloor Observation (EMSO) - European Seas Observatory Network of Excellence (ESONET-NoE);
- Consider local topography and bathymetry effects e.g. where there are pronounced coastal landscapes or islands/archipelagos it may be appropriate to place hydrophones on both sides of the feature;
- As far as possible avoid locations close to other sound producing sources that might interfere with measurements e.g. oil and gas exploration or offshore construction activities. Areas of particularly high tidal currents may also affect the quality of the measurement;
- Monitoring station should be primarily located in important cetacean habitat, as identified by ACCOBAMS (Resolution 4.15);

Indicator Title	Common Indicator 27. Levels of continuous low frequency sound with the use of models as appropriate

- Whenever possible use deep monitoring stations, either autonomous or cabled, to limit the influence of surface and sub-surface noise.

Temporal Scope guidance

Monitoring stations should be able to **continuously** record underwater sound. The temporal scheme for the monitoring may vary according to the type of equipment and the logistics for recovering and/or retrieving data. It is desirable that the deployments cover all the year, but there is no recommended retrieval periodicity with regards to moored equipment. Also, real-time equipment (either cabled stations or monitoring stations transmitting data through satellite or other wireless connection) may be used; The main advantages of these systems are the constant availability of data from land and the constant monitoring of the system status, thus resulting in reduced risk of losing data in case of damage of equipment at sea compared to bottom recorders, and optimised maintenance which is done only when required.

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

Appropriate analysis software (usually algorithms developed in some programming language as Matlab) is used to derive simple statistics: the arithmetic means and 33% Exceedance level. Also, a trend analysis is possible. The arithmetic mean was originally proposed by TG-Noise with regards to the implementation of ambient noise monitoring for the MSFD. In TG-Noise guidance (Dekeling et al. 2014) different methods were tested and the result was that compared to the geometric mean, the median and the mode, the arithmetic mean has the following advantages:

- the arithmetic mean includes all sounds, so there is no risk of neglecting important ones;
- the arithmetic mean is independent of sample duration (the duration of the short cut of sound recording).

Even considering the robustness to sample duration, the TG-Noise recommended that the duration of single short cuts of sound recording (the samples for calculation of statistics) should not exceed 1 minute. Despite such detail was not addressed in the noise monitoring strategy developed by ACCOBAMS (2015), it seems consistent adopting this recommendation for the whole Mediterranean Sea.

In addition, ACCOBAMS considers that values in percentile appear very useful to convey information about how much time noise levels are maintained, welcoming the advice from different works on underwater noise monitoring (e.g. Merchant et al., 2013). In this regard, the adoption of the 33% Exceedance Level addresses the potential seasonal rising in ambient noise due to recreational craft, which is suspected to be heavy in many coastal areas of the Mediterranean region.
Finally, aggregation could be done through transboundary cooperation at the sub-regional level.

Expected assessments outputs
The assessment outputs are the following:
- Levels and maps of mean sound pressure level over a year or other suitable temporal windows;
- Levels and maps of 33% exceedance level over a year or other suitable temporal windows;
  Trend analysis across years or other periods (any robust statistical technique able to detect a trend can be used).

Known gaps and uncertainties in the Mediterranean

The Mediterranean presents a majority of deep-water environment whose soundscape has been poorly studied, although some fixed deep monitoring observatories (2 stations of the European Multidisciplinary Seafloor Observation/ European Seas Observatory Network of Excellence -EMSO/ESONET network, respectively 1 in the NW Mediterranean and 1 in the Ionian Sea) provide long term acoustic data since many years. Obviously, many other temporary deployments from the ‘90s to date were done and data are available for reviewing levels, results, and more with a view of establishing baselines. However, common shortcomings (lack of standards for calibration, and the many source of variability highlighted above in this factsheet), may prevent from extracting meaningful information from such review concerning the Common Indicator 27. Further, the poor AIS coverage in some parts of the Mediterranean, especially the southern part, may affect the quality of monitoring through modelling techniques. However, the work done in the last 10 years on underwater noise from an ecosystem perspective enabled a better understanding.

<table>
<tr><td>Indicator Title</td><td colspan="2">Common Indicator 27. Levels of continuous low frequency sound with the use of models as appropriate</td></tr>
<tr><td colspan="3">The Mediterranean present a majority of deep-water environment whose soundscape has been poorly studied, although some fixed deep monitoring observatories (2 stations of the EMSO/ESONET network, 1 in the NW Mediterranean, 1 in the Ionian Sea) provide long term acoustic data since many years. Obviously, many other temporary deployments from the '90s to date were done and data are available for reviewing levels, results, and more with a view of establishing baselines. However, common shortcomings (lack of standards for calibration, and the many source of variability highlighted above in this factsheet), may prevent from extracting meaningful information from such review concerning the Common Indicator 27. Further, the poor AIS coverage in some parts of the Mediterranean, especially the southern part, may affect the quality of monitoring through modelling techniques. However, the work done in the last 10 years on underwater noise from an ecosystem perspective enabled a better understanding, and thus a better management and mitigation, of the different sources of uncertainties.</td></tr>
<tr><td colspan="3">Contacts and version Date</td></tr>
<tr><td colspan="3">Key contacts within ACCOBAMS and UN Environment/MAP for further information
SECRETARIAT PERMANENT DE L'ACCOBAMS
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jelena.knezevic@unep.org
www.unepmap.org</td></tr>
<tr><td>Version No</td><td>Date</td><td>Author</td></tr>
<tr><td>V.1</td><td>10/07/2016</td><td>ACCOBAMS</td></tr>
<tr><td>V.2</td><td>25/01/2019</td><td>ACCOBAMS in consultations with UN Environment/MAP</td></tr>
<tr><td>V.3~~Final version~~</td><td>31/05/2019</td><td>Approved by the Meeting of MED POL FPs</td></tr>
<tr><td>Final version</td><td>09/09/2019</td><td>Approved by the 7th Meeting of EcAp Coordination Group</td></tr>
</table>

Annex I
The amendments of the IMAP Guidance Factsheets for Common Indicators 13, 14, 17, 18, 20 and 21

1. The amendments of the IMAP Guidance Factsheets for Common Indicators 13, 14, 17, 18, 20 and 21

1.1 Common Indicator 13

1. The update for **Common Indicator 13 (EO5)**: Concentration of key nutrients in water column[3,4] is presented in bellow table.

Indicator Title	Common Indicator 13. Concentration of key nutrients in water column (EO5)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Concentrations of nutrients in the euphotic layer are in line with prevailing physiographic, geographic and climate conditions	Human introduction of nutrients in the marine environment is not conducive to eutrophication	1. Reference nutrients concentrations according to the local hydrological, chemical and morphological characteristics of the un-impacted marine region. 2. Decreasing trend of nutrients concentrations in water column of human impacted areas, statistically defined. 3. Reduction of BOD emissions from land-based sources. 4. Reduction of nutrients emissions from land-based sources
Rational		
Justification for indicator selection Eutrophication is a process driven by enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of nutrients causing changes to the balance of organisms; and water quality degradation. The direct and indirect consequences of eutrophication are undesirable when they degrade ecosystem health and/or the sustainable provision of goods and services, such as algal blooms, dissolved oxygen deficiency, declines in sea-grasses, mortality of benthic organisms and/or fish. Although, these changes may also occur due to natural processes, the management concern begins when they are attributed to anthropogenic sources.		
Scientific References i. Brzezinski M.A., 1985. The Si:C:N ratio of marine diatoms: interspecific variability and the effect of some environmental variables. Journal of Phycology, Vo. 21, pp. 347–357. ii. Conley D.J., Schelske C.L., Stoermer E. F., 1993. Modification of the biogeochemical cycle of silica with eutrophication. Mar. Ecol. Prog. Ser. 101, 179-192.		

[3]Note that this builds upon a previous indicator factsheet developed under Horizon 2020. H2020 Indicators Fact Sheets. Regional meeting on PRTR and Pollution indicators, Ankara (Turkey), 16-17 June 2014. (UNEP(DEPI)/MED WG. 399/4)
[4]MSFD Descriptor 5: Human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.

Indicator Title	Common Indicator 13. Concentration of key nutrients in water column (EO5)

iii. Devlin, M., Painting, S., Best, M., 2007. Setting nutrient thresholds to support an ecological assessment based on nutrient enrichment, potential primary production and undesirable disturbance. Mar. Poll., 55., 65-73

iv. Carstensen J., 2007. Statistical principles for ecological status classification of Water Framework Directive monitoring data. Mar. Poll., 55, 3-15.

v. Phillips,G., Kelly M., Leujak W., Salas F., Teixeira H. 2017. Best Practice Guide on establishing nutrient concentrations to support good ecological status. Common Implementation Strategy for the Water Framework Directive and the Floods Directive. 138 pp.

Policy Context and targets

Policy context description

In the Mediterranean, the UNEP/MAP MED POL Monitoring programme included from its inception the study of eutrophication as part of its seven pilot projects approved by the Contracting Parties at the Barcelona meeting in 1975 (UNEP MAP, 1990a,b). The issue of a consistent monitoring strategy and assessment of eutrophication was first raised at the UNEP/MAP MED POL National Coordinators Meeting in 2001 (Venice, Italy) which recommended to the Secretariat to elaborate a draft programme for monitoring of eutrophication in the Mediterranean coastal waters (UNEP/MAP MED POL, 2003). In spite of a series of assessments reviewing the concept and state of eutrophication, there are important gaps in the capacity to assess the intensity of this phenomenon. Efforts have been devoted to defining the concepts to assess the intensity and to extend experience beyond the initial sites in the Adriatic Sea, admittedly, the most eutrophic area in the entire Mediterranean Sea. In the context of the Mediterranean Sea, the Integrated Monitoring and Assessment Programme (UNEP/MAP, 2016) and the European Marine Strategy Framework Directive (2000/56/EC) are the two main policy tools for the eutrophication phenomenon.

Targets

For each considered marine spatial scale (region, sub-region, local water mass, etc.) the nutrient levels should be compared based on base reference levels and trends monitoring until commonly agreed thresholds have been scientifically assessed and agreed upon in the Mediterranean Sea.

Policy documents

General Policy documents

i. 19th COP to the Barcelona Convention, Athens, Greece, 2016. Decision IG.22/7 - Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria (UNEP(DEPI)/MED IG.22/28)

ii. 19th COP to the Barcelona Convention, Athens, Greece, 2016.Draft Integrated Monitoring and Assessment Guidance (UNEP(DEPI)/MED IG.22/Inf.7)

iii. 18th COP to the Barcelona Convention, Istanbul, Turkey, 2013.Decision IG.21/3 - Ecosystems Approach including adopting definitions of Good Environmental Status (GES) and Targets. UNEP(DEPI)/MED IG.21/9

iv. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

Nutrient/Eutrophication related Policy documents

v. UNEP/MAP MED POL (2003). Eutrophication Monitoring Strategy of UNEP/MAP MED POL. UNEP(DEPI)/MED WG.231/14. UNEP, Athens.

vi. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

vii. UNEP/FAO/WHO (1996). ‘Assessment of the state of eutrophication in the Mediterranean Sea’. MAP Technical Reports Series No 106. UNEP, Athens, 211 pp.

Indicator Title	Common Indicator 13. Concentration of key nutrients in water column (EO5)

viii. UNEP/MAP MED POL (1990a). Activity IV: Research on the effects of pollutants on Marine Organisms and their Populations (UNEP/MAP MED POL Phase I, 1975-1981).
ix. UNEP/MAP MED POL (1990b). Activity V: Research on the effects of pollutants on Marine Communities and Ecosystems (UNEP/MAP MED POL Phase I, 1975-1981).

Indicator analysis methods

Indicator Definition

Concentration of key (inorganic) nutrients in the water column:
Nítrate (NO_3-N)
Nitrite (NO_2-N)
Ammonium (NH_4-N)
Total Nitrogen (TN)
Orthophosphate (PO_4-P)
Total Phosphorus (TP)
Orthosilicate (SiO_4-Si)

Sub-Indicators: Nutrient ratios (molar) of silica, nitrogen and phosphorus where appropriate:
Si:N, N:P, Si:P

Methodology for indicator calculation

All: Spectrophotometry (manually or automated methods and instrumentation)

Indicator units

All: micromol per liter, that is micromolar concentration (μmol/L =μM)
Ratios: adimensional (simple mathematical derivation of ratios from nutrient concentrations)

List of Guidance documents and protocols available

i. OSPAR, 2012. OSPAR MSFD Advice Document on Eutrophication. Approaches to determining good environmental status, setting of environmental targets and selecting indicators for Marine Strategy Framework Directive descriptor 5.
ii. Piha, H., Zampoucas, N., 2011. Review of Methodological Standards Related to the Marine Strategy Framework Directive Criteria on Good Environmental Status. JRC Scientific and Technical Reports, EUR 24743 EN
iii. UNEP/MAP MED POL (2005). Sampling and Analysis Techniques for the Eutrophication Monitoring Strategy of UNEP/MAP MED POL. MAP Technical Reports Series No. 163. UNEP, Athens. 61pp.
iv. Durairaj, P., Sarangi, R.K., Ramalingam, S. *et al.* Seasonal nitrate algorithms for nitrate retrieval using OCEANSAT-2 and MODIS-AQUA satellite data. Environ Monitoring Assess (2015) 187: 176.
v. See also UNEP/MAP website (http://web.unep.org/unepmap)

Data Confidence and uncertainties

Despite the great variability born by the water layers subject to active hydrodynamic processes, monitoring the characteristics of the seawater is still the most direct way of assessing eutrophication. Inorganic nutrients may be determined either at the surface or at various depths.

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

Traditional methods for eutrophication monitoring in coastal waters involve *in situ*sampling/measurements of commonly measured parameters such as nutrients concentration.

Indicator Title	Common Indicator 13. Concentration of key nutrients in water column (EO5)

Concerning available methods for *in situ* measurements, ships provide flexible platforms for eutrophication monitoring, while remote sensing provides opportunities for a synoptic view over regions or sub-regions. Besides traditional ship measurements, ferry-boxes and other autonomous measuring devices have been developed that allow high frequency and continuous measurements.

Sampling for the determination of *in vitro* fluorescence and nutrient analysis may be carried out with relatively little effort if a proper pump and hose are mounted on the ship. The measurements may be done at the surface or just below it with a water intake on the hull of the vessel or at fixed or varying depths with a towed "fish" and pumping system.

Available data sources
MED POL Database.

EMODNET Chemistry:
http://www.emodnet-chemistry.eu/data_access.html

EEA Waterbase - Transitional, coastal and marine waters:
http://www.eea.europa.eu/data-and-maps/data/waterbase-transitional-coastal-and-marine-waters-11

Spatial scope guidance and selection of monitoring stations

The first factor promoting eutrophication is nutrient enrichment. This explains why the main eutrophic areas are to be found primarily not far from the coast, mainly in areas receiving high nutrient loads, despite some natural symptoms of eutrophication can also be found, such as in upwelling areas. Additionally, the risk of eutrophication is linked to the capacity of the marine environment to confine growing algae in the well-lighted surface layer. The geographical extent of potentially eutrophic waters may vary widely, depending on:

(i) the extent of shallow areas, i.e. with depth ≤ 20 m;
(ii) the extent of stratified river plumes, which can create a shallow surface layer separated by a halocline from the bottom layer, whatever its depth;
(iii) extended water residence times in enclosed seas leading to blooms triggered to a large degree by internal and external nutrient pools; and
(iv) upwelling phenomena leading to autochthonous nutrient supply and high nutrient concentrations from deep water nutrient pools, which can be of natural or human origin.

Therefore, the geographical scale of monitoring for the assessment of GES for eutrophication will depend on the hydrological and morphological conditions of an area, particularly the freshwater inputs from rivers, the salinity, the general circulation, upwelling and stratification. The spatial distribution of the monitoring stations should, prior to the establishment of the eutrophication status of the marine sub-region/area, be risk-based and proportionate to the anticipated extent of eutrophication in the sub-region under consideration as well as its hydrographic characteristics aiming for the determination of spatially homogeneous areas. The eutrophication monitoring programmes should pursue to assess the eutrophication phenomena, based on the differentiation of the scale and time dependant signals from human induced versus natural eutrophication.

Temporal Scope guidance

Flexibility should be incorporated into the design of the monitoring programme to take account of differences in each marine sub-region/area. At the Mediterranean Sea latitudes, in general terms, the pre-summer and Winter primary production bloom intensity peaks of natural eutrophication will define the strategy for the sampling frequency, although year-round measurements of nutrients may be more appropriate. The optimum frequency (seasonal 2 to 4 times per year or monthly 12 times per year) for the monitoring of nutrients at the selected stations should be chosen taking into account the necessity of both to control the deviations of the known natural cycles of eutrophication in coastal areas and the

Indicator Title	Common Indicator 13. Concentration of key nutrients in water column (EO5)

control of (decreasing) trends monitoring impacted areas, therefore, from low frequency (minimum)to high frequency measurements.

Therefore, either for impacted or non-impacted coastal waters the optimal frequency per year and sampling locations needs to be selected at a local scale, whilst for open waters the sampling frequency to be determined on a sub-regional level following a risk-based approach.

Mainly, in order to build a robust sampling frequency scale in future a sounded statistical approach has to be developed that takes into account the discriminant limit between classes when the nutrient boundaries approach will be widely accepted. Let consider the approach developed for CI14 - Chlorophyll a concentration in water column as an example to be used, as for this CI accepted boundaries exists.
Sampling frequency is determined by the variability of the measured parameters and is usually determined by how many samples are needed to reliably assess the differences between two neighbouring mean values.
Discriminant limit (ie power of applied test), depends on sample size:
Discriminant limit dM = sd * t(α/2; N1+N2-2) * √ 2; N1+N2-2) 0
For Chl-a log10 units for different sample size N with the significance level: α/2 = 0,025; with an average sd = 0.30

N = 12 t = 2.074 √
N = 24 t = 2.013 √ = 24 = 0.289 dM > |0.17|
N = 52 t = 1,983 √ = 52 = 0.196 dM > |0.12|

Based on the above it follows that a particular area can be characterized best if we measure three relevant depths (typically 0, 5 and 10 m) at one station at least monthly or at three stations one depth (0 m). It is at annual base 36 samples which discriminates around 0.15 Chl-a log10 unit for mesotrophic - eutrophic area that is slightly less than half difference between two classes (0.37 as log10 unit). Due to smaller standard deviation for an oligotrophic area we achieve the same with half the frequency. The next ~~measurement~~ sampling frequency is ~~proposed:~~ suggested as the guidance taking into account specific local conditions:
Eutrophic – mesotrophic: monthly,
Mesotrophic – oligotrophic: monthly near the coast, bimonthly in open waters, and
Oligotrophic: bimonthly near the coast, seasonally in open waters.~~[5]~~

Data analysis and assessment outputs

Despite the individual nutrient concentrations and nutrient ratios will be evaluated based on statistical analysis against known reference levels and known marine eutrophication processes, following the evaluation of information provided by a number of countries and other available information, it has to be noted that the Mediterranean countries are using different eutrophication non-mandatory assessment methods such as TRIX, UNTRIX, Eutrophication scale, EI, HEAT, OSPAR, etc. Nutrients concentrations are part of these tools and is very important to continue to be used at sub-regional or national levels because there is a long-term experience within countries which can reveal / be used for assessing eutrophication trends. However, in order to increase coherency and comparability regarding eutrophication assessment methodologies is recommended that further efforts should be made to harmonize existing tools through workshops, dialogue and comparative exercises at regional/subregional/subdivision levels in Mediterranean with a view to further develop common assessment methods.

Expected assessments outputs

~~[5] Morocco expressed reservation on proposed example for sampling frequency determination~~

Indicator Title	Common Indicator 13. Concentration of key nutrients in water column (EO5)	
As suggested by the on-line expert group on eutrophication established by the Contracting parties it is recommended that with regard to nutrient concentrations, until commonly agreed thresholds have been determined and agreed upon, GES may be determined on a levels and trend monitoring basis.		
Known gaps and uncertainties in the Mediterranean For a complete assessment of eutrophication and GES achievement, GES thresholds and reference conditions (natural background concentrations) are needed not only for chlorophyll *a*, but such values must be set in the near future, through dedicated workshops and exercises also for nutrients, transparency and oxygen as minimum requirements (see also related Common Indicator 14). This should include quality assurance schemes, as well as data quality control protocols. Nutrient, transparency and oxygen thresholds and reference values may not be identical for all areas, since is recognized that area-specific environmental conditions must define threshold values. GES could be defined on a sub-regional level, or on a sub-division of the sub-region (such as the Northern Adriatic), due to local specificities in relation to the trophic level and the morphology of the area.		
Contacts and version Date		
http://www.unepmap.org		
Version No	**Date**	**Author**
V.1	31.5.17	MEDPOL
V.2	10.1.19	MEDPOL
V.3~~Final version~~	31/05/2019	Approved by the Meeting of MED POL FPs
Final version	09/09/2019	Approved by the 7th Meeting of EcAp Coordination Group

1.2 Common Indicator 14

2. The update for **Common Indicator 14** (EO5): Chlorophyll a concentration in water column[6] is presented for in below table.

<table>
<tr><td>Indicator Title</td><td colspan="2">Common Indicator 14. Chlorophyll a concentration in water column (EO5)</td></tr>
<tr><td>Relevant GES definition</td><td>Related Operational Objective</td><td>Proposed Target(s)</td></tr>
<tr><td>Natural levels of algal biomass, water transparency and oxygen concentrations in line with prevailing physiographic, geographic and weather conditions</td><td>Direct and indirect effects of nutrient over-enrichment are prevented</td><td>1. Chlorophyll a concentrations in high-risk areas below thresholds
2. Decreasing trend in chl-a concentrations in high risk areas affected by human activities</td></tr>
<tr><td colspan="3">Rational</td></tr>
<tr><td colspan="3">Justification for indicator selection

Eutrophication is a process driven by enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of nutrients causing changes to the balance of organisms; and water quality degradation. The consequences of eutrophication are undesirable if they appreciably degrade ecosystem health and/or the sustainable provision of goods and services, such as excessive algal blooms, dissolved oxygen deficiency, declines in sea-grasses, mortality of benthic organisms and/or fish. Although, these changes may also occur due to natural processes, the management concern begins when they are attributed to anthropogenic sources.</td></tr>
<tr><td colspan="3">Scientific References

i. Boyer J.N. Kelble C.R., Ortner P.B., Rudnick D.T., 2009. Phytoplankton bloom status: Chlorophyll a biomass as an indicator of water quality condition in the southern estuaries of Florida, USA. Ecological Indicators 9s:s56- s67.
ii. Primpas I., Karydis M., 2011. Scaling the trophic index (TRIX) in oligotrophic marine environments. Environmental Monitoring and Assessment July 2011, Volume 178, Issue 1-4, pp 257-269.
iii. Vollenweider, R.A., Giovanardi F., Montanari, G., Rinaldi A., 1998. Characterization of the trophic conditions of marine coastal waters, with special reference to the NW Adriatic Sea: proposal for a trophic scale, turbidity and generalized water quality index. Environmetrics, 9, 329-357.</td></tr>
<tr><td colspan="3">Policy Context and targets</td></tr>
<tr><td colspan="3">Policy context description

In the Mediterranean, the UNEP/MAP MED POL Monitoring programme included from its inception the study of eutrophication as part of its seven pilot projects approved by the Contracting Parties at the Barcelona meeting in 1975 (UNEP MAP, 1990a,b). The issue of a consistent monitoring strategy and assessment of eutrophication was first raised at the UNEP/MAP MED POL National Coordinators Meeting in 2001 (Venice, Italy) which recommended to the Secretariat to elaborate a draft programme for monitoring of eutrophication in the Mediterranean coastal waters (UNEP/MAP MED POL, 2003). In spite of a series of assessments reviewing the concept and state of</td></tr>
</table>

[6]MSFD Descriptor 5: Human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)
eutrophication, there are important gaps in the capacity to assess the intensity of this phenomenon. Efforts have been devoted to defining the concepts to assess the intensity and to extend experience beyond the initial sites in the Adriatic Sea, admittedly, the most eutrophic area in the entire Mediterranean Sea. In the context of the Mediterranean Sea, the European **Marine** Strategy Framework Directive (200/56/EC) and the Integrated Monitoring and Assessment Programme (UNEP/MAP, 2016), are the two main policy tools for the eutrophication phenomenon.	

Targets

For each defined marine spatial scale (region, sub-region, etc.) the levels should be compared against agreed threshold levels defining High/Good and Good/Medium environmental status based on the indicative thresholds and reference values of Chlorophyll *a*- in Mediterranean coastal water types, according to the Commission Decision of 20 September 2013 (2013/480/EU) establishing, pursuant to Directive 2000/60/EC (WFD), the values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Decision 2008/915/EC, recalling on reference conditions (High/Good) and boundaries of good/moderate status (G/M).

Policy documents

General Policy documents

i. 19th COP to the Barcelona Convention, Athens, Greece, 2016. Decision IG.22/7 - Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria (UNEP(DEPI)/MED IG.22/28)
ii. 19th COP to the Barcelona Convention, Athens, Greece, 2016.Draft Integrated Monitoring and Assessment Guidance (UNEP(DEPI)/MED IG.22/Inf.7)
iii. 18th COP to the Barcelona Convention, Istanbul, Turkey, 2013.Decision IG.21/3 - Ecosystems Approach including adopting definitions of Good Environmental Status (GES) and Targets. UNEP(DEPI)/MED IG.21/9
iv. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

Nutrient/Eutrophication related Policy documents

v. UNEP/MAP MED POL (2003). Eutrophication Monitoring Strategy of UNEP/MAP MED POL. UNEP(DEPI)MED WG.231/14. UNEP, Athens.
vi. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
vii. UNEP/FAO/WHO (1996). 'Assessment of the state of eutrophication in the Mediterranean Sea'. MAP Technical Reports Series No 106. UNEP, Athens, 211 pp.
viii. UNEP/MAP MED POL (1990a). Activity IV: Research on the effects of pollutants on Marine Organisms and their Populations (UNEP/MAP MED POL Phase I, 1975-1981).
ix. UNEP/MAP MED POL (1990b). Activity V: Research on the effects of pollutants on Marine Communities and Ecosystems (UNEP/MAP MED POL Phase I, 1975-1981).

Indicator analysis methods

Indicator Definition

Chlorophyll *a* concentration in the water column (State, Impact Indicator);
Sub-Indicators: Water Transparency (State, Impact Indicator) and Dissolved oxygen (State, Impact Indicator)

Methodology for indicator calculation

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)

Chlorophyll *a*: Spectrophotometry.
ISO 10260 (1992) on spectrometric determination of the chlorophyll *a* concentration provides a standard method for quantification of chlorophyll *a*.
Water transparency: measured as Secchi disk depth or according to ISO 7027:1999 Water Quality-Determination of Turbidity
Dissolved Oxygen: Chemical methods, Oxygen sensors, etc. measured near the bottom (under the euphotic layer/oxycline)

Indicator units

microgram per liter (μg/L) - Chlorophyll *a*
meters – Secchi disk depth; NTU Turbidity Scale (Nephelometric Turbidity Units) – Water transparency
milligram per liter (mg/L) and % Saturation (if temperature and salinity is known) – Dissolved Oxygen

List of Guidance documents and protocols available

i. OSPAR, 2012. OSPAR MSFD Advice Document on Eutrophication. Approaches to determining good environmental status, setting of environmental targets and selecting indicators for Marine Strategy Framework Directive descriptor 5
ii. Piha, H., Zampoucas, N., 2011. Review of Methodological Standards Related to the Marine Strategy Framework Directive Criteria on Good Environmental Status. JRC Scientific and Technical Reports, EUR 24743 EN
iii. UNEP/MAP MED POL, 2005. Sampling and Analysis Techniques for the Eutrophication Monitoring Strategy of UNEP/MAP MED POL. MAP Technical Reports Series No. 163. UNEP, Athens. 61pp.

Data Confidence and uncertainties

Despite the great variability born by the water layers subject to active hydrodynamic processes, monitoring the characteristics of the seawater is still the most direct way of assessing eutrophication. A number of parameters have been identified as providing most information relative to eutrophication e.g. chlorophyll *a*, dissolved oxygen, inorganic nutrients, organic matter, suspended solids, light penetration, aquatic macro-phytes, zoo benthos, etc. They all may be determined either at the surface or at various depths.
If only limited means are available, determination of those parameters that synthesize the most information should be retained. Chlorophyll *a* determination for example, although not very precise representations of the system, are data which provide a great deal of information. Turbidity may also be a good measure of eutrophication, except near the mouths of rivers where inert suspended solids may be extremely abundant. Dissolved oxygen is one parameter that integrates much information on the processes involved in eutrophication, provided it is measured near the bottom or, at least, below the euphotic zone where an oxycline usually appears.

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

Traditional methods for eutrophication monitoring in coastal waters involve *in situ* sampling/measurements of commonly measured parameters such as nutrients concentration, chlorophyll *a* concentration, phytoplankton abundance and composition, transparency and dissolved oxygen concentration. Concerning available methods for *in situ* measurements, ships provide flexible platforms for eutrophication monitoring, while remote sensing provides opportunities for a synoptic view over regions or sub-regions. Besides traditional ship measurements, ferry-boxes and other autonomous measuring devices have been developed that allow high frequency and continuous measurements.

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)

Modelling and remote sensing should also be considered as area integrating in addition to *in situ* measurements, depending on the requirements with respect to data. In general, *in situ* measurements always remain necessary to validate and calibrate the models and data calculated from satellite measurements.
However, satellite data need to be supported by ground truth data. A good strategy appears to be a combination of remote sensing and scanning of the area known or suspected to be affected with automatic measuring instruments such as thermo-salinometer, dissolved oxygen sensors and *in vivo*fluorometer and/or nephelometer. Sampling for the determination of *in vitro* fluorescence and nutrient analysis may be carried out with relatively little effort if a proper pump and hose are mounted on the ship. The measurements may be done at the surface or just below it with a water intake on the hull of the vessel or at fixed or varying depths with a towed "fish" and pumping system.

Available data sources
MED POL Database.

EMODNET Chemistry:
http://www.emodnet-chemistry.eu/data_access.html

EEA Waterbase - Transitional, coastal and marine waters:
http://www.eea.europa.eu/data-and-maps/data/waterbase-transitional-coastal-and-marine-waters-11

Satellite databases such as in EMIS http://mcc.jrc.ec.europa.eu/emis/

Spatial scope guidance and selection of monitoring stations

The extent of eutrophication shows spatial variation, for instance coastal regions versus the open sea. The frequency and spatial resolution of the monitoring programme should reflect this spatial variation in eutrophication status and pressures following a risk-based approach and the precautionary principle.
The geographical extent of potentially eutrophic waters may vary widely, depending on:
(i) the extent of shallow areas, i.e. with depth ≤ 20 m;
(ii) the extent of stratified river plumes, which can create a shallow surface layer separated by a halocline from the bottom layer, whatever its depth
(iii) extended water residence times in enclosed seas leading to blooms triggered to a large degree by internal and external nutrient pools; and
(iv) upwelling phenomena leading to autochthonous nutrient supply and high nutrient concentrations from deep water nutrient pools, which can be of natural or human origin.
Therefore, the geographical scale of monitoring for the assessment of GES for eutrophication will depend on the hydrological and morphological conditions of an area, particularly the freshwater inputs from rivers, the salinity, the general circulation, upwelling and stratification. The spatial distribution of the monitoring stations should, prior to the establishment of the eutrophication status of the marine sub-region/area, be risk-based and proportionate to the anticipated extent of eutrophication in the sub-region under consideration as well as its hydrographic characteristics aiming for the determination of spatially homogeneous areas. The eutrophication monitoring programmes should pursue to assess the eutrophication phenomena, based on the differentiation of the scale and time dependant signals from human induced versus natural eutrophication.

Temporal Scope guidance

The current national eutrophication monitoring programme implemented so far by the Contracting Parties in the framework of the UNEP/MAP MED POL programme should be used as a sound basis for monitoring under the EcAp.
Sampling frequency has to be determined by the variability of the measured parameters and is usually determined by how many samples are needed to reliably assess the differences between two neighbouring mean values.

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)

Discriminant limit (i.e. power of applied test), depends on sample size:

Discriminant limit $dM = sd * t(\alpha/2; N1+N2-2) * \sqrt{(1/N1+1/N2)} \neq 0$

For Chl-a log10 units for different sample size N with the significance level: $\alpha/2 = 0{,}025$; with an average sd = 0.30

N = 12 t = 2.074 $\sqrt{(2/12)}$ = 0.408 dM > |0.25|

N = 24 t = 2.013 $\sqrt{(2/24)}$ = 0.289 dM > |0.17|

N = 52 t = 1,983 $\sqrt{(2/52)}$ = 0.196 dM > |0.12|

Based on the above it follows that a particular area can be characterized best if we measure three relevant depths (typically 0, 5 and 10 m) at one station at least monthly or at three stations one depth (0 m). It is at annual base 36 samples which discriminates around 0.15 chla log10 unit for mesotrophic - eutrophic area that is slightly less than half difference between two classes (0.37 as log10 unit). Due to smaller standard deviation for an oligotrophic area we achieve the same with half the frequency. The next samplingmeasurement frequency is proposed:suggested as the guidance taking into account specific local conditions:

Eutrophic – mesotrophic: monthly,
mesotrophic – oligotrophic: monthly near the coast, bimonthly in open waters, and
oligotrophic: bimonthly near the coast, seasonally in open waters[7].
For open waters sampling frequency to be determined on a sub-regional level following a risk-based approach
Water transparency: *id.* Chlorophyll *a*
Dissolved Oxygen: *id.* Chlorophyll *a*

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

The classification scheme on chlorophyll *a* concentration developed by MEDGIG as an assessment method easily applicable by all Mediterranean countries based on the indicative thresholds and reference values adopted.
The main statistical analysis is based on the typology criteria and settings derived from the analysis of influence of freshwater inputs as the main nutrient drivers. More information on is presented in document the UNEP(DEPI)/MED WG 417/Inf.15. Tree main types were identified:

Type I	coastal sites highly influenced by freshwater inputs,
Type IIA	coastal sites moderately influenced not directly affected by freshwater inputs (Continent influence),
Type IIIW	continental coast, coastal sites not influenced/affected by freshwater inputs (western Basin),
Type IIIE	not influenced by freshwater input (Eastern Basin),
Type Island	coast (western Basin).

Coastal water type III was split in two different sub basins, the western and the Eastern Mediterranean s, according to the different trophic conditions and is well documented in literature. It is recommended to define the major coastal water types in the Mediterranean for eutrophication assessment (Table 1).

Table 1. Major coastal water types in the Mediterranean

[7] Morocco expressed reservation on proposed example for sampling frequency determination

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)

	Type I	Type IIA, IIA Adriatic	Type IIIW	Type IIIE	Type Island-W
σt (density)	<25	25<d<27	>27	>27	All range
salinity	<34.5	34.5<S<37.5	>37.5	>37.5	All range

With the view to assess eutrophication, it is recommended to rely on the classification scheme on Chlorophyll a concentration (µg L-1) in coastal waters as a parameter easily applicable by all Mediterranean countries based on the indicative thresholds and reference values presented in Table 2.

Table 2. Coastal Water types reference conditions and boundaries in the Mediterranean

Coastal Water Typology	Reference conditions of Chla (µg L-1)		Boundaries of Chla (µg L-1) for G/M status	
	G_mean	90% percentile	G_mean	90% percentile
Type I	1,4	3,33* - 3,93**	6,3	10* - 17,7**
Type II-FR-SP		1,9		3,58
Type II-A Adriatic	0,33	0,8	1,5	4,0
Type II-B Tyrrhenian	0,32	0,77	1,2	2,9
Type III-W Adriatic			0,64	1,7
Type III-W Tyrrhenian			0,48	1,17
Type III-W FR-SP		0,9		1,80
Type III-E		0,1		0,4
Type Island-w		0,6		1,2 – 1,22

* aapplicable to Gulf of Lion
** applicable to Adriatic

Further, developments within the European MSFD with regard to eutrophication should also be taken into account.
Further, it has to be noted that the Mediterranean countries are using different eutrophication non-mandatory assessment methods such as TRIX, UNTRIX, Eutrophication scale, EI, HEAT, OSPAR, etc. These tools are very important to continue to be used at sub-regional or national levels because there is a long-term experience within countries which can reveal / be used for assessing eutrophication trends.
However, in order to increase coherency and comparability regarding eutrophication assessment methodologies is recommended that further efforts should be made to harmonize existing tools through workshops, dialogue and comparative exercises at regional/sub-regional/subdivision levels in Mediterranean with a view to further implement the IMAP assessment methods, in a.

Expected assessments outputs

GES thresholds and trends are recommended to be used in a combined way, according to data availability and agreement on GES threshold levels. In the framework of UNEP/MAP MED POL there is experience with regard to using quantitative thresholds. It is proposed that for the Mediterranean region, quantitative thresholds between “good” (GES) and “moderate” (non-GES) conditions for coastal waters could be based as appropriate on the work carried out in the framework of the MEDGIG intercalibration process of the EU Water Framework Directive (WFD). The Contracting Parties are recommended to rely on the classification scheme on chlorophyll a concentration (µg/L) in coastal waters as a parameter easily applicable by all Mediterranean countries based on the indicative thresholds and reference values of chlorophyll a in Mediterranean coastal water types (according to 2013/480/EU, see reference below), recalling on reference conditions and boundaries of good/moderate status (G/M).

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)	
In this context regarding the definition of sub-regional thresholds for chlorophyll a water typology is very important for further development of classification schemes of a certain area. Within the MEDGIG exercise the recommended water types for applying eutrophication assessment is based on hydrological parameters characterizing a certain area dynamics and circulation. COMMISSION DECISION (EU) 2018/229 of 12 February 2018 establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, the values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Commission Decision 2013/480/EU.		
Known gaps and uncertainties in the Mediterranean For a complete assessment of eutrophication and GES achievement, GES thresholds and reference conditions (natural background concentrations) are needed not only for chlorophyll *a*, but such values must be set, in the near future, through dedicated workshops and exercises also, water transparency and oxygen as minimum requirements, where appropriate. This should include quality assurance schemes, as well as data quality control protocols. Further, in order to increase coherency and comparability regarding eutrophication assessment methodologies is recommended that further efforts should be made to harmonize existing tools through workshops, dialogue and comparative exercises at regional/subregional/subdivision levels in Mediterranean with a view to further improve and develop common assessment methods.		
Contacts and version Date		
http://www.unepmap.org		
Version No	**Date**	**Author**
V.1	31.5.17	MEDPOL
V.2	10.1.19	MEDPOL
V.3~~Final version~~	31/05/2019	Approved by the Meeting of MED POL FPs
Final version	09/09/2019	Approved by the 7th Meeting of EcAp Coordination Group

1.3 Common Indicator 17

3. **The update for Common Indicator 17 (EO9)**: Concentration of key harmful contaminants measured in the relevant matrix[8] is presented in below table.

Indicator Title	Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Level of pollution isbelow a determined threshold defined for the area and species	Concentration of priority contaminants is kept within acceptable limits and does not increase	1. Concentrations of specific contaminants below Environmental Assessment Criteria (EACs) or below reference concentrations 2. No deterioration trend in contaminants concentrations in sediment and biota from human impacted areas, statistically defined 3. Reduction of contaminants emissions from land-based sources
Rational		
Justification for indicator selection Environmental chemical pollution is directly linked with humankind activities in all the earth's ecosystems. Marine environmental investigations have detected thousands of man-made chemicals (both inorganic and organic compounds) all over the world oceans, which have been shown to impair the health of the marine ecosystems and their ecosystem services. The study of the occurrence, transport, transformation and fate, through the different ecosystem compartments (seawater column, marine biota, sediment, etc.), as well as the study of their sources and entry routes (land-based, sea-based (marine) and atmospheric wet and dry deposition) are the first steps to assess the pressures, state and impact to the environment understand and to decide further management actions fora growing environmental problem. Currently, new man-made chemicals and emerging pollutants continue to enter the marine environment and interact with the different marine species, habitats and ecosystems (coastal, open ocean, deep-sea areas), increasing the complexity of the chemical pollution threats for the marine environment and their future sustainability to deliver its benefits. The monitoring and assessment of the harmful and noxious substances occurrence, at selected spatial and temporal scales, will determine either a chronic or acute contamination/pollution scenarios.		
Scientific References i. Clark, R.B., 1986. Marine Pollution, Oxford University Press. ii. Neff, J.M., 1979. Polycyclic aromatic hydrocarbons in the aquatic environment. Sources, fates and biological effects. Applied Science Publishers, Ltd., London. iii. Goldberg, E. D., 1975. The Musssel Watch - a first step in global marine monitoring. *Mar.Poll.Bull.*, 6, 111. iv. Bricker, S., Lauenstein, G., Maruya, K., 2014. NOAA's Mussel Watch Program: Incorporating contaminants of emerging concern (CECs) into a long-term monitoring program. *Mar.Poll.Bull.*, 81, 289–290.		

[8]MSFD Descriptor 8: Concentrations of contaminants are at levels not giving rise to pollution effects

Indicator Title	Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)

v. Furdek, M., Vahcic, M., Šcancar, J., Milacic, R., Kniewald, G., Mikac, N., 2012. Organotin compounds in seawater and Mytilusgalloprovincialis mussels along the Croatian Adriatic Coast. *Mar.Poll.Bull.*, 64, 189–199

vi. Nakata, H., Shinohara, R.I., Nakazawa, Y., Isobe, T., Sudaryanto, A., Subramanian, A., Tanabe, S., Zakaria, M.P., Zheng, G.J., Lam, P.K.S., Young Kim, E., Yoon Min, B., Wef, S.U., Hung Viet, P., Tana, T.S., Prudente, M., Donnell, F., Lauenstein, G., Kannan, K., 2012. Asia–Pacific mussel watch for emerging pollutants: Distribution of synthetic musks and benzotriazole UV stabilizers in Asian and US coastal waters. Mar. Pollut. Bull., 64, 2211–2218

vii. Richardson, S., 2004. Environmental Mass Espectrometry: Emerging contaminants and current issues. Anal. Chem., 76, 3337-3364.

viii. Schulz-Bull, D.E., Petrick, G., Bruhn, R., Duinker, J.C., 1998. Chlorobiphenyls (PCB) and PAHs in water masses of the northern North Atlantic. Mar. Chem., 61, 101-114.

Policy Context and targets

Policy context description

In most Mediterranean countries, the monitoring of a range of hazardous chemical substances in different marine compartments are undertaken in response to the UNEP/MAP Barcelona Convention (1976) and its Land-Based Protocol, through the coordination of the UNEP/MAP MED POL Monitoring Program. For Mediterranean EU Countries, the European legislation on the Marine Environment also applies (e.g. EU WFD and EU MSFD), as well as other international and national policy drivers. A considerable amount of founding knowledge and actions are available through the pollution monitoring and assessment component of the UNEP/MAP MED POL Programme during the past decades until today. The environmental assessments have been used for the identification and confirmation of significant marine contaminants occurrence, distributions, levels and trends; as well as, for the continuous development of monitoring strategies and guidance. With respect to the Ecosystem Approach and IMAP, their implementation will continue under the benefits gained from this past knowledge and the policy and practical framework built in the Mediterranean Sea.

Targets

Initial GES targets under Common Indicator 17 will be focused on the control of environmental levels, temporal trend improvements and the reduction of emissions at sources. The monitoring of these targets will be based upon data of a relatively small number of primarily legacy pollutants, reflecting the scope of current programmes and the availability of suitable agreed assessment criteria for them, despite the measurement of other chemicals remains open and is necessary. The inclusion of contemporary and emerging chemicals of new environmental concern and their targets for GES, within IMAP Common Indicator 17, will be implemented as the scientific knowledge advances.

Policy documents

General Policy documents

i. 19th COP to the Barcelona Convention, Athens, Greece, 2016. Decision IG.22/7 - Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria (UNEP(DEPI)/MED IG.22/28)

ii. 19th COP to the Barcelona Convention, Athens, Greece, 2016.Draft Integrated Monitoring and Assessment Guidance (UNEP(DEPI)/MED IG.22/Inf.7)

iii. 18th COP to the Barcelona Convention, Istanbul, Turkey, 2013.Decision IG.21/3 - Ecosystems Approach including adopting definitions of Good Environmental Status (GES) and Targets. UNEP(DEPI)/MED IG.21/9

iv. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (EU Marine Strategy Framework Directive and updates in 2010).

Indicator Title	Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)

v. COMMISSION DIRECTIVE (EU) 2017/845 amending Directive 2008/56/EC of the European Parliament and of the Council as regards the indicative lists of elements to be taken into account for the preparation of marine strategies

vi. 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.

vii. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (and updated revisions).

Contaminants related Policy documents

viii. UNEP/MAP, 1987. Report of the Fifth Meeting of the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against pollution and its Related Protocols. UNEP/IG. 74/5. UNEP/MAP, Athens.

ix. UNEP/MAP, 2005. Fact sheets on Marine Pollution Indicators. Meeting of the UNEP/MAP MED POL National Coordinators. Barcelona, Spain, 24-27 May 2005. UNEP (DEC)/MED/ WG.264/ Inf.14. UNEP, Athens.

x. UNEP/MAP MED POL – Phase III, Programme for the Assessment and Control of Pollution in the Mediterranean Region. MAP Technical Report Series No. 120, UNEP, Athens, 1999.

xi. OSPAR Commission, 2013. Levels and trends in marine contaminants and their biological effects - CEMP Assessment Report 2012. Monitoring and Assessment Series, 2013.

xii. EEA, 2003. Hazardous substances in the European marine environment: Trends in metals and persistent organic pollutants. Topic Report 2/2003. EEA, European Environmental Agency, Copenhagen, 2003. http://www.eea.eu.int

xiii. EEA, 1999 State and pressures of the marine and coastal Mediterranean environment. Environmental issues series nº5. European Environmental Agency, Copenhagen, 1999. http://www.eea.eu.int

xiv. EEA, 2018. European Waters – Assessment of status and pressures 2018. EEA Report /No 7, 2018.

Indicator analysis methods

Indicator Definition

Concentrations of key contaminants in the following matrices (note this is a multiparameter pressure indicator):

MARINE BIOTA: In collected marine organisms, where whole soft tissues or dissected parts are processed according sampling and sample preparation protocols, and primarily, in bivalve species and/or fish the following hazardous substances should be measured:
Trace/Heavy Metals (TM): Total mercury (HgT), Cadmium (Cd) and Lead (Pb)
Organochlorinated compounds (PCBs, Hexachlorobenzene, Lindane and ΣDDTs)
Polycyclic Aromatic Hydrocarbons (PAHs)

The lipid content and flesh fresh/dry weight ratio should be measured in biota for normalisation and reporting purposes

MARINE SEDIMENTS: In coastal and marine areas, continental platform and offshore, sediments should be collected by mechanical means and processed at the laboratory (< 2 mm particle size fraction). Further the following hazardous substances should be measured:
Trace/Heavy Metals: Total mercury (HgT), Cadmium (Cd) and Lead (Pb)

<table>
<tr><td>Indicator Title</td><td>Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)</td></tr>
<tr><td colspan="2">Organochlorinated compounds (PCBs (at least, congeners 28, 52, 101, 118, 138, 153, 180, 105 and 156), aldrin, dieldrin, Hexachlorobenzene, Lindane and ΣDDTs)
Polycyclic Aromatic Hydrocarbons (PAHs)

The aluminium (Al), Total Organic Carbon (TOC) in the < 2mm particle size fraction should be performed for normalization and reporting purposes for TM and OCs, respectively. The < 63µm sediment fraction is also recommended to be complementary for metals.
The liophilization ratio (dry/wet sediment ratio) should be considered for datasets reporting.

SEAWATER: the monitoring and assessment of contaminants in seawater samples collected in coastal, marine and open-sea areas presents specific challenges and higher costs. For the mid/long-term monitoring programmes, such as IMAP, these are recommended to be carried out on a country decision basis.

<u>Sub-indicators:</u> other relevant chemicals (such as tributyltin, TBT; low molecular weight PAHs; etc.) and emerging pollutants are recommended to be carried out on a country decision basis until a firm COP Meeting Decision will be taken.

The chemical compounds above are being used to develop the IMAP Info System and those are included in the list of contaminants of concern which accompanies the Data Dictionaries (DDs) and Data Standards (DSs) for CI17.</td></tr>
<tr><td colspan="2">Methodology for indicator calculation

Trace/Heavy Metals (TM) and Aluminium: Spectrometry, Mass Spectrometry

Organic compounds: Gas or Liquid Chromatography (GC/LC) coupled to a variety of detectors, such as Electron Capture Detectors or Mass Spectrometry, atomic adsorption.

TOC: Elemental Analyser

Particle fractions: in-house mesh validated methods (for < 2 mm) and/or geological sieving methods.

Additional parameters to be recorded: biometrics (size/length, age), biological parameters such as condition index (mussels), condition factor according established protocols and scientific knowledge.</td></tr>
<tr><td colspan="2">Indicator units

Trace/Heavy Metals (TM) and Aluminium: mass/dry or wet weight mass of sample according MEDPOL Database Format Protocols. The dry/wet mass ratios should be calculated and reported.

Organic compounds (OCs): mass/dry or wet weight mass of sample according MEDPOL Database Format Protocols. The dry/wet mass ratios should be calculated and reported.

TOC: Elemental Analyser (as %)

Particle fractions (as %)</td></tr>
<tr><td colspan="2">List of Guidance documents and protocols available</td></tr>
</table>

Indicator Title	Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)

Refer to UNEP Methods and Protocols for Marine Pollution, as well as from other recent documents from regional conventions (e.g. OSPAR) and European Guidelines, such as the Guidance Document No. 33 ON ANALYTICAL METHODS FOR BIOTA MONITORING UNDER THE WATER FRAMEWORK DIRECTIVE, Technical Report - 2014 – 084, ISBN 978-92-79-44679-5.

Data Confidence and uncertainties

Selected analytical methods and measurements are subject to internal Quality Assurance through National Laboratories QA/QC Protocols and Laboratory accreditations, as well as external Quality Assurance by performing regional interlaboratory QA/QC exercises organized by the UNEP/MAP MED POL/IAEA MESL.
Uncertainties in marine data measurements are identified at different levels (cumulative): analytical level (by use of Certified Reference Materials), reporting level (by providing averaged values and the associated uncertainties), database flagging level (primarily according the analytical and reporting compliance, number of non-detected values and levels, fulfilment of the QA/QC Protocols and Interlaboratory Exercises).

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

In line with the Ecosystem Approach and the IMAP implementation, there are considerable benefits to be gained from taking advantage of previous knowledge and information developed through the UNEP/MAP MED POL. These actions include (1) the use of existing experience in the design of monitoring programmes, (2) the use of existing guidance on sampling and analytical methods to inform technical aspects of ecosystem approach monitoring, (3) the use of existing sampling station networks as a framework for the ecosystem approach monitoring networks, (4) the use of existing statistical assessment tools and work on assessment criteria as the basis for the assessments of ecosystem approach data, (5) the use of existing data to describe the distributions and levels of contaminants against EACs and reference concentrations, and (6) the use of existing time series as the basis of monitoring against a “no deterioration” target. The availability of quality assured data is of importance for the assessment of trends and levels and their comparability overtime and across spatial scales.

Available data sources

i. UNEP(DEPI)/MED WG.365/Inf.5. Analysis of the trend monitoring activities and data for the MED POL Phase III and IV (1999-2010). Consultation Meeting to Review MED POL Monitoring Activities. Athens, 22-23 November 2011.
ii. UNEP(DEPI)/MED WG. 365/Inf.8. Development of assessment criteria for hazardous substances in the Mediterranean. Consultation Meeting to Review MED POL Monitoring Activities. Athens, 22-23 November 2011.
iii. UNEP(DEPI)/MED WG. 427/Inf.3. Background to the Assessment Criteria for Hazardous Substances and Biological Markers in the Mediterranean Sea Basin and its Regional Scales.
iv. Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring Marseille, France, 19-21 October 2016.

Spatial scope guidance and selection of monitoring stations

The spatial scope for monitoring should include reference and coastal long-term master stations, including offshore, distributed spatially as relevant and include local spatial refinements, such as transect sampling (for sediment and/or active biomonitoring); and therefore, is a direct function of the risk-based assessments and the long-term monitoring purposes. The selection of the sampling sites for the monitoring of contaminants in the marine environment should consider:

• Risk areas of concern identified on the basis of the review of the existing information.

Indicator Title	Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)

• Vulnerable areas of known past and/or present release of chemical contaminants.
• Offshore areas where risk warrants coverage (aquaculture, offshore oil and gas activity, dredging, mining, dumping at sea and others).
• Monitoring sites representative of other sources, such as shipping and atmospheric inputs.
•Reference monitoring sites: to establish scale-based reference values and background concentrations.
• Monitoring sites representing sensitive pollution sites/areas at national and sub regional scale.
• Monitoring sites in deep-sea sites, offshore stations (sediments) and areas of potential particular concern.

The selected sites should allow the collection of a realistic number of samples over the years (e.g. to be suitable for sediment sampling, to allow sampling a sufficient number of biota for the selected species during the duration of the programme). It is essential that the monitoring strategies are being coordinated at regional and/or sub regional level. The coordination with the monitoring networks for other Ecological Objectives is crucial for cost-effective and future IMAP integrated assessment.

Temporal Scope guidance

Sampling frequencies will be determined according the current status of the national marine monitoring.

INITIAL PHASE MONITORING: to identify key sampling sites/stations within a coastal network which should include: BIOTA samples (bivalves, e.g. *Mytilus galloprovincialis*, *Donax trunculus*, etc. (yearly collection) and fish (i.e. *Mullus barbatus* every 4 years. In this phase monitoring SEDIMENTS (coastal, platform should be collected every two years

ADVANCED PHASE MONITORING (when there is a fully completed MED POL Phase IV implementation with the ongoing reporting of datasets) should include: BIOTA (from 1 to 3 years according the trends and levels of chemicals assessed at the different stations/sites) and SEDIMENTS (from 3 to 6 years depending on the characteristics of sedimentation areas and the chemical concerned known through previous MED POL assessments).

The temporal scope may range from seasonally variable parameters up to large time scales, e.g. sediment core monitoring (years to decades). For temporal trend determinations the sampling frequencies will depend on the ability to detect trends considering the environmental and the analytical variability (ca. total uncertainty). It can be possible to decrease the sampling frequencies and target chemicals in cases where established time trends and levels show concentrations well below levels of concern, and without any upward trend over a number of years (including the stations/sites where recurrently exhibit non-detected contaminants value; that is below detection and quantification limits).

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

Monitoring should allow the necessary statistical data treatments and long-term time-trend data analysis.

Expected assessments outputs

For chemical contaminants, trends analysis and distribution levels for the assessment could be carried out on sub-regional and/or regional level, provided appropriate quality control assured datasets are available. For the assessment of GES, it would be carried out using Mediterranean data from the MEDPOL database and applying a two-level threshold classification (Background Assessment Criteria-BACs and Environmental Assessment Criteria-EACs), such as the OSPAR methodology. However, the revised Mediterranean BACs and EACs for chemical contaminants, such as trace metals

Indicator Title	Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)	
(mercury, cadmium and lead) and organic contaminants (chlorinated compounds and PAHs) in sediments and biota in the Mediterranean Sea should be applied.		
Known gaps and uncertainties in the Mediterranean Important development areas in the Mediterranean Sea over the next few years will include harmonization of monitoring targets (determinants and matrices) within assessment at sub-regions scales, development of suites of assessment criteria, integrated chemical and biological assessment method developments, and review of the scope of the national monitoring programmes to ensure that those contaminants which are considered to be important within each assessment area are included. Through these and other actions, it will be possible to develop targeted and effective monitoring programmes tailored to meet the needs and conditions within each GES assessment sub-region.It has been recognized that the open and deep sea is much less covered by monitoring efforts than coastal areas. There is a need to include within monitoring programmes also areas beyond the coastal areas in a representative and efficient way (where risks warrant coverage).		
Contacts and version Date		
http://www.unepmap.org		
Version No	**Date**	**Author**
V.1	31.05.17	MEDPOL
V.2	11.09.17	MEDPOL
V.2	12.12.18	MEDPOL
V.4~~Final version~~	31/05/2019	Approved by the Meeting of MED POL FPs
Final version	09/09/2019	Approved by the 7th Meeting of EcAp Coordination Group

1.4 Common Indicator 18

4. The update for **Common Indicator 18 (EO9)**: Level of pollution effects of key contaminants where a cause and effect relationship has been established[9] is presented in below table.

<table>
<tr><td>Indicator Title</td><td colspan="2">Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)</td></tr>
<tr><td>Relevant GES definition</td><td>Related Operational Objective</td><td>Proposed Target(s)</td></tr>
<tr><td>Concentrations of contaminants are not giving rise to acute pollution events</td><td>Effects of released contaminants are minimized</td><td>Contaminants effects below threshold
Decreasing trend in the operational releases of oil and other contaminants from coastal, maritime and off-shore activities.</td></tr>
<tr><td colspan="3">Rational</td></tr>
<tr><td colspan="3">Justification for indicator selection

Upon exposure to certain dose of harmful contaminants, marine organisms start manifesting a number of symptoms that are indicative of biological damage, the first ones appearing after a short while at the sub-cellular level. These ’sub lethal’ effects, when integrated, often converge to visible harm for the organisms and possibly to the whole population at a later stage, when it will be too late to limit the extent of biological damage resulting from environmental chemical exposure and ecosystems deterioration. Most of these symptoms have been reproducibly obtained in the laboratory (at high dose) and the various biological mechanisms of response to major xenobiotics are now sufficiently well documented. In the latest decades, scientific research has been intensified towards these alternative cellular and sub-cellular methods for integrated pollution monitoring, despite it revealed a more complex panorama with samples exposed to environmental concentrations, which includes a number of confounding factors hindering the cost-effective and reliable determination of biological effects at cellular and sub-cellular levels. As a consequence, most of these methods (biomarkers), based on the chemical exposure to biological effects cause relationships, are envisaged to monitor hotpots stations, dredging materials assessments and local damage evaluations rather than for continuous long-term environmental monitoring (surveillance). Ongoing research (biomarkers, bioassays) and future research trends, such as ‘omics’ developments, will further define the indicators and the methodologies for these common indicators for toxicological effects.</td></tr>
<tr><td colspan="3">Scientific References

i. European Commission, 2014. Technical report on aquatic effect-based monitoring tools. Technical Report - 2014 – 077.
ii. Davies, I. M. And Vethaak, A.D., 2012. Integrated marine environmental monitoring of chemicals and their effects. ICES Cooperative Research Report N).
iii. Moore, M.N. (1985), Cellular responses to pollutants. Mar.Pollut.Bull., 16:134-139
iv. Moore, M.N. (1990), Lysosomal cytochemistry in marine environmental monitoring. Histochem J., 22:187-191
v. Scarpato, R., L. Migliore, G. Alfinito-Cognetti and R. Barale (1990), Induction of micronuclei in gill tissue of Mytilusgalloprovincialisexposed to polluted marine waters Mar.Pollut.Bull., 21:74-80</td></tr>
</table>

[9]MSFD Descriptor 8: Concentrations of contaminants are at levels not giving rise to pollution effects

Indicator Title	Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)

vi. Lowe, D., M.N. Moore and B.M. Evans (1992), Contaminant impact on interactions of molecular probes with lysosomes in living hepatocytes from dab *Limandalimanda. Mar.Ecol.Progr.Ser.*, 91:135-140

vii. Lowe, D.M., C. Soverchia and M.M. Moore (1995), Lysosomal membrane responses in the blood and digestive cells of mussels experimentally exposed to fluoranthene. *Aquatic Toxicol.*, 33:105-112

viii. George, S.G. and Per-Erik Olsson (1994), Metallothioneins as indicators of trace metal pollution in Biomonitoring of Coastal Waters and Estuaries, edited by J.M. Kees. Boca Raton, FL 33431, Kramer CRC Press Inc., pp.151-171

Policy Context and targets

Policy context description

In most Mediterranean countries, the monitoring of a range of hazardous chemical substances in different marine compartments are undertaken in response to the UNEP/MAP Barcelona Convention (1976) and its Land-Based Protocol, through the coordination of the UNEP/MAP MED POL Monitoring Program. For Mediterranean EU countries, the European legislation on the Marine Environment also applies (e.g. EU WFD and EU MSFD), as well as other international and national policy drivers. A considerable amount of founding knowledge and actions are available through the pollution monitoring and assessment component of the UNEP/MAP MED POL Programme during the past decades until today, including monitoring pilot programmes (Eco-toxicological effects of contaminants). The environmental assessments have been used for the identification and confirmation of significant marine contaminants effects on biota and therefore, impacts on biodiversity; as well as, for the continuous development of monitoring strategies and guidance. With respect to the Ecosystem Approach and IMAP, their implementation will continue under the benefits gained from this past knowledge and the policy and practical framework built in the Mediterranean Sea.

Targets

Initial targets of GES under Common Indicator 18 will be based upon data of a selected biological effects parameters and biomarkers (reflecting the scope of current programmes and research, see Indicator Justification above) and the availability of suitable agreed assessment criteria.

Policy documents

General Policy documents

i. 19th COP to the Barcelona Convention, Athens, Greece, 2016. Decision IG.22/7 - Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria (UNEP(DEPI)/MED IG.22/28)

ii. 19th COP to the Barcelona Convention, Athens, Greece, 2016.Draft Integrated Monitoring and Assessment Guidance (UNEP(DEPI)/MED IG.22/Inf.7)

iii. 18th COP to the Barcelona Convention, Istanbul, Turkey, 2013.Decision IG.21/3 - Ecosystems Approach including adopting definitions of Good Environmental Status (GES) and Targets. UNEP(DEPI)/MED IG.21/9

iv. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

v. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

Contaminants related Policy documents

Indicator Title	Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)

vi. UNEP (1997), The MED POL Biomonitoring Programme Concerning the Effects of Pollutants on Marine Organisms Along the Mediterranean Coasts. UNEP(OCA)/MED WG.132/3, Athens, 15 p.
vii. UNEP (1997), Report of the Meeting of Experts to Review the MED POL Biomonitoring Programme. UNEP(OCA)/MED WG.132/7, Athens, 19 p.
viii. Targets: UNEP(DEPI)/MED WG.421/Inf.9. Integrated Monitoring and Assessment Guidance. Agenda item 5.7: Draft Decision on Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria. Meeting of the MAP Focal Points. Athens, Greece, 13-16 October 2015.

Indicator analysis methods

Indicator Definition

In marine bivalves (such as *Mytilusgalloprovincialis*) and/or fish (such as *Mullus barbatus*)

Lysosomal Membrane Stability (LMS) as a method for general status screening.
Acetylcholinesterase (AChE) assay as a method for assessing neurotoxic effects in aquatic organisms.

Micronucleus assay as a tool for assessing cytogenetic/DNA damage in marine organisms.
Sub-indicators: complementary biomarkers, bioassays and histology techniques and methods are also recommended to be carried out on a country basis (such as, hepatic pathologies assessment, reduction of survival in air by Stress on Stress (SoS), larval embryotoxicity assay, Comet assay, etc.). Metallothionnein in mussels and Ethoxyresorufin-O-deethylase (EROD) activity in fish as a biomarker of chemical exposures.

The biochemical parameters and toxicological measurements above will be used to develop the IMAP Info System which will include Data Dictionaries (DDs) and Data Standards (DSs) for CI18 accordingly.

Methodology for indicator calculation

Lysosomal Membrane Stability (LMS): Biological techniques (neutral red retention), including microscopy

Acetylcholinesterase (AChE) assay: Biochemical techniques, including spectrophotometry

Micronucleus assay: Biochemical techniques, including microscopy

Additional parameters to be recorded: biometrics (size/length, age), biological parameters such as condition index (mussels), condition factor, gonadosomatic index, hepatosomatic index (fish) and data on temperature, salinity and oxygen dissolved.

Indicator units

(retention) minutes - Lysosomal Membrane Stability (LMS)
nmol/min mg protein in gills (bivalves) - Acetylcholinesterase (AChE) assay
Number of cases, ‰ in haemocytes - Micronucleus assay

List of Guidance documents and protocols available

i. European Commission, 2014. Technical report on effect-based monitoring tools. Technical Report 2014 – 077. European Commission, 2014.

Indicator Title	Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)

ii. UNEP/RAMOGE: Manual on the Biomarkers Recommended for the UNEP/MAP MED POL Biomonitoring Programme. UNEP, Athens, 1999.
iii. UNEP/MAP, 2005. Fact sheets on Marine Pollution Indicators. Meeting of the UNEP/MAP MED POL National Coordinators. Barcelona, Spain, 24-27 May 2005. UNEP(DEC)/MED/ WG.264/ Inf.14. UNEP, Athens.
iv. ICES Cooperative Research Report. No.315. Integrated marine environmental monitoring of chemicals and their effects. I.M. Davies and D. Vethaak Eds., November 2012.

Data Confidence and uncertainties

Selected analytical validated methods should be subject to Quality Assurance Protocols and interlaboratory exercises: QA/QC through UNEP/MAP MED POL intercalibration supported exercises in agreement with University of Piemonte Orientale (Italy).

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

With regard the Ecosystem Approach and IMAP implementation, there are considerable benefits to be gained from taking advantage of previous knowledge and information developed through the UNEP/MAP MED POL. These actions include (1) the use of existing experience in the design of monitoring programmes, (2) the use of existing guidance on sampling and analytical methods to inform technical aspects of ecosystem approach monitoring, (3) the use of existing sampling station networks as a framework for the ecosystem approach monitoring networks, (4) the use of existing statistical assessment tools and work on assessment criteria as the basis for the assessments of ecosystem approach data, (5) the use of existing data to describe the distributions and levels of contaminants and effects against EACs and reference concentrations , and (6) the use of existing time series as the basis of monitoring against a "no deterioration" target. The availability of quality assured data is of importance for the assessment of levels and trends, and thus, their comparability overtime and across spatial scales. Therefore, based on the work already carried out, the results of the intercalibration exercises and the scientific and technical publications within the UNEP/MAP MED POL programme on biological effects monitoring, there is a network of laboratories in the Mediterranean region with the capacity to carry out biological effects monitoring activities, in line with the monitoring requirements. Available guidelines and monitoring protocols can be found in the framework of other Regional Seas Conventions (e.g. OSPAR) as well.

Available data sources

i. MED POL Database.
ii. UNEP/RAMOGE: Manual on the Biomarkers Recommended for the UNEP/MAP MED POL Biomonitoring Programme. UNEP, Athens, 1999.
iii. ICES Cooperative Research Report, No 315, November 2012. Integrated marine environmental monitoring of chemicals and their effects. Ed. Ian M. Davis and Dick Vethaack.

Spatial scope guidance and selection of monitoring stations

The spatial scope for monitoring should include reference and coastal long-term master stations, including offshore, distributed spatially as relevant and include local spatial refinements, such as transect sampling, and therefore, is a direct function of the risk-based assessments and the long-term monitoring purpose. The selection of the sampling sites for the monitoring of biological effects in the marine environment should consider:

• Risk areas of concern identified on the basis of the review of the existing information.

Indicator Title	Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)

• Vulnerable areas of known past and/or present release of chemical contaminants.
• Offshore areas where risk warrants coverage (aquaculture, offshore oil and gas activity, dredging, mining, dumping at sea and others).
• Monitoring sites representative of other sources, such as shipping and atmospheric inputs.
• Reference monitoring sites: to establish scale-based reference values and background concentrations.
• Monitoring sites representing sensitive pollution sites/areas at national and sub regional scale.
• Monitoring sites in deep-sea sites, offshore stations (sediments)and areas of potential particular concern

The selected sites should allow the collection of a realistic number of samples over the years (e.g. allow to sample sufficient number of biota for the selected species during the duration of the programme). It is essential that the monitoring strategies are being coordinated at regional and/or sub regional level, in particular with chemical monitoring. The coordination with monitoring for other Ecological Objectives is crucial for cost-effective and future integrated assessment.

Temporal Scope guidance

Sampling frequencies will be determined according the current status of the pilots and national marine monitoring programmes:

INITIAL PHASE MONITORING (PILOT): to identify monitoring stations to collect BIOTA (bivalves, such as *Mytilus galloprovincialis*,) on a yearly basis (or higher frequencies if the environmental variability study needs to be carried out), and in the same manner as for chemical monitoring, focusing on few locations such as hotspots and reference stations.
ADVANCED PHASE MONITORING: when fully completed and reported MED POL Phase IV datasets, including biological effects is achieved, then, at this stage the objective should be the integration of the chemical and biological monitoring on a efficient manner. Therefore, a refinement of the successful strategies for biological effects long-term monitoring should be implemented and maintained based on the experiences from developing pilot monitoring activities (Initial Phase).

For trend determinations the sampling frequencies will depend on the ability to detect trends considering the environmental and the analytical variability (ca. total uncertainty). It can be possible to decrease the sampling frequencies in cases where established time trends and levels show concentrations well below levels of concern, and without any upward trend over a number of years.

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

Monitoring should allow the necessary statistical data treatments and long-term time-trend analysis.

Expected assessments outputs

For biological effects, trends analysis and distribution levels could be carried out on sub-regional level, provided appropriate quality assured datasets are available. For the integrated assessment of GES, it would be carried out using Mediterranean data from the MEDPOL database and applying a two-level threshold classification (such as the OSPAR methodology). Assessing biomarker responses against Background Assessment Criteria (BACs) and Environmental Assessment Criteria (EACs) allows establishing if the responses measured are at levels that are not causing deleterious biological effects, at levels where deleterious biological effects are possible or at levels where deleterious biological effects are likely in the long-term. In the case of

<table>
<tr><td>Indicator Title</td><td colspan="2">Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)</td></tr>
<tr><td colspan="3">biomarkers of exposure, only BAC can be estimated, whereas for biomarkers of effects both BAC and EAC can be established.</td></tr>
<tr><td colspan="3">Known gaps and uncertainties in the Mediterranean

Important development areas in the Mediterranean Sea over the next few years will include harmonization of monitoring targets (determinants and matrices) within assessment sub-regions, development of suites of assessment criteria integrated chemical and biological assessment methods, and review of the scope of the monitoring programmes to ensure that those contaminants which are considered to be important within each assessment area are included in monitoring programmes. Through these and other actions, it will be possible to develop targeted and effective monitoring programmes tailored to meet the needs and conditions within each GES assessment sub-region.
It has been recognized that the open and deep sea is much less covered by monitoring efforts than coastal areas. There is a need to include within monitoring programmes also areas beyond the coastal areas in a representative and efficient way, where risks warrant coverage.</td></tr>
<tr><td colspan="3">Contacts and version Date</td></tr>
<tr><td colspan="3">http://www.unepmap,org</td></tr>
<tr><td>Version No</td><td>Date</td><td>Author</td></tr>
<tr><td>V.1</td><td>31.05.17</td><td>MEDPOL</td></tr>
<tr><td>V.2</td><td>12.12.18</td><td>MEDPOL</td></tr>
<tr><td>V.3~~Final version~~</td><td>31/05/2019</td><td>Approved by the Meeting of MED POL FPs</td></tr>
<tr><td>Final version</td><td>09/09/2019</td><td>Approved by the 7th Meeting of EcAp Coordination Group</td></tr>
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1.5 Common Indicator 20

5. The update for **Common Indicator 20 (EO9):** Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood[10] i's presented in below table.

Indicator Title	Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Concentrations of contaminants are within the regulatory limits for consumption by humans.	Levels of known harmful contaminants in major types of seafood do not exceed established standards	1. Concentrations of contaminants are within the regulatory limits set by legislation.
Rational		
Justification for indicator selection One of the potential risks associated with the occurrence of harmful substances (chemicals, nanoparticles, microplastics, toxins) in the marine environment is the human exposure through commercial fish and shellfish species (primarily, from wild fisheries and aquaculture). These organisms are exposed to environmental contaminants which enter their organism through different mechanisms and pathways according their thropic level, which include from filter feeding to predatory strategies (crustaceans, bivalves, fish). Consequently, there exist both bioaccumulation and biomagnification processes of these chemicals released in the marine environment. Common examples are the well-known bioaccumulation of metals and organic compounds in commercial bivalve species (such as the *Mytillusgalloprovincialis* in the Mediterranean Sea) or alkyl mercury compounds (methylmercury) in tuna fish, which should be increased by new and emerging contaminants in the near future.		
Scientific References i. Vandermeersch, G. *et al.* 2015. Environmental contaminants of emerging concern in seafood – European database on contaminant levels. Environmental Research, 143B, 29-45. ii. Maulvault, A.M. *et al.* 2015. Toxic elements and speciation in seafood samples from different contaminated sites in Europe. Environmental Research, 143B, 72-81. iii. Molin, M. *et al.*, 2015. Arsenic in the human food chain, biotransformation and toxicology – Review focusing on seafood arsenic. Journal of Trace Elements in Medicine and Biology, 31, 249-259. iv. Bacchiocchi, S. *et al.* 2015. Two-year study of lipophilic marine toxin profile in mussels of the North-central Adriatic Sea: First report of azaspiracids in Mediterranean seafood. Toxicon, 108, 115-125. v. Perello, G. *et al.*, 2015. Human exposure to PCDD/Fs and PCBs through consumption of fish and seafood in Catalonia (Spain): Temporal trend. Food and Chemical Toxicology, 81, 28-33. vi. Zaza, S. *et al.* 2015. Human exposure in Italy to lead, cadmium and mercury through fish and seafood product consumption from Eastern Central Atlantic Fishing Area. Journal of Food Composition and Analysis, 40, 148-153. vii. Cruz, R. Brominated flame retardants and seafood safety: A review. Environment International, 77, 116-131. viii. Dellate, E. *et al.* 2014. Individual methylmercury intake estimates from local seafood of the Mediterranean Sea, in Italy. Regulatory Toxicology and Pharmacology, 69, 105-112.		

[10]MSFD Descriptor 9: Contaminants in fish and other seafood for human consumption do not exceed levels established by Union legislation or other relevant standards

Indicator Title	Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9)

ix. Spada, L. *et al.* 2014. Mercury and methylmercury concentrations in Mediterranean seafood and surface sediments, intake evaluation and risk for consumers. International Journal of Hygiene and Environmental Health, 215, 418-42.

Policy Context and targets

Policy context description

The understanding of the health risks to humans (maximum levels, intake, toxic equivalent factors, etc.) and the food safety prevention, including emerging contaminants, through the consumption of potentially poisoned seafood is a challenge and a priority policy issue for governments, as well as a major societal concern. There are different initiatives and regulations at national and international levels mainly for the fishery economic sector, which have established public health recommendations and maximum regulatory levels for different contaminants in numerous marine commercial target species. Methylmercury poisoning continues as a global priority policy issue and in 2013 the Global Legally Binding Treaty (Minamata Convention on Mercury) was launched by UNEP. Further, the US Food and Drugs Administration, the European Food Safety Authority, as well as Food and Agriculture Organization (FAO), are also national and international authorities with regard seafood safety, respectively.

Targets

Initial targets of GES under Common Indicator 20 will be to maintain the chemical contaminants of human health concern under regulatory levels in seafood set/recommended/agreed by national and/or international authorities and their trends with regard their occurrence should decrease pointing towards zero events.

Policy documents

General Policy documents

i. 19th COP to the Barcelona Convention, Athens, Greece, 2016. Decision IG.22/7 - Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria (UNEP(DEPI)/MED IG.22/28)
ii. 19th COP to the Barcelona Convention, Athens, Greece, 2016.Draft Integrated Monitoring and Assessment Guidance (UNEP(DEPI)/MED IG.22/Inf.7)
iii. 18th COP to the Barcelona Convention, Istanbul, Turkey, 2013.Decision IG.21/3 - Ecosystems Approach including adopting definitions of Good Environmental Status (GES) and Targets. UNEP(DEPI)/MED IG.21/9
iv. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).
v. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

Contaminants related Policy documents

vi. EU 1881/2006. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. European Commission.
vii. US FDA http://www.fda.gov/Food/FoodborneIllnessContaminants/Metals/ucm115644.htm
viii. Joint FAO/WHO Expert consultation on the risk and benefits of fish consumption. FAO Fisheries and Aquaculture Report No. 978. ISSN 2070-6987. Rome, January, 2010.
ix. List of maximum levels for contaminants in foods set by the FAO/WHO Codex Alimentarius Commission can be found at ftp://ftp.fao.org/codex/Meetings/cccf/cccf7/cf07_INFe.pdf

Indicator Title	Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9)

x. Global Legally Binding Treaty (Minamata Convention on Mercury) http://www.mercuryconvention.org/

Indicator analysis methods

Indicator Definition

Number of detected regulated contaminants* in commercial species.

Number of detected regulated contaminants* exceeding regulatory limits.

(*lists of regulated contaminants can be found in the links from the previous section, including the European Regulation EU 1881/2006)

Additional parameters required: sample identification, location, date and biometrics

Sub-indicators: other relevant chemicals and emerging pollutants are recommended to be carried out on a country decision basis.

The chemical compounds list, as in the case of CI17, accompanies the development of the IMAP Info System along Data Dictionaries (DDs) and Data Standards (DSs) for CI20.

Methodology for indicator calculation

Number of detected contaminants: monitoring by national regulatory and inspection bodies through statistics and databases

Number of detected contaminants exceeding regulatory limits: monitoring by national regulatory and inspection bodies through statistics and databases

Indicator units

(frequencies, %) - Number of detected contaminants in individual commercial species

(Frequencies, %) - Number of detected contaminants exceeding regulatory limits in appropriate units, for example, mg/kg fresh weight (parts per million, ppm, and fresh weight) or µg/g fresh weight (part per billion, ppb, fresh weight).

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

There are no directly-applicable monitoring protocols in order to fulfil the requirement of this Common Indicator. Risk-based public health methodologies to define the monitoring are recommended.

Available data sources

At present national databases (if available), research papers and environmental databases (the MED POL Database)

Spatial scope guidance and selection of monitoring stations

Risk-based methodologies to define monitoring are recommended.
Guidance for monitoring stations: environmental monitoring, fish markets, aboard fishing fleets, sampling at regular inspections by national authorities

Temporal Scope guidance

Indicator Title	Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9)	
Risk-based methodologies to define monitoring are recommended. The temporal scope is highly linked to the data confidence and uncertainty of the indicator. Yearly statistics would be the basic time period.		
Data analysis and assessment outputs		
Statistical analysis and basis for aggregation Monitoring should allow the necessary statistical data treatments and long-term time-trend evaluations. Geographic reporting scales (within IMAP implementation) should be also considered in terms of indictor aggregation: (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		
Expected assessments outputs Assessment outputs would be based on trend analysis and annual statistics		
Known gaps and uncertainties in the Mediterranean As this is a new Common Indicator within the context of marine environmental protection policy (*ca*. Ecosystem Approach and IMAP implementation) its applicability beyond food consumer protection and public health would need to be determined, although intuitively reflects the health status of the marine environment in terms of their delivery of benefits (e.g. fisheries industry). Thus, monitoring protocols, risk-based approaches, analytical testing and assessment methodologies would need to be further examined between Contracting Parties national food safety authorities, research organisations and/or environmental agencies.		
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Version No	**Date**	**Author**
V.1	31.05.17	MED POL
V.2	12.12.18	MED POL
V.3~~Final version~~	31/05/2019	Approved by the Meeting of MED POL FPs
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1.6 Common Indicator 21

6. The update for **Common Indicator 21 (EO9)**: Percentage of intestinal enterococci concentration measurements within established standards is presented in below table.

Indicator Title	Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Concentrations of intestinal enterococci are within established standards	Water quality in bathing waters and other recreational areas does not undermine human health	Increasing trend in the percentage of intestinal enterococci concentration measurements within established standards

Indicator Title	Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)

Rational

Justification for indicator selection

The Mediterranean Sea continues to attract every year an ever-increasing number of international and local tourists that among their activities use the sea for recreational purposes. The establishment of sewage treatment plants and the construction of submarine outfall structures have decreased the potential for microbiological pollution, despite major hotpots still exist. High levels of intestinal enterococci bacteria in recreational marine waters (coasts, beaches, tourism spots, etc) are known to be indicative of human pathogens, which is a serious public health concern, as well as economical. Therefore, intestinal enterococci concentrations are frequently used as a faecal indicator bacteria proxy or general indicators of faecal contamination in the marine environment. It has been suggested and later on demonstrated that *enterococci sp*. might be more appropriate than traditional *Escherichia coli* in marine waters as an index of faecal pollution. Currently, is the only faecal indicator bacteria recommended by the US Environmental Protection Agency (US EPA, 2012) for brackish and marine waters, since they correlate better than faecal coliforms or *E.coli*. The World Health Organization (WHO) is also in line with this approach (Ashbolt et al., 2001; Kay et al., 2004). Within the framework of Integrated Monitoring and Assessment Programme (UN/MAP IMAP) this indicator has been selected.

Scientific References

i. Ashbolt, N.J., Grabow, W.O.K, and Snozzi, M., 2001. Indicators of microbial water quality, Chapter 13. In: Water Quality: Guidelines, Standards and Health. 2001 World Health Organization (WHO). Edited by Lorna Fewtrell and Jamie Bartram. Published by IWA Publishing, London, UK.
ii. Cabelli VJ, Dufour AP, Levin MA, McCabe LJ, Haberman PW. 1979. Relationship of microbial indicators to health effects at marine bathing beaches. Am. J. Public Health, 69, 690–696
iii. Byappanahalli, MN. *et al*., 2012. Enterococci in the environment. Microbiol. Mol. Biol.Rev., 76, 685-706
iv. Kay, D. et al, 2004. Derivation of numerical values for the World Health Organization guidelines for recreational waters. Water Research 38 (2004) 1296–1304
v. Kay D, *et al*. 1994. Predicting likelihood of gastroenteritis from sea bathing: results from randomised exposure. Lancet, 344, 905–909
vi. Prüss A. 1998. Review of epidemiological studies on health effects from exposure to recreational water. Int. J. Epidemiol., 27, 1–9
vii. US EPA RWQC 2012. Recreational Water Quality Criteria. OFFICE OF WATER 820-F-12-058. Scientific document.

Policy Context and targets

Policy context description

The World Health Organisation (WHO) has been concerned with health aspects of the management of water resources for many years and published various documents concerning the safety of the water environment, including marine waters, and its importance for health. Revised Mediterranean guidelines for bathing water quality were formulated in 2007 based on the WHO guidelines for “Safe Recreational Water Environments” and on the EC Directive for “Bathing Waters” (EU/2006/7), and through Decision IG.20/9 (Criteria and Standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol. COP17, Paris, 2012). The proposal was made in an effort to provide updated criteria and standards that can be used in the Mediterranean countries and to harmonize their legislation in order to provide homogenous data. Therefore, the standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol, could be further used to define GES for the indicator on pathogens in bathing waters.

Targets

Indicator Title	Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)

Initial target of GES under Common Indicator 21 will be an increasing trend in measurements to test that levels of intestinal enterococci comply with established national or international standards and the methodological approach itself. Particularly, under Decision IG.20/9 and the EU 2006/7 Directive, excellent (95^{th} percentile < 100 CFU/100 mL) or good (95^{th} percentile < 200 CFU/100 mL) qualitycategories for the "last assessment"; which means the last four years (see documents below)

Policy documents

General Policy documents

i. 19th COP to the Barcelona Convention, Athens, Greece, 2016. Decision IG.22/7 - Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria (UNEP(DEPI)/MED IG.22/28)
ii. 19th COP to the Barcelona Convention, Athens, Greece, 2016.Draft Integrated Monitoring and Assessment Guidance (UNEP(DEPI)/MED IG.22/Inf.7)
iii. 18th COP to the Barcelona Convention, Istanbul, Turkey, 2013.Decision IG.21/3 - Ecosystems Approach including adopting definitions of Good Environmental Status (GES) and Targets. UNEP(DEPI)/MED IG.21/9
iv. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).
v. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

Contaminants related Policy documents

vi. UNEP(DEPI)/MED IG 20/8. Decision IG.20/9. Criteria and Standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol. COP17, Paris, 2012.
vii. UNE/MAP MED POL, 2010. Assessment of the state of microbial pollution in the Mediterranean Sea. MAP Technical Reports Series No. 170 (Amended).
viii. WHO, 2003. Guidelines for safe recreational water environments. VOLUME 1: Coastal and fresh waters. WHO Library. ISBN 92 4 154580. World Health Organisation, 2003.
ix. Directive 2006/7/EC of the European Parliament and of the council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0007&from=EN

Indicator analysis methods

Indicator Definition

The concentration (Colony-forming unit, CFU) of intestinal enterococci in the water sample (normalised to 100 mL) collected at one beach location.

Methodology for indicator calculation

A methodology has been proposed by Directive 2006/7/EC with the following specification:
Based upon percentile evaluation of the log10 normal probability density function of microbiological data acquired from the particular bathing water, the 90^{th} and 95^{th}percentile values are derived as follows:
1) Take the log10 value of all bacterial enumerations in the data sequence to be evaluated. (If a zero value is obtained, take the log10 value of the minimum detection limit of the analytical method used instead)
2) Calculate the arithmetic mean of the log10 values (μ).
3) Calculate the standard deviation of the log10 values (σ).

Indicator Title	Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)

The upper 90-percentile point of the data probability density function is derived from the following equation: upper 90-percentile = antilog (μ + 1,282 σ). The upper 95-percentile point of the data probability density function is derived from the following equation: upper 95-percentile = antilog (μ + 1,65 σ).

Indicator units

The 90th and 95th percentiles of the log10 normal probability density function of the CFU datasets measured at one single location according established monitoring and assessment protocols and standards.

List of Guidance documents and protocols available

i. ISO 7899-1[Water quality – Detection and enumeration of intestinal enterococci: Part 1: Miniaturized method (Most Probable Number) for surface and wastewater]
ii. ISO 7899-2 [Water quality – Detection and enumeration of intestinal enterococci: Part 2: Membrane filtration method].
iii. UNEP(DEPI)/MED IG 20/8. Decision IG.20/9. Criteria and Standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol. COP17, Paris, 2012.

Data Confidence and uncertainties

As in the case of analytical chemistry, the data confidence originates in the maintenance of internal QA/QC programmes by national laboratories, as well as regular interlaboratory or proficiency testing exercises. It should be mentioned that the level of uncertainty in measurements could be considered low, provided the above is fulfilled. On the other hand, the ISO 7899-2 methodology describes the isolation of intestinal enterococci (*Enterococcus faecalis, E. faecium, E. durans*and *E. hirae*), pointing out that, other Enterococcus species and some species of the genus Streptococcus (namely *S. bovis*and *S. equinus*) may occasionally be detected. These Streptococcus species do not survive long in water and are probably not enumerated quantitatively. Further, for purposes of water examination, *enterococci sp.* can be regarded as indicators of faecal pollution, despite it should be mentioned that some enterococci found in water can occasionally also originate from other habitats.

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

Revised Mediterranean guidelines for bathing waters were formulated in 2007 based on the WHO guidelines for "Safe Recreational Water Environments" and on the EC Directive for "Bathing Waters" (EU/2006/7), and through Decision IG.20/9 (Criteria and Standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol. COP17, Paris, 2012). The proposal was made in an effort to provide updated criteria and standards that can be used in the Mediterranean countries and to harmonize their legislation in order to provide homogenous data.

Available data sources

For some Mediterranean countries European and non-European, the European Environmental Agency (EEA) has published a number of reports and the datasets are available through their website services. https://www.eea.europa.eu/data-and-maps/indicators/bathing-water-quality

Spatial scope guidance and selection of monitoring stations

Sampling should be performed in recreational waters where microbiological pollution could threat the recreational uses. The measurements are made in selected monitoring stations during the summer season focusing in the touristic beaches and other sites of concern. The full description of indications to prepare a monitoring strategy can be found in Directive 2006/7/EC of the European Parliament and of the council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC.

Temporal Scope guidance

Indicator Title	Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)

According Annex IV (EU Directive 2006/7EC), the temporal scope guidance is as follows:

1. One sample is to be taken shortly before the start of each bathing season. Taking account of this extra sample and subject to paragraph 2 (below), no fewer than four samples are to be taken and analysed per bathing season.
2. However, only three samples need be taken and analysed per bathing season in the case of a bathing water that either:
(a) has a bathing season not exceeding eight weeks; or
(b) is situated in a region subject to special geographical constraints.
3. Sampling dates are to be distributed throughout the bathing season, with the interval between sampling dates never exceeding one month.
4. In the event of short-term pollution, one additional sample is to be taken to confirm that the incident has ended. This sample is not to be part of the set of bathing water quality data. If necessary to replace a disregarded sample, an additional sample is to be taken seven days after the end of the short-term pollution.

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

Monitoring should allow the necessary statistical data treatments, as well as time-trend evaluations. In order to comply with the stated Common Indicator within IMAP, the geographic reporting scales (nested approach) should be taken into account. However, the balance between data, locations and spatial resolution should be carefully considered for coherence in areas (1) and (2), as this Common Indicator is largely (if not entirely) evaluated in coastal waters (3) and (4):

(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

Expected assessments outputs

For pathogenic microorganisms in bathing water, monitoring for the assessment of GES could be carried out on a sub-regional and/or local level due to the nature of microbiological contamination (the impact is restricted to a relatively short distance from the pollution source due to the short survival time of microorganisms in seawater and dilution effects).

Distribution maps and temporal trend assessment (short periods) are also envisaged.

Known gaps and uncertainties in the Mediterranean

Within the context of Ecosystem Approach and IMAP implementation its applicability beyond bathing waters (recreational waters) protection and management would need to be determined, although intuitively reflects the health status of the coastal environment in terms of their delivery of benefits (e.g. tourism).

Contacts and version Date

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Version No	**Date**	**Author**
V.1	31.05.17	MED POL
V.2	12.12.18	MED POL
V.3	29.04.19	MED POL
V4~~Final version~~	31/05/2019	Approved by the Meeting of MED POL FPs

Indicator Title	Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)	
Final version	09/09/2019	Approved by the 7th Meeting of EcAp Coordination Group

Appendix VII

UNEP/MED WG.467/6
Indicator Guidance Factsheets for EO7 and EO8 Coast and Hydrography
Common Indicators 15, 16 and 25

UNITED NATIONS

EP

UNEP/MED WG.467/6

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

UNEP

8 August 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Agenda Item 7: Updated IMAP Guidance Factsheets for Common Indicators 13, 14, 15, 16, 17, 18, 20 and 21; New proposal for Candidate Indicators 25, 26 and 27

Indicator guidance factsheets for EO7 and EO8 Coast and Hydrography Common Indicators 15, 16 and 25

UNEP/MAP
Athens, 2019

Note by the Secretariat

The document reflects conclusions and recommendations of the CORMON meeting on Coast and Hydrography (Rome, Italy, 21-22 May 2019) for the Common Indicator (CI) 15 related to the Ecological Objective 7 (Hydrography), CIs 16 and 25 related to Ecological Objective 8 (Coastal Ecosystems and Landscape).

With regard to CI15 the CORMON agreed to replace the existing Guidance Factsheet with the one presented below with the following title: "Location and extent of the habitats potentially impacted by hydrographic alterations" so to reflect the precautionary principle and risk assessment approach. The indicator focuses on the assessment of physical loss including the footprint of the structures, permanent changes of seafloor and in addition permanent hydrographic changes of the surrounding area with a view to determining areas of potentially impacted habitats. Other parameters to be monitored (such as salinity and temperature) are structure-specific.

The request for development of this alternative version was expressed by several Contracting Parties at many occasions such as at the PAP/RAC Focal Points meetings, at Sub-regional meeting on Coast and Hydrography (December 2017), in comments on QSR assessment factsheets and in particular at the 6th EcAp Coordination Group meeting (September 2017). It is believed that current Common Indicator 15 is too complex and not mature enough to be implemented at the Mediterranean scale. It requires substantial financial, technical and human capacities that are not available in many Mediterranean countries. Some simplification of the Guidance Factsheet has been already done also by the EU (in the MSFD) what showed that the originally developed method for monitoring of hydrographic changes and related impacts on habitats was too ambitious.

With regard to CI 16 "Length of coastline subject to physical disturbance due to the influence of manmade structures" the CORMON agreed on minor changes to the Guidance Factsheet and in particular expressed the importance of the definition of GES. It emphasized that due to national circumstances such as socio-economic, historic, cultural and alike, a unique target and GES cannot be specified quantitatively (as a threshold value). It was therefore agreed that the definition of GES and related targets and measures should be left to the Contracting Parties taking legal obligations of the Barcelona Convention into account, in particular the ICZM Protocol.

The Meeting agreed on the removal of "*impervious surface in the coastal fringe (100m from the coastline)"* and "*the land claim, i.e. the surface area reclaimed from the 1980's onward (ha)"* from the list of criteria for calculation of this indicator. Minor adjustments to the Guidance Factsheet namely, replacement of the term 'manmade structures' with the term 'human made structures' to respect the gender-neutrality was endorsed by the Meeting.

Human induced coastal erosion was recognized as an important process affecting coastline, so the CORMON suggested developing a relevant indicator under this EO.

The CORMON meeting welcomed and endorsed the Guidance Factsheet for the CCI 25 "Land cover change" and proposed to put the on the IMAP List of Common Indicators. Convinced that this indicator is mature enough and that its monitoring is very important for the ecosystem approach implementation as well as for the reporting on the evolution and state of coastal zone as requested by the ICZM Protocol, this CCI 25 will also significantly contribute to the integration of the land and marine environment of coastal zones, i.e. to take LSI into account.

Similar to the CI 16, the Meeting agreed that the GES, targets and measures cannot be expressed quantitatively but, due to country specific circumstances (socio-economic, cultural, historical), should be defined by the countries themselves. In doing so the Contracting Parties should take their spatial development and planning policies into account, as well as the legal obligations of the Barcelona Convention, in particular the ICZM Protocol.

Finally following the approval by the SPA/BD Thematic Focal Points Meeting (Portorož, Slovenia, 18-21 June 2019) of the Reference List of Marine and Coastal Habitat Types in the Mediterranean, this list will be annexed to the Common Indicator Guidance Factsheet for CI 15, as an important integration element for EO1 And EO7, to ensure coherence and coordination in the work for populating and amending this indicator.

Table of Contents

1. Indicator guidance factsheet for the Common Indicator 15

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.	
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Negative impacts due to new structure are minimal with no influence on the larger scale coastal and marine system.	Alterations due to permanent constructions on the coast and watersheds, marine installations and seafloor anchored structures are minimised.	Planning of new structures takes into account all possible mitigation measures in order to minimize the impact on coastal and marine ecosystem and its services integrity and cultural/historic assets. Where possible, promote ecosystem health.
Rationale		

Justification for indicator selection

After agreeing to progressively apply the ecosystem approach (EcAp) to the management of human activities in the Mediterranean at the 15th Meeting of the Contracting Parties to the Barcelona Convention (COP15, 2008), the Contracting Parties agreed, at COP17 in 2012, on an overall vision and goals for EcAp, and on 11 ecological objectives for the Mediterranean. Among these ecological objectives was the Ecological Objective 7 („Alteration of hydrographical conditions“), with its clearly outlined operational objectives and indicators. EO7 corresponds to Descriptor 7 (Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems) of the European Marine Strategy Framework Directive (MSFD).

Ecological Objective 7 („Alteration of hydrographical conditions“) addresses permanent alterations in the hydrographical regime of currents, waves and sediments due to new large-scale developments that have the potential to alter hydrographical conditions. An agreed common indicator - 'Location and extent of habitats impacted directly by hydrographic alterations' considers marine habitats which may be affected or disturbed by changes in hydrographic conditions (currents, waves, suspended sediment loads).

There is a clear link between EO7 and other ecological objectives, especially EO1 (Biodiversity). Such link needs to be determined on a case-by-case basis. Refer to Annex 1 for habitats to be considered in EO7. Ultimately, the assessment of impacts, including cumulative impacts, is a cross-cutting issue for EO1 and EO7.

Scientific References

EC JRC (2015). Review of Commission Decision 2010/477/EU concerning MSFD criteria for assessing good environmental status Descriptor 7: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems

EMEC Ltd (2005). Environmental impact assessment (EIA) guidance for developers at the European Marine Energy Centre.

OSPAR Commission (2012). MSFD Advice document on Good environmental status - Descriptor 7: Hydrographical conditions. A living document - Version 17 January 2012.

OSPAR Commission (2013). Report of the EIHA Common Indicator Workshop.

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations

Royal Haskoning DHV (2012). Environmental Impact Assessment (EIA) and Appropriate Assessment (AA) Evaluation of assessment tools and methods. Lot 2: Analysis of case studies of port development projects in European estuaries. Tidal Rover Development (TIDE) Interreg IVB

Some reference and guidance documents on EIA can be found at : http://ec.europa.eu/environment/eia/eia-support.htm and in the „Guidance Document on how to reflect changes in hydrographical conditions in relevant assessments" (UNEP/MAP/PAP, 2015).

Policy Context and targets

Policy context description

Following the COP17 agreement on an overall vision and goals for EcAp, on 11 ecological objectives, operational objectives and indicators for the Mediterranean, a six-year cyclic review process of EcAp implementation was established (EcAp MED I 2012-2015), with the next EcAp cycle set to cover 2016-2021.

At COP18, in 2013, the targets for achieving GES of the Mediterranean Sea and its coastal zone by 2020 were adopted. In addition, through Decision IG. 21/3 (the so called "COP18 EcAp Decision") the EcAp roadmap was agreed on. The Contracting Parties also agreed to design an Integrated Monitoring and Assessment Programme (IMAP) by COP19, which would, for the first time, ensure a common assessment basis for the Mediterranean marine and coastal environment. At COP19, in 2016, the IMAP was adopted. The IMAP provides guidance to the parties on how to practically implement quantitative monitoring and assessment of the ecological status of the Mediterranean Sea and coast in line with the EcAp.

As part of the EcAp roadmap, expert-level monitoring discussions took place in the various Correspondence Groups on Monitoring (CORMONs) meetings on Biodiversity and Fisheries; Pollution and Litter; and Coast and Hydrography sub-clusters. An Integrated Correspondence Group on Monitoring Meeting (Integrated CORMON) took place on 30 March-1 April 2015, to discuss the main elements of the Integrated Monitoring and Assessment Programme.

As for Protocols of the Barcelona Convention relevant for the EO7, the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean calls to Contracting Parties of the Barcelona Convection for continuous monitoring of ecological processes, population dynamics, landscapes, as well as the impacts of human activities (Article 7 b). In addition, it calls to Parties to evaluate and take into consideration the possible direct or indirect, immediate or long-term impacts, including the cumulative impact of the projects and activities, on protected areas, species and their habitats (Article 17).

Another Protocol of the Barcelona Convention, the Protocol on the Integrated Coastal Zone Management in the Mediterranean, in its Article 9, calls for Parties to minimize negative impacts on coastal ecosystems, landscapes and geomorphology, coming from infrastructure, energy facilities, ports and maritime works and structures; or where appropriate to compensate these impacts by non-financial measures. In addition, the Article 9 demands maritime activities to be conducted "in such a manner as to ensure the preservation of coastal ecosystems in conformity with the rules, standards and procedures of the relevant international conventions".

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations

Out of other international legislation that can be relevant for the EO7 Ecological Objective, it is essential to mention Marine Strategy Framework Directive – MSFD 2008/56/EC since EcAp's EO7 corresponds to MSFD's Descriptor 7 to large extent. The hydrographical conditions outlined under the MSFD are, to a large extent, comparable to the hydromorphological conditions referred to under the Water Framework Directive (WFD) which calls for the protection of all water resources, including coastal waters. EO7 overlaps with other policy frameworks, such as the Environmental Impact Assessment (EIA) procedure on the assessment of the environmental impacts of certain public and private projects; the Strategic Environmental Assessment (SEA) procedure on the assessment of the effects of certain plans and programs on the environment; assessments undertaken under Marine Spatial Planning (MSP); and in the context of integrated coastal zone management (ICZM).

Targets

Planning of new structures takes into account all possible mitigation measures in order to minimize the impact on coastal and marine ecosystem and its services, integrity and cultural/historic assets. Where possible, promote ecosystem health.

Policy documents

Protocol on the ICZM in the Mediterranean - http://www.pap-thecoastcentre.org/pdfs/Protocol_publikacija_May09.pdf

Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean - http://www.rac-spa.org/sites/default/files/protocole_aspdb/protocol_eng.pdf

MSFD Directive - http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN

Other EU-related documents can be found at: http://ec.europa.eu/environment/eia/eia-support.htm

Indicator analysis methods

Indicator Definition

The EO7 Common Indicator reflects location and extent of the habitats potentially impacted by the alterations and/or the circulation changes induced by them. It concerns area/habitat and the proportion of the total area/habitat where alterations of hydrographical conditions are expected to occur (estimations by modelling or semi-quantitative estimation).

Methodology for indicator calculation

Methodology used for indicator measurement encompasses elaboration on:
(i) Mapping of area where human activities may cause permanent alterations of hydrographical conditions (using i.e. existing EIA, SEA and Maritime Spatial Planning -MSP); and
(ii) Mapping of habitats of interest in this area of hydrographical changes; and
(iii) Intersection of the spatial map of the areas of hydrographical changes with spatial maps of habitats to determine the areas of individual habitat types that are impacted by hydrographical changes.

New structures to be considered under EO7 assessment:

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations

As far as the type and dimension of structures to be taken into account: use the case by case approach depending on the nature of the coast, the function of the structure and the depth reached by the structure where appropriate threshold values are taken into account (such as absolute surface in m², range of depths where structure will be built (to avoid habitat "segmentation")). As an additional criterion it was agreed that all permanent structures, for which an EIA and/or a planning/building permit is required, should be considered.

Hydrographical conditions to be considered:

- At least, waves and currents changes (can be used to assess changes in bottom shear stress, turbulence and alike).
- For sandy sites or sites with natural sediment dynamic, changes in sediment transport processes and turbidity and induced changes in morphology of the coast.
- If the new structure involves water discharge, water extraction or changes in fresh water movements: assessment of salinity and/or temperature changes.

Steps to assess hydrographical alterations:
In case of insufficient data and resources and if the implementation of hydrodynamic modelling is not feasible, a simplified approach for assessing hydrographical alterations is proposed.
Following new decision on the MSFD (Decision 2017/048/UE, May 2017), an alternative approach proposes to assess first the hydrographical alterations as a result of physical loss (permanent changes to the seabed in term of bathymetry, morphology or nature substrate) induced by the structure itself or human activities in its surroundings.
Such approach aims to focus on:

1. The hold of the structure (location and extend on the sea floor). In this area, the presence of the structure will definitively alter the existing habitats (physical loss).
2. Permanent changes to the seabed related to the structure and due to human activities. For instance, the creation of a port often requires the digging of basins and the dumping of materials at sea. These diggings and discharges, leading to permanent bathymetric and eventually substrate changes and modifying waves and currents propagation, will also definitively alter the existing habitats.
3. Effects of the structure on hydrographical conditions in its neighbourhood. The existence of the structure will modify the regime of currents and agitation and also the coastal transit with creation of erosion and deposition zones. For instance, in a harbour, the presence of dikes attenuates the currents and the swell inside the basins and leads to decantation of suspended material (vases, organic matter, debris plants.) inducing changes in benthic settlements.

First level of assessment: assessment of physical loss induced by the structure itself (on sea floor and in water column)
The objective here is to represent by a polygon (GIS data) the exact location and extend on sea floor of the expected construction, i.e. a footprint (and not only the extent of the submerged part of the structure). These data can be taken from the construction plan of the structure that should be present in the EIA or another planning document.
A proposal for attribute's GIS data can be found in Chapter „Expected assessment outputs" below.

Second level of assessment: assessment of permanent changes to the seabed due to human activities (related to the construction and the use of the structure)
The objective here is to represent by a polygon (GIS data) the exact location and extend of dredged and disposal areas leading to permanent changes in bathymetry. These changes can happen during the

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations

construction of the structure (digging of basins) or for its normal use (channels dredging to maintain a certain depth).
Information relative to these activities can be found in the EIA or can be asked to the project manager responsible for its construction or to the structure owner.

Third level of assessment: assessment of hydrographical changes induced by the structure in the surrounding area
The first possibility to assess these alterations is to use the information provided by the EIA if available. Even if the EIA does not fully meet the needs of this indicator, it should at least provide some information on the main expected hydrographic changes since they may compromise the use or sustainability of the structure. For instance, in case of a port or a marina, the attenuation of agitation, being the objective, should be well studied. The same way, on a coast with strong sediment transit, the impact of the structure on erosion and sedimentation changes should be studied as they could compromise the use or the durability of the structure.

If the EIA does not provide a sufficient level of information, other available sources of information concerning similar or close sites have to be explored: historical evolution of sediment supply, analysis of the evolution of the coastline and the seabed, analysis of the impact of existing defence structures and ports on the morphodynamics of the coastline and alike.
These available data and studies are not directly applicable to assess hydrographical alterations induced by the new structure. Nevertheless, they can be used by experts to extrapolate evolution tendencies on the site of interest, thus providing a first level of characterization of expected hydrographic alterations and allowing to roughly specify their extent and location.
In the case where no information can help to characterize the extent of the expected hydrographic alterations, a buffer zone proportional to the largest dimension of the structure may be used to assess this extend (eg a buffer zone of 5 times the cross-shore length of the structure). If this approach is used to assess the extend, this must be clearly said in the attribute table relative to this GIS layer (see *Expected assessments outputs*).

For the first level of assessment, it is clear that under the hold of the structure the hydrographical conditions and the habitats will be definitively and permanently altered. On the other side, for the second and third levels of assessment, depending on the available data, the actual knowledge and the assumptions followed, there may be some degree of uncertainty in the assessment of location and extend of expected hydrographical alterations. To take into account these uncertainties and the limits of the assessments, it is proposed to notify them in the attribute table relative to these assessments (A proposal for attribute's GIS data can be found in „Expected assessment outputs“). These notifications will help to identify and subsequently improve the evaluations deemed to be the least reliable.
At the end, the results of the above assessments are integrated on one single GIS layer (i.e. hydrographical alterations GIS layer). The last step of the EO7 indicator calculation consists of overlaying hydrographical alterations GIS layer with habitats GIS maps/layer. Calculations are made with GIS tools in order to define habitats potentially impacted by hydrographic alterations.

If the assessment of hydrographic alterations presents a high level of uncertainty, a risk-based approach can be used to identify habitats that are most sensitive to expected alterations. To do this sensitivity matrix can be used (see for instance: La Rivière M. et al., 2018. *An assessment of French Mediterranean benthic habitats' sensitivity to physical pressures.* UMS PatriNat, AFB-CNRS-MNHN. Paris, 86 pp.).

Due to the ecological importance of *Posidonia* meadows in the Mediterranean Sea and their vulnerability to coastal development, a specific paragraph for this habitat is presented.

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations

Particular considerations for *Posidonia* meadows:

In addition to direct impacts, induced by the structure itself, which will definitively destroy the meadow by recovery, some construction techniques and then indirect impacts, following its construction, on currents and sedimentary transport, may also alter this habitat, on areas much larger than the structure footprint.

Indeed, the *Posidonia* is very sensitive to water turbidity, even transient. Also, during the construction of the structure, a turbid cloud can be generated (discharge at sea of fine materials). This turbid cloud will decrease the transparency of the water, and therefore photosynthesis, in the short term; it can also be deposited on the seagrass meadow that can cause smothering by hyper sedimentation. The thinnest sediments can also be resuspended during storms, thus decreasing the transparency of the water in the long term. Major seagrass meadow destructions due to these phenomena have been observed, for example, in France following the construction of the ports of Pointe Rouge in Marseille and Mouillon in Toulon.
Moreover, the construction machines are often fixed on the bottom, for stability reasons, directly and / or by means of anchors, which has a very negative impact on the bottoms: digging holes (feet of the machines) or furrows (chains of anchors) in the *Posidonia oceanica* meadows.

Once the structure is built, its presence can modify the sedimentary transit and induce areas of erosion and accumulation around it. These modifications will alter the equilibrium between the sedimentation rate and the vertical growth of *Posidonia*. So, if the rate of sedimentation **exceeds 5-7cm / year**, the vegetative points die; conversely, if this rate is zero or negative (sediment departure), the rhizomes are loosened; they are then very sensitive to breakage (hydrodynamism, anchors, trawling, etc.)
It should also be noted that it is extremely rare for a seagrass meadow to survive in a harbor basin in the medium or long term.

In order to avoid all these phenomena, it is therefore advisable to:

- Use materials and construction techniques that minimize the suspension of fine particles that can induce turbidity in the surrounding waters. (for example: the dumping of fine materials (diameter less than 1 mm) at sea, or of blocks mixed with fine materials, is to be excluded completely; when rockfill is installed, it is advisable to rinse the blocks of rock; geotextile protective screens must be put in place around the site to minimize turbidity induced).
- Avoid the use of construction machines located at sea by favouring the use of machines lying on the ground. if it is essential to use them at sea, they must not be anchored or relied on *Posidonia* meadows.
- Avoid carrying out construction work in summer, when the plant rebuilds its reserves for the following year
- Build a new development at several tens of meters from the closest living *Posidonia* meadow
- Avoid including *Posidonia* meadow in a port basin
- Monitor the condition of the surrounding seagrass, both during and at the end of the work.

(These elements on *Posidonia* meadows have been taken from : Boudouresque et al., 2006, Préservation des herbiers à *Posidonia oceanica*. RAMOGE pub.: 1-202, N°ISBN 2-905540-30-3)

Indicator units

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations

- km2 of impacted habitats
- proportion (%) of the total area/habitats impacted

List of Guidance documents and protocols available

UNEP/MAP/PAP (2015). Guidance document on how to reflect changes in hydrographical conditions in relevant assessment (prepared by Spiteri, C.). Priority Actions Programme. Split, 2015.

UNEP(DEPI)/MED IG.22. UNEP(DEPI)/MED IG.22/Inf.7 (2016). Draft Integrated Monitoring and Assessment Guidance

UNEP(DEPI)/MED WG.433/1 (2017) PAP/RAC Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) on Coast and Hydrography – Working Document

Advice document on hydrographical conditions (Descriptor 7) in the context of MSFD, published by OSPAR Commission (2012);

Scientific and technical review of the MSFD Commission Decision 2010/477/EU in relation to Descriptor 7 carried out by the EC JRC; etc.

Data Confidence and uncertainties

Data used or produced for the monitoring should be in agreement with Shared Environmental Information System (SEIS) principles. More on SEIS principles can be found in Draft Integrated Monitoring and Assessment Guidance.

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

At this stage, there is no clear available methodology and monitoring protocols (see **Known gaps and uncertainties in the Mediterranean).**
Some methodologies or protocols could be proposed, once done an inventory of existing and available data in Mediterranean Sea.

For more details, see “Guidance document on how to reflect changes in hydrographical conditions in relevant assessments“.

Available data sources
Global marine data source at the scale of the Mediterranean Sea:
- EMODnet Central Portal (http://www.emodnet.eu/)
- Mediterranean Marine Data (http://www.mediterranean-marinedata.eu/)
- Copernicus, Marine environment monitoring service (http://marine.copernicus.eu/)

Available regional or local data sources (in each country) should be also identified.

Spatial scope guidance and selection of monitoring stations

The monitoring will focus on habitats of interest, around new permanent constructions (lasting more than 10 years) in coastal waters.

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations

The study area should depend on the footprint of the new construction considered and on the local (or regional) geographical and marine conditions. It should be large enough:

- to show all the hydrographic alterations induced by the construction, even for long term;
- to follow all the habitats of interest that could be potentially impacted.

At first, the spatial scale (in cross-shore and long-shore directions) to be used should be about 10 to 50 times the characteristic length of the structure. Depending on the first results obtained for this area, the area should be enlarged or zoomed in around the structure.

It should be highlighted if monitoring was performed in sensitive areas, such as marine protected areas, spawning, breeding and feeding areas and migration routes of fish, seabirds and marine mammals, since they are priority.

Temporal Scope guidance

To correctly assess changes in time on habitats induced by constructions, different monitoring timescales are proposed:

- Before construction, initial state assessment (baseline conditions):
  Monitoring should provide the initial hydrodynamics conditions surrounding the future construction.
- During construction: monitoring should ensure that impacts due to works are limited in space and in time.
- After construction, short term changes (0 to 5 years after): at least yearly up to 5 years.
  During this period, strong changes should happen on hydrographical, morphological and habitats conditions. The monitoring frequency should be high* enough to assess these changes. It should be annual (at the same period of year) and provide, each year, the changes in hydrodynamic conditions (assessed by comparing present and initial conditions).
- After construction (5 to 10 years after): at least biennium to 10 years.
  Same as before with a lower* monitoring frequency as the changes should be lower.
- Long term changes (10 to15 years after construction)
  Same as before with a lower* monitoring frequency as the changes should be lower.

* The monitoring frequencies to be used in these different phases should depend on the intensity of changes in hydrographical and morphological conditions occurring on the site (case by case).

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

Expected assessments outputs

All the outputs that came out of the monitoring (I.e. trend analysis, distribution maps, etc.) should be listed, along with source(s) where they can be found.

The outputs to be reported are (map and GIS data):

- The area and location where the future structure will be built;
- The area and location where alterations in hydrographical conditions are expected to occur and those areas where alterations are actually occurring;
- The area and location of the habitats of interest potentially impacted by these alterations;
- The area and location of these habitats of interest previously identified for the whole analysis unit (to assess the proportion of total habitats that are altered).

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations

For the area and location where the future structure will be built, additionally to the surface representation of the structure, some information has to be provided as attributes of the GIS layer. The following attributes are proposed:

Country	*Locality / District*	*ID of the structure*	*Role of structure*	*Type of structure*	*Materials*	*Extend on the sea floor (in m², ha or km²)*
Specify the country	*Specify the location of the structure*	*The ID must be unique to identify the structure. It could be a number or a numbered code using letters from the previous column*	*Harbour, coastal defense, marine energy, ...*	*Quay, groynes, wind farm,...*	*Concrete, rockfill, ...*	*Area of the structure on sea floor. The used unity has to be provided in the name of the field*

If the structure is composite (in terms of type, materials, ...), several GIS surface objects could be defined.

For the area and location of expected hydrographical alterations, additionally to the surface representation of these alterations, some information has to be provided as attributes of the GIS layer. The following attributes are proposed:

Country	*Locality / District*	*ID of the structure*	*Nature of expected hydrographic alterations*	*Data used*	*Method of alterations assessment*	*Level of assessment confidence*	*Extend of hydrographical alteration (in m², ha or km²)*
Specify the country	*Specify the location of the structure*	*The ID must be unique to identify the structure. It could be a number or a numbered*	*Waves/currents attenuation; anthropic changes of bathymetry; changes in sediment transit inducing erosion/sedimentation;*	*Data provided by EIA ; dredging/disposal scheme ; ...*	*Modeling; expert judgment ; Analogy with similar and close site;...*	*Low/Medium/Good*	*Area of the structure on sea floor. The used unity has to be provided in the name of the field*

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations

		code using letters from the previous column					

If different extend of hydrographical alterations can be identified (in terms of nature, intensity, …) several GIS surface objects could be defined.

For each GIS data layer produced, a metadata file must be added. This file must provide information on: creation date of the GIS data, GIS data author, contact information, source agency, map projection and coordinate system, scale, error, explanation of symbology and attributes, data dictionary, data restrictions, and licensing (see for instance INSPIRE Directive).

Known gaps and uncertainties in the Mediterranean

There are general difficulties, not particular to the Mediterranean context, that can be identified for this EO7:
- Lack of coherence in definitions, standard approaches in the development and application of indicators and in the assessment of impacts, together with lack of methodological standards.
- Lack of knowledge and understanding on the link between physical pressures and biological impacts and on the cumulative impacts.

Another difficulty comes from the hydrographical alterations that EO7 indicator should assess. These alterations, around a particular coastal construction, often change in intensity, in area and indeed in time, depending on the off-shore hydrographical conditions (calm weather/extreme event; seasonality of waves height and directions; local wind conditions…) and on the morphologic history of the site (the present state is due to the succession of these different conditions).
So, a work to define which hydrographical conditions and temporal scale have to be used to assess hydrographical alterations by numerical modelling must be carried out.

Like everywhere, there is certainly a lack of physical characteristics data in the Mediterranean Sea (bathymetric data, seafloor topography, current velocity, wave exposure, turbidity, salinity, temperature, etc.), that will be the main problem to implement this indicator, in particular to define the base-line conditions. To identify these lacks, a global and clear inventory of existing and available data in Mediterranean Sea should be done.

Nevertheless, data can be collected from regional models (bathymetry, hydrodynamics, salinity, temperature). These data with coarse resolution will need to be refined close to the location of the new structure.

In case of no sufficient data, the use of assessment methods needing less data (empirical formulae, expert judgment, comparison with similar sites) should be considered, as well as acquisition/monitoring of missing data, promoting regional cooperation.

Contacts and version Date

Key contacts within UNEP for further information

Ecological Objective 7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.	
Indicator Title	Location and extent of the habitats potentially impacted by hydrographic alterations	
Version No	**Date**	**Author**
V.1	27/6/16	PAP/RAC
V2	11/07/16	Olivier Brivois
V3	13/07/16	Olivier Brivois
V4	16/03/17	Olivier Brivois
V5	19/06/18	Olivier Brivois
V6	26/07/18	Olivier Brivois

Annex 1. Reference list of habitats to be considered

2. Indicator guidance factsheet for EO8 Coastal Ecosystems and Landscapes Common Indicator 16 "Length of coastline subject to physical disturbance due to the influence of human-made structures"

Ecological Objective 8:	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved	
Indicator Title	Length of coastline subject to physical disturbance due to the influence of human-made structures	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Physical disturbance to coastal areas induced by human activities should be minimized.	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved.	Negative impacts of human activities on coastal areas are minimized through appropriate management measures.
GES, targets and measures cannot be expressed quantitatively (as a threshold value) but due to country specific circumstances (socio-economic, cultural, historical) should be defined by the countries themselves. In doing so the CPs should take their spatial development and planning policies into account, as well as the legal obligations of the Barcelona Convention, in particular the ICZM Protocol. The above GES definition and Proposed target(s) are just examples.		
Rationale		
Justification for indicator selection Mediterranean coastal areas are particularity threatened by coastal development that modifies the coastline through the construction of buildings and infrastructure needed to sustain residential, commercial, transport and tourist activities. The land, intertidal zone and near-shore estuarine and marine waters are increasingly altered by the loss and fragmentation of natural habitats and by the proliferation of a variety of built structures, such as ports, marinas, breakwaters, seawalls, jetties and pilings. These coastal human-made infrastructures cause irreversible damage to landscapes, losses in habitat and biodiversity, and strong influence on the configuration of the shoreline. Indeed, physical disturbance due to the development of artificial structures in the coastal fringe can disrupt the sediment transport, reduce the ability of the shoreline to respond to natural forcing factors, and fragment the coastal space. The modification of emerged beach and elimination of dune system contribute to coastal erosion phenomena by lessening the beach resilience to sea storms. Coastal defence infrastructures have been implemented to solve the problem together with beach nourishment but preserving the natural shoreline system with adequate sediment transport from river has proved to be the best solution. Monitoring the length of coastline subject to physical disturbance due to the influence of human-made structures and its trend is of paramount importance to preserve habitat, biodiversity and prevent coastal erosion phenomena, as well as for its importance in land-sea interactions. Until now there has not been systematic monitoring in Mediterranean regarding this, in particular not quantitatively based monitoring or any major attempt to homogenously characterize coastal ecosystems on a wider Mediterranean basis. The status assessment of EO8 aims to fill this gap.		
Scientific References Boak, E., H. & Turner I., L. (2005), Shoreline definition and detection: a review. Journal of Coastal Research 21(4), 688-703. Deichmann, U., Ehrlich, E., Small, E., and Zeug, G. (2011). Using high resolution satellite data for the identification of urban natural disaster risk (GFDRR (Global Facility for Disaster Reduction and Recovery)).		

Ecological Objective 8:	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	Length of coastline subject to physical disturbance due to the influence of human-made structures

European commission and Directorate General Environment (2004a). Living with coastal erosion in Europe: Sediment and Space for Sustainability. A guide to coastal erosion management practices in Europe (The Netherlands: Eurosion project).

European commission and Directorate General Environment (2004b). Living with coastal erosion in Europe: Sediment and space for sustainability. Guidelines for incorporating coastal erosion issues into Environmental Assessment (EA) procedures (The Netherlands: Eurosion project).

Markandya, A., Arnold, S., Cassinelli, M., and Taylor, T. (2008). Protecting coastal zones in the Mediterranean: an economic and regulatory analysis. J. Coast. Conserv. 12, 145–159.

McLachlan, A., Brown, A.C., 2006. The Ecology of Sandy Shores. Academic Press, Burlington, MA, USA, 373 pp

Özhan, E. (2002). Coastal erosion management in the Mediterranean: an overview (Split: UNEP/MAP/PAP).

Rochette, J., Puy-Montbrun, G., Wemaëre, M., and Billé, R. (2010). Coastal setback zones in the Mediterranean: a study on Article 8-2 of the Mediterranean ICZM Protocol. n°05/10 December 2010, IDDRI

Sanò, M., Jiménez, J.A., Medina, R., Stanica, A., Sanchez-Arcilla, A., and Trumbic, I. (2011). The role of coastal setbacks in the context of coastal erosion and climate change. Ocean Coast. Manag. 54, 943–950.

UNEP/MAP/PAP (2001). White paper: coastal zone management in the Mediterranean. (Split).

UNEP/MAP (2013). Approaches for definition of Good Environmental Status (GES) and setting targets for the Ecological Objective (EO) 7 “Hydrography” and EO8 “Coastal ecosystems and landscape” in the framework of the Ecosystem Approach.

Policy Context and targets

Policy context description

ICZM Protocol (Article 8, point 3):

The Parties shall also endeavour to ensure that their national legal instruments include criteria for sustainable use of the coastal zone. Such criteria, taking into account specific local conditions, shall include, inter alia, the following:

(a) identifying and delimiting, outside protected areas, open areas in which urban development and other activities are restricted or, where necessary, prohibited;
(b) limiting the linear extension of urban development and the creation of new transport infrastructure along the coast;
(c) ensuring that environmental concerns are integrated into the rules for the management and use of the public maritime domain;
(d) providing for freedom of access by the public to the sea and along the shore;
(e) restricting or, where necessary, prohibiting the movement and parking of land vehicles, as well as the movement and anchoring of marine vessels, in fragile natural areas on land or at sea, including beaches and dunes.

Targets

Ecological Objective 8:	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	Length of coastline subject to physical disturbance due to the influence of human-made structures

Negative impacts of human activities on coastal areas are minimized through appropriate management measures.

Additional country-specific criteria should be taken into account for definition of targets, measures and interpretation of results regarding this indicator due to strong socio-economic, historic and cultural dimensions in addition to characteristic geomorphological and geographical conditions in each respective country (reflected in policy documents, strategies and other country-specific documents). Interpretation of results should be left to the countries taking above criteria into account.

Policy documents

Protocol on the ICZM in the Mediterranean - http://www.pap-thecoastcentre.org/pdfs/Protocol_publikacija_May09.pdf

Indicator analysis methods

Indicator Definition

The monitoring aim of the EO8 common indicator is twofold: (i) to quantify the rate and the spatial distribution of the Mediterranean coastline artificialitsation and (ii) to provide a better understanding of the impact of those structures to the shoreline dynamics. It has an operational target on impact, thus it is associated to concrete implementation measures related to specific human activities (i.e. appropriate management measures) to minimize negative impacts and to inform about progress towards GES.

Methodology for indicator calculation

The monitoring of this Common Indicator entails an inventory of the length and location of human-made coastline (hard coastal defence structures, ports, marinas (see Figure 1). Soft techniques e.g. beach nourishment are not included.

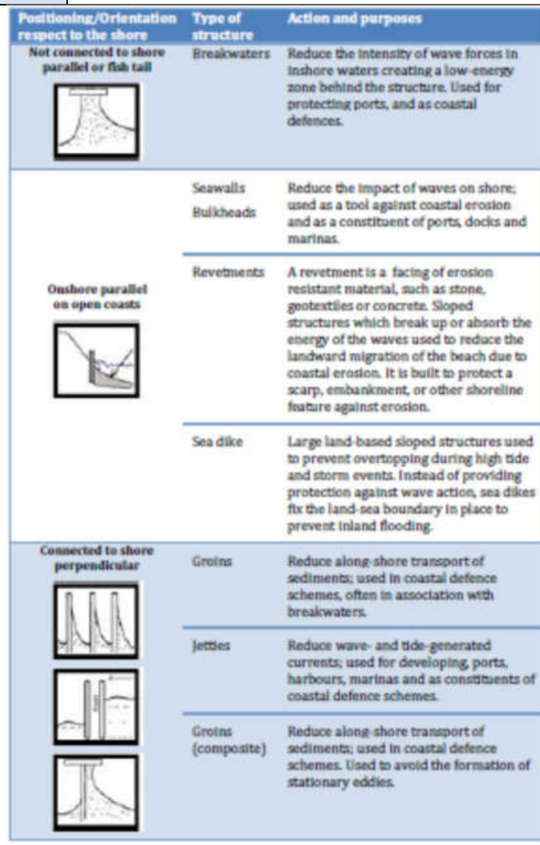
With regard to the coastline to be considered: the fixed reference official coastline as defined by responsible Contracting Party should be considered. The optimal resolution should be 5 m or 1: 2000 spatial scale.

Once a proper geographic scale has been established, monitoring should focus, in particular, on the location, the spatial extent and the types of coastal structures taking into account the minimum coastal length that can be classified as artificial or natural.

The identification procedure of human-made structures should be carried on based on typical situations added to the indicator guidance factsheet, including the minimum size (length, width of human-made structures) to be taken into account.

As monitoring should be done every 6 years, every CP should fix a reference year in the time interval 2000-2012 in order to eliminate the bias due to old or past human-made infrastructures.

Ecological Objective 8:	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	Length of coastline subject to physical disturbance due to the influence of human-made structures



Positioning/Orientation respect to the shore	Type of structure	Action and purposes
Not connected to shore parallel or fish tail	Breakwaters	Reduce the intensity of wave forces in inshore waters creating a low-energy zone behind the structure. Used for protecting ports, and as coastal defences.
Onshore parallel on open coasts	Seawalls Bulkheads	Reduce the impact of waves on shore; used as a tool against coastal erosion and as a constituent of ports, docks and marinas.
	Revetments	A revetment is a facing of erosion resistant material, such as stone, geotextiles or concrete. Sloped structures which break up or absorb the energy of the waves used to reduce the landward migration of the beach due to coastal erosion. It is built to protect a scarp, embankment, or other shoreline feature against erosion.
	Sea dike	Large land-based sloped structures used to prevent overtopping during high tide and storm events. Instead of providing protection against wave action, sea dikes fix the land-sea boundary in place to prevent inland flooding.
Connected to shore perpendicular	Groins	Reduce along-shore transport of sediments; used in coastal defence schemes, often in association with breakwaters.
	Jetties	Reduce wave- and tide-generated currents; used for developing, ports, harbours, marinas and as constituents of coastal defence schemes.
	Groins (composite)	Reduce along-shore transport of sediments; used in coastal defence schemes. Used to avoid the formation of stationary eddies.

Figure 1. Hard coastal defence structures, modified from the EUROSION Shoreline Management Guide, EU, 2004. Taken from IMAP guidelines, page 134, Table 1.

Indicator units

- Km of artificial coastline and % of total length of coastline.
- Percentage (%) of natural coastline on the total coastline length.

The length of artificial coastline should be calculated as the sum of segments on reference coastline identified as the intersection of polylines representing human-made structures with reference coastline ignoring polylines representing human-made structures with no intersection with reference coastline. The minimum distance between coastal defence structures should be set to 10 m in order to classify such segments as natural, i.e. if the distance between two adjacent coastal defence structures is less than 10 m, all the segment including both coastal defence structures is classified as artificial.

List of Guidance documents and protocols available

Monitoring and assessment methodological guidance on EO8: coastal ecosystems and landscapes (within IMAP guidelines)

Ecological Objective 8:	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	Length of coastline subject to physical disturbance due to the influence of human-made structures
EUROSION Shoreline Management Guide (European Commission and Directorate General Environment, 2004, Annex 2)	
Data Confidence and uncertainties Regarding data confidence, both geographic scale and resolution of images have to be properly selected depending on type and density of coastal human-made structures. A specific cost/benefit analysis has to be carried on to choose the right balance among resolution, an acceptable level of uncertainties and the necessity to assure comparability of results at Mediterranean level.	
Methodology for monitoring, temporal and spatial scope	
Available Methodologies for Monitoring and Monitoring Protocols Space and airborne earth observation systems are the most suitable tool to conduct the monitoring strategy of the EO8 common indicator, i.e. very high resolution (VHR) satellite imagery, aerial photographs, laser scanners etc. Beyond earth observation data, identification techniques and procedures used through GIS tools also have to be described	
Available data sources CORINE land cover, national spatial plans, World Imagery Basemap feature (in ArcGIS 10.1), Landsat satellite imagery, Google earth, aerial photographs surveys.	
Spatial scope guidance and selection of monitoring stations The exact territorial extent of the monitoring should be presented. The optimum spatial scale for a proper identification of human-made structures should be 5 m by satellite imagery or aerial photographs.	
Temporal Scope guidance Monitoring human-made structures data should be updated at least every 6 years, while shoreline survey of sandy coastline under anthropogenic pressure should be, if possible, repeated annually (at the same time of the year)	
Data analysis and assessment outputs	
Statistical analysis and basis for aggregation The total length of coastline estimated as being subjected to physical disturbance due to the influence of human-made structures should be summed. In addition, the share of this coastline in total country's coastline should be determined. If an official coastline is available, i.e. an institutional body provides a GIS polyline, then such coastline can be used to “project” the identified human-made structures in order to classify parts of the coastline as being subjected to physical disturbance due to the influence of human-made structures. Geographic scale of maps and cartography used to identify human-made structures could be different but not too much form the ones used for the official coastline. In case if such official coastline is not available or its geographic scale is too coarse with respect to one needed to properly identify human-made structures, then coastline will be defined by the same maps/cartography used for human-made structures identification.	
Expected assessments outputs	

Ecological Objective 8:	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	Length of coastline subject to physical disturbance due to the influence of human-made structures

The total length of coastline influenced by human-made structures and the share of this coastline in total country's coastal length should be provided on a map showing the coastline subject to physical disturbance due to human-made structures (artificial segments) in red line and the rest (natural segments) in green line.
The assessment output should be reported as a common shape file format with GRS as WGS84. Shape file with other GRS will also be accepted if provided with a complete .prj file that allows GRS transformations by standard GIS tools.

Known gaps and uncertainties in the Mediterranean

In order to implement EO8 indicator with an acceptable level of accuracy, recent data sources with proper spatial resolution and complete coastline coverage should be used jointly with adequate GIS tools and expert team.
Capacity building can be readily assessed for each CP as such resources are generally available for the Mediterranean Region also taking into account the increasing efforts on satellite imagery products (ESA Sentinels constellation). So, once a common framework of data sources, GIS procedures and way of representing the output of EO8 indicator are agreed, a common implementation work for all CPs could be in principle settle down.

Contacts and version Date

Key contacts within UNEP/MAP for further information

Version No	**Date**	**Author**
V.1	27/6/16	PAP/RAC & Giordano Giorgi
V.2	27/7/16	Giordano Giorgi
v.3	23 March 2018	PAP/RAC

3. Indicator guidance factsheet for EO8 Coastal Ecosystems and Landscapes Common Indicator 25 “Land cover change”

<table>
<tr><td>Ecological Objective</td><td colspan="2">The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved</td></tr>
<tr><td>Indicator Title</td><td colspan="2">Land cover change</td></tr>
<tr><td>Relevant GES definition</td><td>Related Operational Objective</td><td>Proposed Target(s)</td></tr>
<tr><td>- Linear coastal development minimised, with perpendicular development being in balance with integrity and diversity of coastal ecosystems and landscapes.
- Mixed land-use structure achieved in predominantly man-made coastal landscapes</td><td>Integrity and diversity of coastal ecosystems, landscapes and their geomorphology are preserved.</td><td>Proposed targets should be considered as general recommendations to be adapted to regional/local specificities and knowledge.

- No further construction within the setback zone
- Change of coastal land use structure, dominance of urban land use reversed
- Keep, and increase where needed, landscape diversity</td></tr>
<tr><td colspan="3">GES, targets and measures cannot be expressed quantitatively (as a threshold value) but due to country specific circumstances (socio-economic, cultural, historical) should be defined by the countries themselves. In doing so the CPs should take their spatial development and planning policies into account, as well as the legal obligations of the Barcelona Convention, in particular the ICZM Protocol. The above GES definition and Proposed target(s) are just examples.</td></tr>
<tr><td colspan="3">Rationale</td></tr>
</table>

Justification for indicator selection

The UNEP/MAP’s Correspondence Group on Monitoring (CORMON) on Coast and Hydrography agreed, in May 2013, on a specific candidate common indicator for the Mediterranean region addressing land cover change.

Identifying and understanding the processes of land cover change (i.e. how land cover has been changed by humans and the processes that result in landscape transformation) is especially relevant for critical and vulnerable areas such as coastal zones, where several competitive uses are pressing. In this context urbanization, or land take, is the most dramatic change given the (almost) irreversibility of the process. The associated impacts could be listed as follows (Figure 1):

- *Habitat loss with the associated impact on related ecosystem functions like C sequestration, regulation of water cycle, or biomass production.*
- *Fragmentation. The division of natural habitats in smaller parcels contributes to the isolation of number of species and also compromises its viability.*

Therefore, the accumulated impacts of urbanization highly compromise ecosystem integrity. Since impacts are dependent on the scale and pace of changes it is important to consider these aspects when monitoring land cover changes.

Beyond the process of urbanization there are other changes that are less irreversible and also have important consequences:

- *Conversion from forest to agricultural use. This results in habitat loss, habitat fragmentation and, consequently, loss of biodiversity. There is also a decrease on the degree of soil coverage by vegetation which in turn determines the risk of erosion. Also this type of change results in a net loss of soil carbon.*
- *Conversion from agriculture to semi-natural. The impact strongly depends on the conditions at the time of abandonment. If conditions are favorable, land abandonment can lead to a recovery of natural vegetation. However, in case of unfavorable conditions like low vegetation coverage and/or steep slope, agricultural abandonment could lead to further land degradation.*

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

- *Conversion from agricultural land to forest (forestation). This change involves tree plantation and it has a positive impact on land stability by increasing the vegetation cover of the soil and the increase of C sequestration. In terms of biodiversity it strongly depends on the species used for plantation. Native species definitely increase diversity and connectivity.*

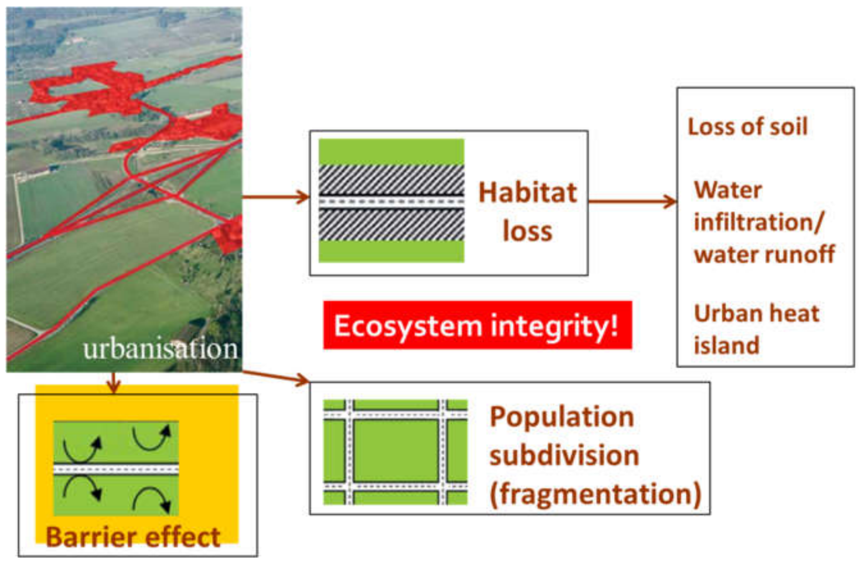


Figure 1. ***Overview of major impacts on land take***

Scientific References

References are grouped by the topic addressed. Within each section references are sorted by relevance (the first ones are more relevant to the current indicator)

Land us/land cover change and related impacts:

- Bajocco, S., De Angelis, A., Perini, L., Ferrara, A. i Salvati, L., 2012, 'The Impact of Land Use/Land Cover Changes on Land Degradation Dynamics: A Mediterranean Case Study', *Environmental Management*, 49(5), p.980-989.
- Dale,V. H. , Brown, S. , Haeuber, R. A. , Hobbs, N. T. , Huntly, N. , Naiman, R. J. , Riebsame, W. E. , Turner, M. G. and Valone, T. J., 2000. Ecological principles and guidelines for managing the use of land. *Ecological Applications* 10:639–670.
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- Haines-Young, R., 2009, 'Land use and biodiversity relationships', *Land Use Policy*, 26, p.S178-S186.

Methodology to compute land use change indicator:

- Breton, F., Ivanov, E., Morisseau, F., Nowell, M. 2014. *D4.2 Report, accompanying database and supporting materials on LEAC Methodology and how to apply it in CASES*. PEGASO 06/Deliverable. URL: http://www.pegasoproject.eu/images/stories/WP4/D4.2%20LEAC_UAB_140401.pdf

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

- EEA, 2006. The changing faces of Europe's coastal areas, EEA report. European Environment Agency ; Office for Official Publications of the European Communities, Copenhagen, Denmark : Luxembourg.
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- Weber, J.-L., 2007, 'Implementation of land and ecosystem accounts at the European Environment Agency', *Ecological Economics*, 61(4), p.695-707.
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Policy Context and targets

Policy context description

After agreeing on including the candidate common indicator on Land use change in CORMON on Coast and Hydrography in 2013, it was decided that this candidate common indicator would need further testing, pilot implementation (including during the initial phase of IMAP), before the Contracting Parties could agree to its regional usage as a common indicator.
In order to follow-up on this CORMON Coast and Hydrography recommendation, an EcAp pilot project took place in the Adriatic to test the feasibility of this candidate common indicator on the sub-regional level, in the framework of an EU funded project on the "Implementation of the Ecosystem Approach in the Mediterranean by the Contracting Parties in the context of the Barcelona Convention for the Protection of the Marine Environment and the Coastal region of the Mediterranean and its Protocols (EcAp-MED project 2012-2015)".
The main conclusions of the Pilot project suggest that by using the common remote data and a common method for processing and presenting the results are feasible and a very positive step forward as far as monitoring the processes, the state and evolution of the coastal zones.
The results of this pilot are presented in document UNEP(DEPI)/MED WG.420/Inf.18.

As for the protocols of the Barcelona convention, The ICZM protocol identifies the need of balanced use of coastal zones in several articles.
For example, the **Article 5** sets the objectives of integrated coastal management:

(a) to facilitate, through the rational planning of activities, the sustainable development of coastal zones by ensuring that the environment and landscapes are taken into account in harmony with economic, social and cultural development;
(b) preserve coastal zones for the benefit of current and future generations;
(c) ensure the sustainable use of natural resources, particularly with regard to water use;
(d) ensure preservation of the integrity of coastal ecosystems, landscapes and geomorphology;

In **Article 6**, where general principles of ICZM are discussed, it is highlighted that the formulation of land use strategies, plans and programs covering urban development and socioeconomic activities, as well as other

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

relevant sectoral policies, shall be required (f). In addition, the Article 6 calls for the allocation of uses throughout the entire coastal zone to be balanced, and unnecessary concentration and urban sprawl to be avoided(h).

The **Article 8** calls to Contracting Parties to ensure that their national legal instruments include criteria for sustainable use of the coastal zone. Some of such criteria ask for "identifying and delimiting, outside protected areas, open areas in which urban development and other activities are restricted or, where necessary, prohibited" (a). In addition, it asks for limiting the linear extension of urban development and the creation of new transport infrastructure along the coast(b).

In addition, the EU's Habitats Directive (92/43/EEC), Birds Directive (2009/147/EC), as well as Convention of Biological Diversity can also be relevant for policy context regarding land cover change.

Targets

- *No further construction within the setback zone*
- *Change of coastal land use structure, dominance of urban land use reversed*
- *Keep, and increase, where needed, landscape diversity*

Interpretation of targets and setting the measures to achieve them should be left to the countries.
The reason is the strong socio-economic, historic and cultural dimensions in addition to specific geomorphological and geographical conditions in each country. In other words: although the indicator is a simple tool to show trends in land-cover changes for interpretation purposes, additional criteria should be taken into account i.e. due to strong socio-economic, historic and cultural dimensions in addition to specific geomorphological and geographical conditions the interpretation should be left to the countries.
These targets should be taken as general guidelines that need to be considered in light with the local knowledge. Given the relevance of the socio-economic, historic and cultural dimension, in addition to specific geographical conditions, local experts will provide the needed input in support to this indicator.

Policy documents

ICZM Protocol (available in different languages at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A22009A0204(01))

Convention on Biological Diversity (www.cbd.int)

Habitats Directive (92/43/EEC)
http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043

Birds Directive (2009/147/EC)
http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0147

Indicator analysis methods

Indicator Definition

Land use/land cover change is the change of purpose to which land is profited by humans (e.g., protected areas, forestry for timber products, plantations, row-crop agriculture, pastures, or human settlements). Different parameters can be considered for evaluation of indicator on land use/land cover change. The parameters are summed in Table 1. The combined analysis of these parameters entails an inventory of the urbanization pressures on coastal ecosystems. In practice the parameters can identify: (i) where pressures are higher (by amount of change and by pace of the process); (ii) spatial trends (along the coast and landwards); and (iii) areas for priority action. However, responsible (local) institutions are necessary to correctly interpret these processes and to understand the drivers behind them.

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

Table 1. ***Description of the parameters calculated for the indicator Land Cover Change***

Parameter	*Units*	*Data required*	*Reporting units*	*Meaning*
Area of built-up land in coastal zone as a proportion of the total area in the same unit	*% of artificial areas*	*Artificial surfaces at a single time shot*	*Coastal zone as defined by the country* *Also coastal strips (<300m*, 300m-1km, 1-10 km).*	*State of urban areas at a particular time. This is used as a baseline, i.e. initial condition for the analysis of changes.*
Area of built-up land in coastal units as a proportion of the area of built-up land in the wider coastal unit	*% of artificial areas*	*Artificial surfaces at a single time shot*	*Narrower coastal strips within the wider ones (or even within the whole coastal unit).*	*This parameter shows to what extent the process of urbanization has been more intense on the coast than on the inland. It also reflects the relevance of economic activities on the coast as a driver of urban development.*
Land take as % initial urban area on the coastal zone	*% of increase of urban areas*	*Artificial surfaces at t_0 and t_1*	*Coastal zone as defined by the country.* *Also coastal strips (<300m*, 300m-1km, 1-10 km)*	*Intensity of the process of urbanization in a given period of time.*
Change of forest and semi-natural areas	*% of change of forest and semi-natural areas*	*Forest and semi-natural land at t_0 and t_1*	*Coastal zone as defined by the country.* *Also coastal strips (<300m*, 300m-1km, 1-10 km)*	*This parameter would reflect to what extent management is leading to an increase, maintenance or decrease of forest and semi-natural areas. This represents the land cover closer to "natural land" excluding wetlands (specific indicator).*
Change of wetlands	*% of change of wetlands*	*Wetlands at t_0 and t_1*	*Coastal zone as defined by the country.* *Also coastal strips (<300m*, 300m-1km, 1-10 km*	*This parameter will indicate how effective is the protection of wetlands, in terms of coverage. The indicator could reflect and increase, maintenance or a decrease of wetlands.*
Change of protected areas	*% of change of protected areas*	*Protected areas at t_0 and t_1*	*Coastal zone as defined by the country.* *Also coastal strips (<300m*, 300m-1km, 1-10 km*	*This parameter shows how the extent of protected areas changes in time.*

**the 300m wide coastal strip is proposed as relevant representation of the coastal setback (also considering the resolution issues)*

Methodology for indicator calculation

*1. **Data compilation** - Land cover classes are typically mapped from digital remotely sensed data through the process of a supervised digital image classification or, alternatively, determined by in situ monitoring. Land cover classes needed for the indicator are listed in the Table 2. If more detailed classification is available, then it could be provided making the clear link with Table 2.*

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

Table 2. ***Land cover classes for the Land Cover Change indicator***

LU/LC class	*Definition*
Artificial surfaces (also referred as built-up areas)	*Surfaces with dominant human influence but without agricultural land use.* *These areas include all artificial structures and their associated non-sealed and vegetated surfaces.* *Artificial structures are defined as buildings, roads, all constructions of infrastructure and other artificially sealed or paved areas. Associated non-sealed and vegetated surfaces are areas functionally related to human activities, except agriculture.* *Also, the areas where the natural surface is replaced by extraction and / or deposition or designed landscapes (such as urban parks or leisure parks) are mapped in this class.* *The land use is dominated by permanently populated areas and / or traffic, exploration, non-agricultural production, sports, recreation and leisure.*
Agricultural	*It includes: arable land, permanent crops, pastures and heterogeneous agricultural areas (complex cultivation patterns, land principally occupied by agriculture, with significant areas of natural vegetation).*
Forest and semi-natural land	*It includes: forests, scrub and/or herbaceous vegetation associations, open spaces with little or no vegetation*
Wetlands	*Inland marshes, peatbogs, salt marshes, salinas, intertidal flats*
Water bodies	*Water courses, water bodies, coastal lagoons, estuaries, sea and ocean.*
Protected areas	*Surfaces with any of the protection status (such as Natura 2000, IUCN or national-specific categories with the objectives to protect biodiversity, habitats, species, landscapes and alike in the coastal zone)*

2. ***Data processing***

Data processing includes the following steps (Figure 2):

(i) Pre-processing

Land cover data could be available in two formats: vector data (polygons) or raster data (grid). For practical reasons, and to simplify the computing process, the first step is to ensure that all the data is in a grid of 1 ha. Conversion of vector data to a grid, or raster, is a common procedure in GIS techniques. Most of the GIS software provides different options to convert vector data into a grid. Here the 'Maximum area' criterion is suggested as one of the most standard methods.

(II) Combining data

Once the data is available in 1 ha grid, the different layers are combined. This process is automatically done by any GIS software and creates an associated table with all the information available for each cell in the grid. The layers to be combined are listed as follows:

1. *Baseline land cover data (y0).*
2. *Land cover change data (y0-y1)*
3. *Delimitation of coastal zone*

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

4. *Administrative unit where the coastal zone belongs (NUTS3 or equivalent)*

Therefore the minimum information that the resulting table should contain is as follows:

1. *Grid ID. Unique identifier for each cell in the grid of 1 ha*
2. *Coastal zone. Yes/No. Boolean parameter that indicates if the cell is within the coastal zone, as defined by the country*
3. *Administrative unit. Code that identifies the administrative unit where the cell is located (NUTS3 of equivalent).*
4. *Land cover class at t_0. Code for the land cover class of the cell.*

(iii) extracting statistics

As a result of the previous step a table should be available with the unique code of each cell of the 1 ha grid and all related parameters. Therefore the extraction of the statistics for the calculation of the indicator could be done in a spreadsheet and does not require any GIS processing (see Data analysis and assessment outputs section for the details).

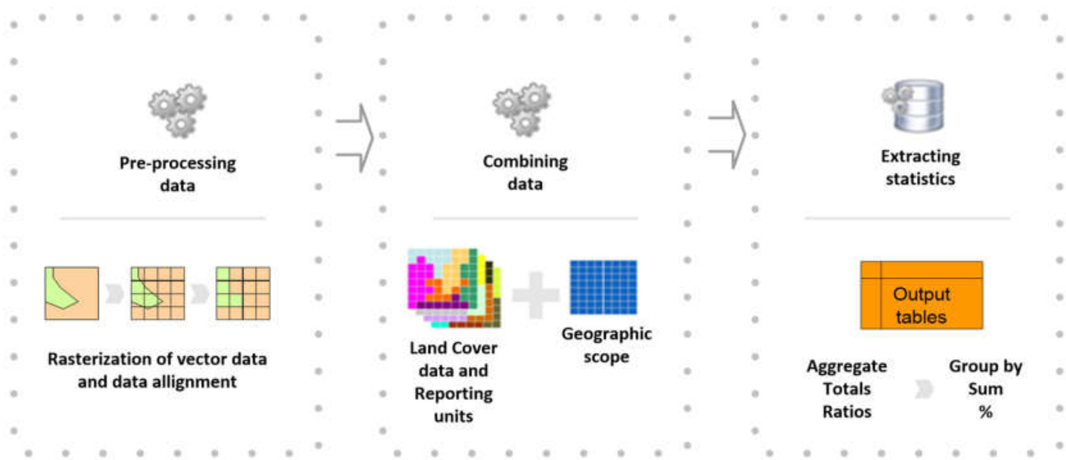

Figure 2. ***Data processing for the Land Cover Change indicator***

Indicator units

The first monitoring will focus on the base line. The indicator units are indicated below:

1. *km^2 of built-up area in coastal zone*
2. *%of built-up area in coastal zone*
3. *%of other land cover classes in coastal zone*
4. *% of built up area within coastal strips of different width (see Table 1) compared to wider coastal units*
5. *% of other land cover classes within coastal strips of different width (see Table 1) compared to wider coastal units*
6. *km^2 of protected areas within coastal strips of different width*

For second monitoring the following units will also be relevant:

7. *% of increase of built-up area, or land take*

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

8. *% of change of other land cover classes*
9. *% of change of protected areas*

List of Guidance documents and protocols available

Pilot project in the Adriatic on testing the candidate common indicator 'Land use change' in the Mediterranean, by: Anna Marín. Raquel Ubach. and JaumeFons-Esteve. Coordinated by: Marko Prem, PAP/RAC. URL: http://www.pap-thecoastcentre.org/pdfs/Pilot%20Adriatic_Final_Sep2015.pdf

Data confidence and uncertainties

Production of land use/land cover data from remote sensing is always a compromise between precision and efforts required to derive the information from satellite images. The data sources listed below (see Available data sources) have been validated by the responsible institutions or providers of the data. Additionally, if analogue maps from official institutions are available they could be digitalised and used accordingly.
Quality assurance/control always involve a selection of percentage of points where the derived information is checked against "ground truth" –usually ancillary information like official maps, cadastre,... but also field inspections.

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

The most elaborated guidelines are available from the Corine Land Cover programme (currently integrated in the Copernicus Programme).

http://www.eea.europa.eu/publications/technical_report_2007_17

Available data sources

The data sources listed below are transnational data bases (the first one only European, the rest global). Existing national data (official) is also suitable for this indicator.

- Corine land Cover (only European coverage)
http://land.copernicus.eu/pan-european/corine-land-cover

- GlobCover. Global land cover dataset at 300m resolution from the MERIS sensor on the ENVISAT satellite.
http://due.esrin.esa.int/page_globcover.php

-Climatge Change Initiative Land Cover map. Global land cover dataset at 300m resolution, for 1998-2002, 2003-2007, 2008-2012.
http://maps.elie.ucl.ac.be/CCI/viewer/index.php

-GLC-SHARE: Global Land Cover data combined from 'best available' national land cover maps. 1km resolution.
http://www.fao.org/geonetwork/srv/en/main.home?uuid=ba4526fd-cdbf-4028-a1bd-5a559c4bff38

Spatial scope guidance and selection of monitoring stations

The exact territorial extent (coastal area for the analysis) of the monitoring should be defined. The Mediterranean ICZM Protocol defines the landward limit of coastal zone as the "limit of the competent coastal units as defined by the Parties (Article 3)." In other words, the landward limit will be country-specific, e.g. dependant on definition given by certain Contracting party when ratifying the Protocol.

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

As for the resolution of the source data it is a „compromise between precision and efforts needed in processing the satellite images. The following indications could be considered minimum requirements:

- *Minimum mapping unit of 25 ha and 100 m of linear elements*
- *Minimum change detection 5 ha*

Temporal Scope guidance

The temporal scale should be 5 years, in order to be effective on the counteracting negative effects and taking early actions on problematic areas.

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

The statistics can be computed as follows:

1. *Percentage of built-up area in coastal zone.*
   a) *Filter the data by the grids belonging to the coastal zone*
   b) *Calculate total area by counting the total number of cells. This is the area in km^2.*
   c) *Filter, within the coastal zone, by land cover "artificial areas" (see Table 1 for the definition of land cover classes).*
   d) *Calculate area of "artificial areas" by counting the number of cells. This is the area in km^2.*
   e) *Divide 1d by 1b in order to obtain the percentage of artificial area on the coastal zone.*
2. *Percentage of other land cover classes on the coastal zone. As complementary to "Percentage of built-up area in coastal zone" the same procedure could be applied to each land cover class as defined in Table 1. In that case the procedure described in 1 will be replicataed by changing "artificial areas" with the other land cover classes*
3. *Area of built-up land in coastal units as a proportion of the area of built-up land in the wider reference region.*
   a) *Filter the data by the grids belonging to the entire administrative unit where the coastal zone belongs (NUTS3 or equivalent).*
   b) *Filter by land cover "artificial areas" (see Table 1 for the definition of land cover classes).*
   c) *Calculate area of "artificial areas" by counting the number of cells. This is the area in km^2.*
   d) *Sum 1d with 3c.*
   e) *Divide 1d by3d. This value is the percentage of built-up area within the administrative unit that is located on the coastal zone.*
4. *Land take as % of initial urban area on the coastal zone. This parameter will start to be computed on the second monitoring since the first monitoring focus only on the baseline (state at t_0).*
   a) *Filter the data by the grids belonging to the coastal zone.*
   b) *Calculate total area by counting the total number of cells. This is the area in km^2.*
   c) *Filter, within the coastal zone, by land cover "artificial areas" (see Table 1 for the definition of land cover classes) for t_0.*
   d) *Filter, within the coastal zone, by land cover "artificial areas" (see Table 1 for the definition of land cover classes) for t_1.*
   e) *Calculate 4d-4c and then divide by 4c. This provides the percentage of land take compared to*

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

the initial built-up area.

5. *Change of forest and semi-natural land. This parameter will start to be computed on the second monitoring since the first monitoring focus only on the baseline (state at t_0).*
   a) *Filter the data by the grids belonging to the coastal zone.*
   b) *Calculate total area by counting the total number of cells. This is the area in km^2.*
   c) *Filter, within the coastal zone, by land cover "Forest and semi-natural land" (see Table 1 for the definition of land cover classes) for t_0.*
   d) *Filter, within the coastal zone, by land cover "Forest and semi-natural land" (see Table 1 for the definition of land cover classes) for t_1.*
   e) *Calculate 5d-5c and then divide by 5c. This provides the percentage of change of forest and semi-natural areas for the given period.*
6. *Change of wetlands. This parameter will start to be computed on the second monitoring since the first monitoring focus only on the baseline (state at t_0).*
   a) *Filter the data by the grids belonging to the coastal zone.*
   b) *Calculate total area by counting the total number of cells. This is the area in km^2.*
   c) *Filter, within the coastal zone, by land cover "Wetlands" (see Table 1 for the definition of land cover classes) for t_0.*
   d) *Filter, within the coastal zone, by land cover "Wetlands" (see Table 1 for the definition of land cover classes) for t_1.*
   e) *Calculate 6d-6c and then divide by 6c. This provides the percentage of change of wetlands for the given period.*

The above mentioned analysis can be complemented with the following ones that provide additional insight on the land cover indicator.

7. *Additional analytical units*
   a) *Setback zone (if defined by country). Given the relevance of this part of the coastal area, as referred on the ICZM protocol, the indicators on % of built-up and land take can be analysed for this specific zone.*
   b) *Elevation breakdown within the coastal area. Distance to the coast and elevation are elements that configure different habitat distribution and patterns. With available local knowledge 3 to 5 elevations classes could be considered to be analysed independently within the coastal area in order to better link the pressure of land take to specific habitats. An example follows: < 50 m asl, 50 – 300 m, >300 m).*
8. *Additional parameters*
   What has been lost by urbanization?
   a) *Filter the data by the grids belonging to the coastal zone.*
   b) *Calculate total area by counting the total number of cells. This is the area in km^2.*
   c) *Develop a pivot table with land cover classes at t_0, on rows, and land cover classes at t_1 on columns. Cells in this matrix will contain the area that has changed from certain land cover class at $t_0$to a new class in t_1.*
   d) *Select the column for "Built-up areas".*
   e) *Values on the rows indicate the different land cover classes at t_0 that have been converted into built-up area.*
   f) *Values from 5 can be divided by the corresponding area of the same class at t_0. This will provide the percentage of certain land cover class that has been converted into built-up.*

Ecological Objective	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved
Indicator Title	*Land cover change*

Expected assessments outputs

The outputs are detailed below:

- *Digital map with the land cover classes for the coastal area. Land cover classes should follow the classification provided in Table1. If more detailed classification is available, then it could be provided making the clear link with Table 1. The following specifications will ensure the interoperability of the maps provided by different institutions/countries:*
    - *Format: raster GeoTIFF (Geographic Tagged Image File Format) 1 ha*
    - *Metadata:*
        - *Title of the map*
        - *Geographic reference.*
            - *Bounding box.*
            - *Coordinate reference system*
        - *Temporal reference (year)*
        - *Responsible organisation*
- Spreadsheet with the calculated indicators as described in the methodology.
- Starting with the second monitoring, additional maps will be provided indicating areas of land take (new urbanization). The specifications for these maps are the same as indicated above.

Known gaps and uncertainties in the Mediterranean

The definition of the analytical units of the coastal zone could be revised in view of more detailed data on habitats distribution, or input from national experts. In any case it is important to take into account the implications of the different delineations on the interpretation of the results.
The use of remote sensing and the selected resolution is the main constrain when analysing the outcomes

- *Not all changes are observed since there is minimum change detection. Therefore, the patterns observed indicate that changes are underestimated. In any case the proposed approach is still relevant since it provides an idea of the magnitude of the processes of urbanization.*
- *Given the resolution and processing, linear elements are not well captured; therefore, linear elements perpendicular to the coast, for example, are not detected.*
- *The information currently available does not allow identifying built-up on the territorial waters.*

Since these limitations arise from the definition of the resolution, there is space for improvement if it is needed. However, there is always a trade-off between resolution and efforts required to obtain the information.

In addition, countries may obtain data from different sources (different resolution, different level of precision) which may make comparability of data difficult.

Contacts and version Date

Key contacts within UNEP for further information

Version No	**Date**	**Author**
V.1	27/6/16	PAP/RAC
V.2	20/07/16	UAB
v.3	01/04/19	PAP/RAC

Appendix VIII

UNEP/MED WG.467/14
Draft Updated Reference List of Marine Habitat Types for the Selection of Sites to be included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean

UNITED NATIONS

EP

UNEP/MED WG.467/14

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

UNEP

8 August 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Agenda Item 8: Monitoring Protocols for IMAP Common Indicators Related to Pollution and Guidance on monitoring concerning IMAP Common Indicators related to Biodiversity and Non-Indigenous Species

Draft Updated Reference List of Marine Habitat Types for the Selection of Sites to be included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean

UNEP/MAP
Athens 2019

Note by the Secretariat

The Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean and the Action plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean (MAP Phase II), adopted by the Contracting Parties to the Barcelona Convention in 1995, contain provisions for the preparation of inventories at national as well as regional level.

At their 10th Ordinary Meeting (Tunis, 18-21 November 1998), the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution adopted common criteria for the preparation of national inventories of natural sites of conservation interest.

The criteria provided for the establishment of a reference list of marine and coastal natural habitat types, to be drafted on the basis of a model classification. At the same Meeting the Contracting Parties invited the Regional Activity Centre for Specially Protected Areas (SPA/RAC) to work on the elaboration of a model classification of marine habitat types for the Mediterranean region, as well as a reference list of habitat types.

The COP 11(Malta, 27-30 October 1999) adopted the Classification of benthic marine habitat types for the Mediterranean region and the Reference List of Marine Habitat Types for the Selection of Sites to be included in the National Inventories of Natural Sites of Conservation Interest.

The 19th Meeting of the Contracting Parties requested SPA/RAC to revise the Reference List of Marine and Coastal Habitat Types in the Mediterranean for consideration by COP 20, taking in full account the biodiversity-related MAP Ecological Objectives, IMAP, and GES targets (Decision IG.22/12).

At their 20th Ordinary Meeting (Tirana, Albania, 17-20 December 2017), the Contracting Parties, took note of the updated Reference List of Marine and Coastal Habitat Types in the Mediterranean, so that it can be used, where necessary, as a first basis for identifying reference habitats to be monitored at the national level under the IMAP and requested the (SPA/RAC) to finalize, in consultation with its focal points, the Classification of benthic marine habitat types for the Mediterranean region and the Reference List of Marine and Coastal Habitat Types in the Mediterranean, with a view to submitting them to the Contracting Parties at their 21st Ordinary Meeting (Decision IG.23/8).

In this context, SPA/RAC convened a meeting of experts (Rome, Italy 22-23 January 2019)[1], thanks to the kind invitation of the Government of Italy and financial support of the MAVA Foundation for Nature. The Expert Meeting reviewed and endorsed the Draft Updated Classification of benthic marine habitat types and the Draft Updated Reference List of Marine Habitat Types for the Mediterranean region and invited SPA/RAC to submit them to the 14th Meeting of SPA/BD Focal Points and MAP Focal Points meetings and to the 21st Ordinary Meeting of the Contracting Parties, for adoption.

The 14th Meeting of SPA/BD Thematic Focal Points (Portorož, Slovenia, 18-21 June 2019) endorsed the proposed lists and invited SPA/RAC to submit it for adoption by the COP 21.

The updating of the Reference List of Marine and Coastal Habitat Types in the Mediterranean allows the inclusion of the recent habitat types identified since their adoption in 1999. The proposed list is aligned with the updated structure of the revised marine component of EUNIS habitats classification. This will enable a coherent use of the proposed list in national inventories and monitoring programmes and homogenous and adequate assessment of the MAP Ecological objective One (EO1) and respective Common indicators at the whole Mediterranean level.

[1]The meeting documents could be downloaded at the following link :http://www.rac-spa.org/habitats.html

Draft Updated Reference List of Marine Habitat Types for the Selection of Sites to be included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean

<u>LITTORAL</u>

MA1.5 Littoral rock

MA1.51 Supralittoral rock

MA1.51a Supralittoral euryhaline and eurythermal pools (enclave of mediolittoral)

MA1.51b Wracks of dead leaves of macrophytes

MA1.52 Mediolittoral caves

MA1.53 Upper mediolittoral rock

MA1.531 Association with encrusting Corallinales creating belts (e.g. *Lithophyllum bissoides*, *Neogoniolithon* spp.)

MA1.54 Lower mediolittoral rock

MA1.541 Association with encrusting Corallinales creating belts (e.g. *Lithophyllum bissoides*, *Neogoniolithon* spp.)

MA1.542 Association with Fucales

MA1.544 Facies with *Pollicipes pollicipes*

MA1.545 Facies with Vermetidae (*Dendropoma* spp.) (vermetid reefs)

MA1.54a Mediolittoral euryhaline and eurythermal pools (enclave of infralittoral)

MA2.5 Littoral biogenic habitat

MA2.51 Lower mediolittoral biogenic habitat

MA2.511 Association with encrusting Corallinales creating platforms

MA2.512 Facies with *Sabellaria* spp. (reefs of *Sabellaria*)

MA2.513 Facies with Vermetidae (*Dendropoma* spp.) (vermetid reefs)

MA2.51a Banks of dead leaves of macrophytes (*banquette*)

MA3.5 Littoral coarse sediment

MA3.51 Supralittoral coarse sediment

MA3.511 Association with macrophytes

MA3.51a Deposit of dead leaves of macrophytes

MA3.52 Mediolittoral coarse sediment

MA3.521 Association with indigenous marine angiosperms

MA3.52a Deposit of dead leaves of macrophytes

MA4.5 Littoral mixed sediment

MA4.51 Supralittoral mixed sediment

MA4.511 Association with macrophytes

MA4.51a Deposit of dead leaves of macrophytes

MA4.52 Mediolittoral mixed sediment

MA4.521 Association with indigenous marine angiosperms

MA4.52a Deposit of dead leaves of macrophytes

MA5.5 Littoral sand

MA5.51 Supralittoral sands

MA5.511 Association with macrophytes

MA5.51a Deposit of dead leaves of macrophytes

MA5.52 Mediolittoral sands

MA5.521 Association with indigenous marine angiosperms

MA5.52a Deposit of dead leaves of macrophytes

MA6.5 Littoral mud

MA6.51 Supralittoral mud

MA6.511 Association with macrophytes

MA6.52 Mediolittoral 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*, *Ruppia maritima*)

INFRALITTORAL

MB1.5 Infralittoral rock

MB1.51 Algal-dominated infralittoral rock

MB1.51a Well illuminated infralittoral rock, exposed

MB1.511a Association with Fucales

MB1.513a Association with encrusting Corallinales creating belts (e.g. *Titanoderma trochanter*, *Tenarea tortuosa*)

MB1.514a Association with indigenous Mediterranean *Caulerpa* spp.

MB1.516a Facies with Scleractinia (e.g. *Cladocora caespitosa*)

MB1.51b Moderately illuminated infralittoral rock, exposed

MB1.512b Association with indigenous Mediterranean *Caulerpa* spp.

MB1.515b Facies with Scleractinia (e.g. *Astroides calycularis*)

MB1.51c Well illuminated infralittoral rock, sheltered

MB1.511c Association with Fucales

MB1.514c Association with indigenous Mediterranean *Caulerpa* spp.

MB1.516c Facies with Scleractinia (e.g. *Cladocora caespitosa*)

MB1.51d Moderately illuminated infralittoral rock, sheltered

MB1.512d Association with indigenous Mediterranean *Caulerpa* spp.

MB1.514d Facies with Alcyonacea (e.g. *Eunicella* spp.)

MB1.51e Lower infralittoral rock moderately illuminated

MB1.511e Association with Fucales

MB1.512e Association with Laminariales (kelp beds)

MB1.513e Association with indigenous Mediterranean *Caulerpa* spp.

MB1.515e Facies with Alcyonacea (e.g. *Eunicella* spp.)

MB1.516e Facies with Scleractinia (e.g. *Cladocora caespitosa*)

MB1.52 Invertebrate-dominated infralittoral rock

MB1.52a Moderately illuminated infralittoral rock, sheltered

MB1.521a Association with indigenous Mediterranean *Caulerpa* spp.

MB1.524a Facies with Scleractinia (e.g. *Astroides calycularis*, *Cladocora caespitosa*, *Polycyathus muellerae*, *Pourtalosmilia anthophyllites*)

MB1.525a Facies with Alcyonacea (e.g. *Eunicella* spp., *Paramuricea clavata*, *Corallium rubrum*)

MB1.53 Infralittoral rock affected by sediments

MB1.532 Facies with large and erect sponges (e.g. *Axinella polypoides*, *Axinella cannabina*)

MB1.533 Facies with Scleractinia(e.g. *Cladocora caespitosa*)

MB1.534 Facies with Alcyonacea (e.g. *Eunicella* spp., *Leptogorgia* spp.)

MB1.537 Facies with endolitic species (e.g. *Lithophaga lithophaga*, *Cliona* spp.)

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

MB1.541 Association with marine angiosperms or other halophytes

MB1.542 Association with Fucales

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

MB1.56 Semi-dark caves and overhangs (see MC1.53)

MB2.5 Infralittoral biogenic habitat

MB2.51 Reefs in algal-dominated habitat

MB2.511 Facies with Vermetidae (*Dendropoma* spp.) (vermetid reefs)

MB2.52 Reefs on fine sand in very shallow waters

MB2.521 Facies with *Sabellaria* spp. (reefs of *Sabellaria*)

MB2.53 Reefs of *Cladocora caespitosa*

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

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

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*

MB3.5 Infralittoral coarse sediment

MB3.51 Infralittoral coarse sediment mixed by waves

MB3.511 Association with maërl or rhodolithes (e.g. *Lithothamnion* spp., *Neogoniolithon* spp., *Lithophyllum* spp., *Spongites fruticulosa*)

MB3.52 Infralittoral coarse sediment under the influence of bottom currents

MB3.521 Association with maërl or rhodolithes (e.g. *Lithothamnion* spp., *Neogoniolithon* spp., *Lithophyllum* spp., *Spongites fruticulosa*)

MB5.5 Infralittoral sand

MB5.52 Well sorted fine sand

MB5.521 Association with indigenous marine angiosperms

MB5.53 Fine sand in sheltered waters

MB5.531 Association with indigenous marine angiosperms

MB5.533 Association with indigenous Mediterranean *Caulerpa* spp.

MB5.539 Facies of *Tritia neritea* and nematodes (in hydrothermal vents)

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

MB5.541 Association with marine angiosperms or other halophytes

MB5.542 Association with Fucales

MB6.5 Infralittoral mud sediment

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

MB6.511 Association with marine angiosperms or other halophytes

CIRCALITTORAL

MC1.5 Circalittoral rock

MC1.51 Coralligenous

MC1.51a Algal-dominated coralligenous

MC1.512a Association with Fucales or Laminariales

MC1.51b Invertebrate-dominated coralligenous

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

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

MC1.516b Facies with the Zoantharia *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*)

MC1.51c Invertebrate-dominated coralligenous covered by sediment

See MC1.51b for examples of reference facies

MC1.52 Shelf edge rock

MC1.52a Coralligenous outcrops

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*)

MC1.52b Coralligenous outcrops covered by sediment

See MC1.52a for examples of reference facies

MC1.52c Deep banks

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

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

MC1.523c Facies with Scleractinia (e.g. D*endrophyllia* spp.)

MC1.53 Semi-dark caves and overhangs

MC1.53a Walls and tunnels

MC1.531a Facies with sponges (e.g. *Axinella* spp., *Chondrosia reniformis*, *Petrosia ficiformis*)

MC1.533a Facies with Alcyonacea (e.g. *Eunicella* spp., *Paramuricea* spp., *Corallium rubrum*)

MC1.534a Facies with Scleractinia (e.g. *Leptopsammia pruvoti*, *Phyllangia mouchezii*)

MC1.536a Facies with Bryozoa (e.g. *Reteporella grimaldii*, *Pentapora fascialis*)

MC1.53b Ceilings

See MC1.53a for examples of reference facies

MC1.53c Detritic bottom

See MC3.51 for examples of reference associations and facies

MC1.53d Brackish water caves or caves subjected to freshwater runoff

MC1.531d Facies with *Heteroscleromorpha* spp. sponges

MC2.5 Circalittoralbiogenic habitat

MC2.51 Coralligenous platforms

MC2.512 Association with Fucales

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

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

MC2.518 Facies with the Zoantharia *Savalia savaglia*

MC2.519 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madraci spharensis*, *Phyllangia mouchezii*)

MC2.51A Facies with Vermetidae and/or Serpulidae

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

MC3.5 Circalittoral coarse sediment

MC3.51 Coastal detritic bottoms (without rhodoliths)

MC3.511 Association with Laminariales

MC3.512 Facies with large and erect sponges (e.g. *Spongia lamella*, *Sarcotragus foetidus*, *Axinella* spp.)

MC3.514 Facies with Alcyonacea (e.g. *Alcyonium* spp., *Eunicella* spp., *Leptogorgia* spp.)

MC3.515 Facies with Pennatulacea (e.g. *Pennatula* spp., *Virgularia mirabilis*)

MC3.518 Facies with Bryozoa (e.g. *Turbicellepora incrassata*, *Frondipora verrucosa*, *Pentapora fascialis*)

MC3.519 Facies with Crinoidea (e.g. *Leptometra* spp.)

MC3.52 Coastal detritic bottoms with rhodoliths

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

MC3.522 Association with *Peyssonnelia* spp.

MC3.523 Association with Laminariales

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

MC3.526 Facies with Alcyonacea (e.g. *Alcyonium* spp., *Paralcyonium spinulosum*)

MC3.527 Facies with Pennatulacea (e.g. *Veretillum cynomorium*)

MC4.5 Circalittoral mixed sediment

MC4.51 Muddy detritic bottoms

MC4.512 Facies with Alcyonacea (e.g. *Alcyonium* spp., *Spinimuricea* spp.)

MC4.513 Facies with Pennatulacea (e.g. *Veretillum cynomorium*)

MC6.5 Circalittoral mud sediment

MC6.51 Coastal terrigenous muds

MC6.511 Facies with Alcyonacea (e.g. *Alcyonium* spp.) and Holothuroidea (e.g. *Parastichopus* spp.)

MC6.512 Facies with Pennatulacea (e.g. *Pennatula* spp., *Virgularia mirabilis*)

<u>OFFSHORE CIRCALITTORAL</u>

MD1.5 Offshore circalittoral rock

MD1.51 Offshore circalittoral rock invertebrate-dominated

MD1.512 Facies with large and erect sponges (e.g. *Spongia lamella*, *Axinella* spp.)

MD1.513 Facies with Alcyonacea (e.g. *Alcyonium* spp., *Callogorgia verticillata*, *Ellisella paraplexauroides*, *Eunicella* spp., *Leptogorgia* spp., *Paramuricea* spp., *Swiftia pallida*, *Corallium rubrum*)

MD1.514 Facies with Antipatharia (e.g. *Antipathella subpinnata*)

MD1.515 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madracis pharensis*)

MD1.517 Facies with the Zoantharia *Savalia savaglia*

MD1.51B Facies with Bryozoa (e.g. *Myriapora truncata*, *Pentapora fascialis*)

MD1.52 Offshore circalittoral rock invertebrate-dominated covered by sediments

See MD1.51 for examples of reference facies

MD1.53 Deep offshore circalittoral banks

MD1.531 Facies with Antipatharia (e.g. *Antipathella subpinnata*)

MD1.532 Facies with Alcyonacea (e.g. *Nidalia* spp.)

MD1.533 Facies with Scleractinia (e.g. *Dendrophyllia* spp.)

MD2.5 Offshore circalittoral biogenic habitat

MD2.51 Offshore reefs

MD2.511 Facies with Vermetidae and/or Serpulidae

MD2.52 Thanatocoenosis of corals, or Brachiopoda, or Bivalvia (e.g. *Modiolus modiolus*)

See MD1.51 for examples of reference facies

MD3.5 Offshore circalittoral coarse sediment

MD3.51 Offshore circalittoral detritic bottoms

MD3.511 Facies with the Bivalvia *Neopycnodonte* spp.

MD3.514 Facies with Crinoidea (e.g. *Leptometra* spp.)

MD4.5 Offshore circalittoral mixed sediment

MD4.51 Offshore circalittoral detritic bottoms

See MD3.51 for examples of reference facies

MD5.5 Offshore circalittoral sand

MD5.51 Offshore circalittoral sand

See MD3.51 for examples of reference facies

MD6.5 Offshore circalittoral mud

MD6.51 Offshore terrigenous sticky muds

MD6.511 Facies with Pennatulacea (e.g. *Pennatula* spp., *Virgularia mirabilis*)

MD6.513 Facies with the Bivalvia *Neopycnodonte* spp.

UPPER BATHYAL

ME1.5 Upper bathyal rock

ME1.51 Upper bathyal rock invertebrate-dominated

ME1.512 Facies with large and erect sponges (e.g. *Spongia lamella*, *Axinella* spp.)

ME1.513 Facies with Antipatharia (e.g. *Antipathes* spp., *Leiopathes glaberrima*, *Parantipathes larix*)

ME1.514 Facies with Alcyonacea (e.g. *Acanthogorgia* spp., *Callogorgia verticillata*, *Placogorgia* spp., *Swiftia pallida*, *Corallium rubrum*)

ME1.515 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madrepora oculata*, *Desmophyllum cristagalli*, *Desmophyllum pertusum*, *Madracis pharensis*)

ME1.516 Facies with Cirripeda (e.g. *Megabalanus* spp., *Pachylasma giganteum*)

ME1.517 Facies with Crinoidea (e.g. *Leptometra* spp.)

ME1.518 Facies with the Bivalvia *Neopycnodonte* spp.

ME1.52 Caves and ducts in total darkness

ME2.5Upper bathyal biogenic habitat

ME2.51 Upper bathyal reefs

ME2.512 Facies with large and erect sponges (e.g. *Leiodermatium* spp.)

ME2.513 Facies with Scleractinia (e.g. *Madrepora oculata*, *Desmophyllum cristagalli*)

ME2.514 Facies with the Bivalvia *Neopycnodonte* spp.

ME2.515 Facies with Serpulidae reefs (e.g. *Serpula vermicularis*)

ME2.52 Thanatocoenosis of corals, or Brachiopoda, or Bivalvia, or sponges

See ME1.51 for examples of reference facies

ME3.5 Upper bathyal coarse sediment

ME3.51 Upper bathyal coarse sediment

ME3.511 Facies with Alcyonacea (e.g. *Alcyonium* spp., *Chironephthya mediterranea*, *Paralcyonium spinulosum*, *Paramuricea* spp., *Villogorgia bebrycoides*)

ME4.5 Upper bathyal mixed sediment

ME4.51 Upper bathyal mixed sediment

ME4.511 Facies with the Bivalvia *Neopycnodonte* spp.

ME5.5 Upper bathyal sand

ME5.51Upper bathyal detritic sand

ME5.512 Facies with Pennatulacea (e.g. *Pennatula* spp., *Pteroeides griseum*)

ME5.513 Facies with Crinoidea (e.g. *Leptometra* spp.)

ME5.515 Facies with the Bivalvia *Neopycnodonte* spp.

ME5.517 Facies with Bryozoa

ME5.518 Facies with Scleractinia (e.g. *Caryophyllia cyathus*)

ME6.5 Upper bathyal muds

ME6.51 Upper bathyal muds

ME6.512 Facies with Pennatulacea (e.g. *Pennatula* spp., *Funiculina quadrangularis*)

ME6.513 Facies with Alcyonacea (e.g. *Isidella elongata*)

ME6.514 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madrepora oculata*, *Desmophyllum cristagalli*)

ME6.516 Facies with Crinoidea (e.g. *Leptometra* spp.)

ME6.518 Facies with the Bivalvia *Neopycnodonte* spp.

ME6.51B Facies with Bryozoa (e.g. *Candidae* spp., *Kinetoskias* spp.)

ME6.51C Facies with giant Foraminifera (e.g. Astrorhizida)

LOWER BATHYAL

MF1.5 Lower bathyal rock

MF1.51 Lower bathyal rock

MF1.512 Facies with Alcyonacea (e.g. *Dendrobrachia* spp.)

MF1.513 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madrepora oculata*, *Desmophyllum cristagalli*, *Desmophyllum pertusum*)

MF1.514 Facies with chemiosynthetic benthic species (e.g. Siboglinidae, *Lucinoma* spp.)

MF2.5 Lower bathyal biogenic habitat

MF2.51 Lower bathyal reefs

MF2.511Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madrepora oculata*, *Desmophyllum cristagalli*, *Desmophyllum pertusum*)

MF2.52 Thanatocoenosis of corals, or Brachiopoda, or Bivalvia, or sponges

See MF1.51 for examples of reference facies

MF6.5 Lower bathyal muds

MF6.51 Sandy muds

MF6.512 Facies with Alcyonacea (e.g. *Isidella elongata*)

MF6.514 Facies with Pennatulacea (e.g. *Pennatula* spp., *Funiculina quadrangularis*)

ABYSSAL

MG1.5 Abyssal rock

MG1.51 Abyssal rock

MG1.512 Facies with Alcyonacea

MG6.5 Abyssal mud

MG6.51 Abyssal mud

MG6.512 Facies with Alcyonacea (e.g. *Isidella elongata*)

There are some geomorphologic / hydrologic features not included in the above list because their presence is independent from the depth zone and the substrate type, but they must also be considered due to the role they play in the Mediterranean ecosystem[2]. They can hold a "complex of habitats" and geoforms that cannot be treated isolated, and therefore, they do not fit inside other categories. Among them:

- Hydrothermal vents
- Cold seeps (sulfide, methane – e.g. pockmarks, mud volcanoes)
- Brine pools
- Freshwater resurgences
- Seamounts (including banks, hills, etc.)
- Submarine canyons
- Escarpments
- Boulders fields

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

Annex I: the revised the marine section of the EUNIS habitat classification[3]

Table 1. Level 2 units of the marine component of the revised EUNIS habitats classification, including proposed level 2 codes

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

Table 2. Updated EUNIS habitat classification

Level 1: Marine habitats (code M)

Level 2: Depth zone

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

Substrate type

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

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

[3]Evans D., Aish A., Boon A., Condé S., Connor D., Gelabert E., Michez N., Parry M., Richard D., Salvati E., Tunesi L. 2016. Revising the marine section of the EUNIS habitat classification. Report of a workshop held at the European Topic Centre on Biological Diversity, 12-13 May 2016. ETC/BD report to the EEA: 8 pp.

Annex II: criteria for the selection of the Reference List of Marine Habitat Type

The eight traits used for the selection are the following:

1. Fragility: degree of susceptibility of the habitat to degradation (i.e., maintaining its structure and functions) when faced to natural and anthropogenic disturbances;
2. Resilience^{-1}: inability to recover quickly from a disturbance. Usually it is related to life-history traits of component species that make recovery difficult (i.e., slow growth rates, late age of maturity, low or unpredictable recruitment, long-lived);
3. Uniqueness or rarity: degree of rarity, i.e. unusual or very infrequent, at the Mediterranean level;
4. Importance of the habitat for hosting rare, threatened, endangered or endemic species that occur only in discrete areas;
5. Species diversity: the number of species hosted in the habitat;
6. Structural complexity: degree of complexity of physical structures created by biotic and abiotic features;
7. Capacity of modifying the physical environment and the ecosystem processes (i.e., geomorphological traits, fluxes of matter and energy), with a particular relevance to the occurrence of bio-constructors;
8. Significance of the habitat for the survival, spawning/reproduction of species not necessarily typical for the habitat during all their life cycle, and other (ecosystem) services provided by the habitat.

The 3-levels of score have been used to score each habitat type, in relation to each trait and in relation to other habitats situated in the same bathymetric zone. The score 1 corresponds to a low level, the score 2 to a medium level, and the score 3 to a high level. All habitat types having a rating of 3 in "Uniqueness or Rarity" (i.e., those that are extremely rare) have been selected for the inclusion in the reference list regardless of their final rating. No water column habitats or habitats of anthropogenic origin have been considered for the inclusion in the reference list. When the main habitat-forming species is a non-indigenous species, it has not been selected for the references list whatever it is its final rating.

Inclusion of a habitat in the reference list depends on the final rating (i.e., the total score) adding the values of the eight traits altogether. The minimum score reached by a habitat can be 8 (score 1 to each of the eight traits), whilst the maximum score can be 24 (score 3 to each of the eight traits). Following an analysis on the frequency distribution of the total scores for all the habitats (up to the level 5 of the classification), two groups with a normal distribution have been clearly identified (Fig. 1).

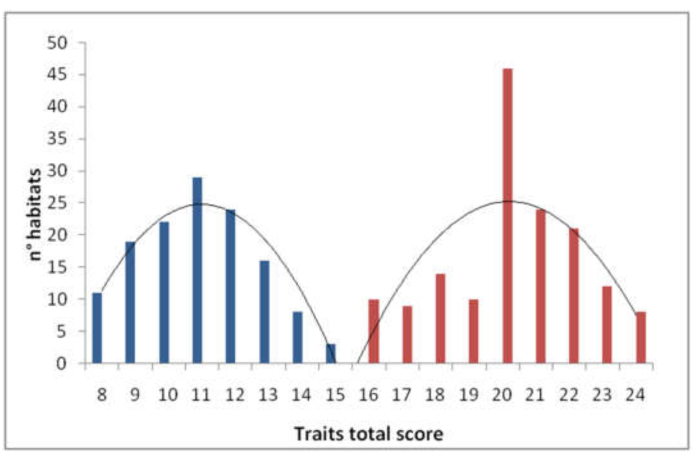

Figure 1. Number of habitats (up to the level 5 of the classification) belonging to each class of the traits total score. The model describing a normal distribution is also represented for both groups.

The two groups are separated by a threshold value of 16. All habitats reaching a total score in the eight traits equal or higher than 16, should be included in the updated reference list as priority habitats. In particular, the following two categories of habitats can be defined:

- Priority habitats: are habitats reaching a total score ≥ 16. For these habitats conservation and strict protection are absolutely mandatory;
- Least relevant habitats are habitats reaching a total score < 16. These habitats do not require special conservation or management measures and can thus be used, but always provided a sustainable use of them.

Appendix IX

UNEP/MED WG.467/15
Defining the Most Representative Species for IMAP Candidate Indicator 24 and related Monitoring Protocols

UNITED NATIONS

EP

UNEP/MED WG.467/15

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

UNEP

8 August 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Agenda Item 8: Monitoring Protocols for IMAP Common Indicators Related to Pollution and Guidance on monitoring concerning IMAP Common Indicators related to Biodiversity and Non-Indigenous Species

Defining the Most Representative Species for IMAP Candidate Indicator 24 and Related Monitoring Protocols

Note by the Secretariat

This document includes changes introduced following comments received at the 7th Meeting of the Ecosystem Approach Coordination Group. All changes are indicated in Track Changes mode.

UNEP/MAP
Athens, 2019

Note by the Secretariat

The Integrated Monitoring and Assessment Programme for the Mediterranean Sea and Coast and Related Assessment Criteria (IMAP), was adopted in 2016 from the Contracting Parties to the Barcelona Convention (Decision IG.22/7). IMAP provides the requirements for monitoring 23 Common Indicators addressing biodiversity, pollution and marine litter. IMAP also contains one Candidate Indicator 24 on the "*Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles*."

With the aim to improve knowledge of the impact of marine litter on marine fauna and also to facilitate the development of the IMAP Candidate Indicator 24, SPA/RAC in consultation with MED POL elaborated the report on the most representative species for the IMAP Candidate Indicator 24 (UNEP/MED WG.467/Inf.15).

Based on the proposal made to consider marine turtles as the most representative species to assess Candidate Indicator 24 of IMAP, work was undertaken by SPA RAC to elaborate specific protocols for monitoring interactions between marine litter and marine turtles, mainly focusing on ingestion and entanglement; taking also into account the outcome of scientific projects such as the EU-funded INDICIT project (DG ENV 2017-2018).

The Joint Meeting of the Ecosystem Approach Correspondence Group on Marine Litter Monitoring and ENI SEIS II Assessment of Horizon 2020/National Action Plans of Waste Indicators (Podgorica, Montenegro, 4-5 April 2019) reviewed both documents (i.e. the report on the most representative species and the monitoring protocol) and following their revision, both reports were submitted to MED POL Focal Points Meeting (Istanbul, Turkey, 29-31 May 2019) for further review, consideration and approval.

POL and SPA/RAC for the selection of indicator species for monitoring ingestion of marine litter by marine organisms in the Mediterranean, supported by a full report presented under UNEP/MED WG.467/Inf.15. The second part contains the protocols for monitoring interactions between marine litter and marine turtles (i.e. ingestion and entanglement) with a view to harmonize methods of data collection for monitoring and assessment in the Mediterranean.

The Meeting of MED POL Focal Points held in Istanbul, Turkey on 29- 31 May 2019 agreed on the proposed selection of indicator species for monitoring ingestion of marine litter by marine organisms in the Mediterranean, as well as the related Protocol for monitoring interactions between marine litter and marine turtles, and recommended their submission for approval of the 7th Meeting of EcAp Coordination Group.

List of Abbreviations

CITES	The Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	The Convention for the Conservation of Migratory Species
EC	The European Commission
EO	Ecological Objective
GES	Good Environmental Status

GESAMP	The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GI	Gastrointestinal
INDICIT	Implementation of Indicators of Marine Litter on Sea Turtles and Biota In Regional Sea Conventions And Marine Strategy Framework Directive Areas
IMAP	The Integrated Monitoring and Assessment Programme and related Assessment Criteria
MAP	Mediterranean Action Plan
MEDPOL	Mediterranean Pollution Assessment and Control Programme
MSFD	Marine Strategy Framework Directive
OSPAR	Convention for The Protection of The Marine Environment of The North-East Atlantic
RPML	Regional Plan on Marine Litter Management in the Mediterranean Plan for Marine Litter
SPA/RAC	Specially Protected Areas Regional Activity Centre
TG ML	Technical Group on Marine Litter

Table of Contents

1. Introduction

1. In the Mediterranean, marine litter pose a critical problem because of its great quantity and effects on marine fauna. To deal with this problem, UN Environment/Mediterranean Action Plan - Barcelona Convention adopted the first ever legally binding Regional Plan on Marine Litter Management in the Mediterranean (Decision iG.21/71).

2. One of the steps identified in the Regional Plan on Marine Litter is linked to the implementation of the integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coasts and Related Assessment Criteria (IMAP) and its 10th Ecological Objective (EO10) i.e. Marine Litter, partly based on the Candidate indicator 24 "*Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles*".

3. During this process it is essential to improve knowledge of the impact of marine litter on marine fauna and also to assess the IMAP Candidate indicator 24. This particularly involves continuing the work of selecting the most representative species to be used for the development and assessment of the IMAP Candidate indicator 24. MED POL and SPA/RAC have worked in developing and preparing the report "*Defining the Most Representative Species for IMAP Candidate Indicator 24*", which comes up with the following findings:

a. Marine litter affects various compartments of the marine environment and monitoring its impacts on marine organisms is of growing importance.
b. Whatever temporal and spatial scale is considered, marine litter (mainly plastics) interact with a vast range of marine species. The different types of impact of marine litter on these organisms can be classified according to the modes of action such as entanglement, ingestion and transportation of species that may be colonized on them.
c. Until now, no monitoring has been implemented to assess the impact of marine litter on marine organisms in the Mediterranean; but we have good scientific and technical basis to start doing so.
d. On the basis of the available information, the approach that uses monitoring of the ingestion of marine litter by marine turtles is consistent and compatible with the whole set of the identified biological, methodological, environmental, logistic and ethical constraints. The target species for the IMAP Candidate indicator 24 and also for monitoring at basin scale are the marine turtles species, which are most commonly found in the Mediterranean, i.e. *Caretta caretta*. *Caretta caretta* has a wide distribution throughout the Mediterranean Sea and a great deal of information is already available. The potential for developing a monitoring network corresponds to the needs expressed by the Contracting Parties to the Barcelona Convention.
e. The use of cetaceans as indicator species can only be considered on an opportunistic basis, and at the initiative of each Contracting Party that has pre-existing stranding monitoring networks.

f. Although protocols for monitoring the ingestion of marine litter by seabirds have been used for a long time in other marine regions, work is still required to identify the most representative species for developing a monitoring programme on the impact of marine litter on seabirds in the Mediterranean. A pilot monitoring programme of marine litter in cormorants' nests is recommended, at the initiative of the Contracting Parties to the Barcelona Convention.
g. Monitoring the ingestion of micro-plastics by fishes or invertebrates presents a strong potential for developing a monitoring programme on the ingestion of marine litter by marine organisms in the Mediterranean. Supplementary work is however necessary to complete a rigorous protocol which eliminates any risk of contamination of the samples examined and thus of false positives due, for example, to the presence of natural fibres. For these pilot studies or for more in-depth research work, priority should be given to common fish species with a wide distribution and easily fished fish species, which are sensitive to micro particles. The selection of nekto-benthic fishes, already identified as being the most affected (i.e. *Boops boops*), of important commercial interest (i.e. *Mullus sp.*), or of farmed molluscs such as the mussel Mytilus edulis, could facilitate the monitoring approach.
h. Concerning the entrapment/entanglement of marine species, observations have so far been poorly described, which restricts the development of corresponding monitoring networks. Carrying out coordinated pilot experiments based on a strategy of improved data collection, seems to be the most suitable preliminary step before envisaging developing regional monitoring. Work should focus on the prevalence of entrapment/entanglement of Mediterranean species, the identification and mapping of risk areas (presence of active or ghost fishing gear, distribution of susceptible species, probability of encounters between susceptible species and marine litter, etc.), and the rationalization of observation procedures on the basis of existing arrangements (stranding networks, Marine Protected Areas, Observation networks, opportunistic analyses of diving using submersibles or ROVs/Remotely Operated Vehicles).

4. All the recommended approaches should permit:

i. acquiring of better information to support the implementation of reduction measures; and
ii. defining of a Regional Plan-friendly monitoring strategy.

Part I

2. Proposal for the Selection of Species for the Development of the Candidate Indicator 24

5. Monitoring the impacts of marine litter on marine fauna depends strongly on the availability of indicator species to measure the prevalence and effects of ingestion of marine litter and entanglement/strangling. Monitoring these effects can be designed within a multi-species approach in order to cover the range of impacts linked to both the diverse types of marine litter, of varied size (micro-particles and macro-litter) and nature (plastics, metal, glass, etc.), and also with the varied ways of life (sedentary, benthic, nekto-benthic, pelagic, aerial) and feeding (detritus-eaters, suspension eaters, omnivores, carnivores) of the species that interact with it. The multiplicity of approaches needed to take this variability into account thus requires the use of many target species, and this is only possible if infrastructures crafted using diverse skills are in place. In the present state of our knowledge, monitoring can only be done gradually, stage by stage, depending on the degree of maturity of the indicators. initially it is recommended that a pilot monitoring network be developed based on the use of the *Caretta caretta* marine turtle species[1], the indicator of ingestion of marine litter by this species being at the most advanced stage of development.

[1] The 7th Meeting of EcAp Coordination Group agreed to submit for consideration of the next Meetings of CORMONs on Marine Litter and Biodiversity the proposal related to the inclusion of *Chelonia mydas, in addition to Caretta caretta*, among

6. It seems reasonable to also envisage starting experimental work to test the potential of new indicator species, mainly to measure the impact of micro-plastics, in particular certain species of fish that have a high rate of ingestion and wide distribution (*Boops boops*, *Mullus sp.*) and invertebrates, particularly the mussel *Mytilus galloprovincialis*, present throughout a vast area of the Mediterranean Basin. Table 1 lists the species/taxa already used, or that could be used, as bio-indicators, and their potential for use in the context of monitoring.

Table 1: Selection of indicator species for monitoring ingestion of marine litter by marine organisms in the Mediterranean

Taxon	Type of litter	Method	Infrastructure	Indicative Species	Priority	Remarks
Birds	macro-litter	Autopsy	Stranding networks, by-catch	To be researched	+	Work needed in the Mediterranean
Cetaceans	macro-litter	Autopsy	Stranding networks, by-catch	All species	+	Small number of species, low rate of ingestion, opportunistic approach only
Cetaceans	micro-plastics	Autopsy / chemical	Stranding networks, by-catch	All species	+	Sampling and measuring difficult
Marine turtles	macro-litter	Autopsy / excreta monitoring	Stranding networks, by-catch, rescue centers	*Caretta caretta*	+++	Necessity of mastering biological parameters
Nektobenthic fishes	micro-plastics	Stomach contents	Coastal fishing and trawling	*Mullus sp., Boops sp.*	++	Wide distribution of species, easily caught
Demersal fishes	macro-litter	Stomach contents	Scientific and commercial trawling	*Scyliorhinus sp.*	+	Opportunistic collection possible
Pelagic fishes	micro-plastics	Stomach contents	Commercial fishing		+	Opportunistic collection possible
Molluscs	micro-plastics	Stomach contents / chemical	Collection, farming, chemical monitoring networks	*Mytilus sp.*	++	Existing collection networks, concerning public health
Crustacean	micro-plastics	Stomach contents / chemical	Collection		+	Work needed in the Mediterranean
Other invertebrates	micro-plastics	Stomach contents / chemical	Collection	Sea cucumbers	+	Work needed in the Mediterranean

7. Concerning the entanglement / strangling, it is still necessary, under the present conditions, to organize the collection of information and to define the monitoring modes (Table 2). The mobilization of stranding networks must be considered as a priority by the Contracting Parties to the Barcelona Convention on a voluntary basis at first for experimental monitoring of entanglement/strangling of the main most sensitive species (mammals, birds, turtles).

8. The potential of monitoring marine litter in nests must be re-examined by experts in order to propose guidelines; to this effect, an experimental monitoring should be set up, particularly in the Mediterranean protected areas and on the basis of voluntary action by the Contracting Parties.

the marine turtle species that could be used as indicator species in the Mediterranean for testing the implementation of IMAP Candidate Indicator 24, with a particular focus on ingestion and entanglement.

9. As part of future development, we recommend that the potential of surface and underwater observation campaigns (Table 1) be assessed. The interest of shallow diving, especially in Marine Protected Areas, and using submersibles or ROVs (Remotely Operated Vehicles) for greater depths as tools for collecting observations on entanglement/strangling of the most affected species (invertebrates and fishes) must be assessed. This last approach (submersibles/ROVs) should not be dissociated from operations of inventorying or reducing abandoned fishing gear/nets in areas defined as priority areas within the context of the Un Environment/MAP Regional Plan on Marine Litter Management in the Mediterranean.

Table 2: Monitoring arrangements and indicator species to be tested for monitoring entanglement/strangling in the Mediterranean

SPECIES	TYPES OF LITTER	METHOD	EXISTING NETWORKS	SPECIES	PRIORITY	REMARKS
Birds	Fishing gear, macro-litter	Observations , diagnosis	Stranding networks	All species	+	The monitoring must be organized per system with the following priorities: 1) Pilot study concerning opportunistic monitoring by stranding networks 2) Evaluation and tests of video/diving monitoring systems in protected areas 3) Surface observation test
Cetaceans	Lost nets, ghost nets	Observations , diagnosis	Stranding & observation networks at sea	All species	+	
Turtles	Lost nets, ghost nets	Video monitoring (diving and ROVs)	Stranding & observation networks at sea	All species	+	
Nektobenthic fishes	Fishing gear	Video monitoring (diving and ROVs)	Video monitoring (diving and ROVs)	All species	+++	
Pelagic fishes	Lost nets, surface ghost nets	Observations, fishing	networks of sea observation	Big pelagic sharks	++	
Invertebrates	Lost nets, macro-litter	Video monitoring (diving and ROVs)	Protected area monitoring, scientific campaign	All species	+	
Birds	Meso-/ macro-litter	Observation, litter in nests	Nesting monitoring networks	European Shag	+	Indicator of effect partially concerning strangling. To be tested on a pilot scale

Part II

3. Protocols for monitoring interactions between marine litter and marine turtles[2]

10. The protocol presented under the present document intends to provide technical support and guidance with regards to monitoring the impact of marine litter, especially through ingestion and entanglement, on marine biota. The hereunder presented monitoring protocol provides a response to the requirements under the European Commission (EC) Marine Strategy Framework Directive (MSFD) (i.e. Indicator 10.2.1 "*Trends in the amount and composition of litter ingested by marine animals*" (Criteria D10C3), and the Regional Sea Conventions i.e. OSPAR (Indicator EcoQO3) and Barcelona Convention (10th Ecological Objective (EO10) on Marine Litter of the Integrated Monitoring and Assessment Programme and related Assessment Criteria (IMAP)).

11. EO10 of IMAP consists of two Common Indicators and a single Candidate Indicator. EO10 Candidate Indicator 24 is referring to the "Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles). Marine turtles have been proposed as indicator species to study marine litter ingestion on biota through the

[2] The elaboration of the protocols has been prepared by SPA/RAC in the framework of the EU-funded Marine Litter MED Project, with support of regional experts, in full synergy with the Protocols developed under EU-Funded INDICIT Project.

development and the implementation of one major indicator “Litter ingested by sea turtles”.[3] On the basis of the information available, the approach that uses the monitoring of marine turtles’ ingestion of litter seemed consistent and compatible with the whole set of biological, methodological, environmental, logistical and ethical constraints identified (RAC/SPA, 2017). Some elements have already been suggested in this perspective (Table 3).

12. Standardized methodologies for extracting marine litter ingested from dead and live individuals are presented to the present document. This document originates from the merge and integration between, the INDICIT protocol (INDICIT[4], 2018) established from original methodologies tested first ever in Italy (Matiddi et al., 2011), later transposed into the MSFD guideline (MSFD TG ML, 2013), regularly improved in cooperation with various stakeholders (rescue centres, stranding networks, etc.); and the Marine Litter MED[5] Project protocol (UN Environment/MAP Specially Protected Areas Regional Activity Centre[6], 2017).

13. Species and habitat conservation policies recognise the pressure that waste of human-origin exerts on marine turtle populations as a potential threat. In the context of the Convention for the Conservation of Migratory Species (Bonn Convention or CMS), Resolution 10.4 on Marine Litter and Resolution 11.30 on Managing Marine Litter, have recently been repealed and put together in a new Resolution that will reflect how the context has changed since they were published in accordance with developments made in other surroundings. In this Resolution, the CMS invites the Parties (paragraph 24 b) to draft reports on measures implemented and their relative success in marine litter management. It also invites the Secretariat of the CMS family Accords (paragraph 28 b) to submit data on the impacts of marine litter, including micro-plastics, on the migratory species covered by these Accords with a view to their being examined by the Scientific Council.

Table 3: Types of data and categories of litter, the use of which has been advised in the context of the programmes for monitoring the impact of litter on marine turtles/biota, by UNEP/MAP/MEDPOL and MSFD.

a. Data capture sheet, according to UNEP/MAP, suggested by MEDPOL (2016)

Place	Date of sampling	Date of analysis	Species	
No. of sample Observer	Observer		Organ*	
	Storage conditions (fresh/frozen, duration)			
Item	Category (code)	Size (**)	Weight	Colour
Comments				

* Oesophagus, and/or stomach, and/or intestine (if parts have not been distinguished)
** (1 = <2.5 cm, 2 = 2.5-5 cm, 3 = 5-10 cm, 4 = 10-20 cm, 5 = > 20 cm)

b. List of recognised litter codes and categories (from UNEP/MAP, 2016). For the purposes of harmonization, the codes are taken from the main list of litter categories as defined by MSFD

Plastic polymers	Codes	Items
	G2	Plastic bags
	G48	Synthetic rope
	G51	Fishing net

[3] As part of the Regional Plan on Marine Litter (PRDM) Decision G. 21/7 , one of the measures is linked to implementing the (IMAP), partly based on Ecological Objective 10’s pilot indicator on amounts of litter ingested by marine organisms or these organisms’ rates of entanglement. the PRDM selected the most representative species for the common indicator IMAP CI 18.)
[4] https://www.indicit-europa.eu
[5] https://web.unep.org/unepmap/what-we-do/projects
[6] https://www.rac-spa.org

	G119	Sheet-like plastic
	G122	Plastic fragments
	G81-G82	Polystyrene
	G78-79	Plastic fragments (>5 mm)
	G112	Industrial pellets
	G107 to G111, G113 to G116	Other micro-plastics (<5 mm)
Rubber	G125	Balloons
Supra-category 'Natural cloth/textile'	G145	
Supra-category 'Paper/cardboard'	G146	
Supra-category 'Wood' (processed)	G170	
Metal	G183	Fish hooks
	G198	Other metal
Supra-category 'Other'		

14. In the proposed protocol, both "basic" and "*optional*" parameters are proposed to be collected. The **basic parameters** (thereafter noted in bold) correspond to the minimum parameters which are fundamental to determine the indicator criteria. The ***optional parameters*** (thereafter noted in bold italic grey) aim at acquiring further knowledge on loggerheads' feeding behaviour and the probability to ingest marine litter and micro-litter, as well as to better specify the indicator criteria which are under development. The ***optional parameters*** can also help to better assess the impacts of litter related to entanglement.

15. An **observation sheet** is provided in Annex II. In order to facilitate data banking and statistical analysis, data must be filled in the corresponding **standardized table**, by respecting the units and proposed menu choices, and specifying remarks or other proposals in the last column "Note". **All boxes must be filled,** either by the information (quantitative or qualitative data), by 0 or by "NA" (information not available or not evaluated). A printable summary of the main manipulations is provided in Annex IV to the present document.

3.1. Preliminary Information

3.1.1 Regulatory aspects

16. The following protocols describe the technical operations that should be implemented during the recording of information and while taking samples from live or dead marine turtles. The surveyor will have to ensure beforehand the conditions of intervention on the sea turtles in the country where he/she intervenes and to comply with the regulations in force. These operations may require making requests for permission which may lie under different regulations. The requests that may be required are described as follows: i) action on protected species, if the species enjoy national protected status, ii) action on a live wild animal in the context of an animal experiment, even if the activities described here are not intrusive, and iii) the arrangements advocating health precautions to be taken regarding infectious diseases and zoonosis.

17. If specimens have to be moved for analysis to and/or from a state that is a signatory to the Washington Convention (CITES), it will also be necessary to make a request for a 'CITES permit' since all species of marine turtle appear in Annex 1 to this Convention.

3.1.2 Rules of hygiene

18. Action on specimens of marine turtles, whether these are dead or alive, must respect a certain number of rules of basic hygiene. We recommend applying a certain number of basic rules mentioned below.

19. Marine turtles may carry agents that are pathogenic to human beings (see Baron, 2014 for references) such as salmonella, mycobacteria, Leptospira, *Pseudomonas sp.*, *Aeromonas sp.*, amoeba etc. On the carcass, different anaerobic bacteria are developed and can infect people, especially if they are accidentally hurt while examining and handling.

20. The intervention zone must be marked-off from the bystanders and handling necessitates to wear a protective suit with glasses, gloves and rubber boots. Note that although gloves represent a protection, they can also, once soiled, represent a source of contamination. Thus, the surveyor must be very careful while separating those items that must remain away from the soiled items. For the soiled items a different process should be followed including washing and disinfection, or to be thrown in separate bins.

21. If the people providing the information (e.g. fishermen, firemen, etc.) have touched the turtle with their bare hands, they must be given advice and instruction on hygiene and should be particularly told to wash their hands carefully after the action. A disinfectant soap (e.g. chlorhexidine) could be also provided to them when they arrive at the place (e.g. rescue center) where the marine turtle will be delivered. The same precautions will be taken by surveyors who have not worn gloves.

22. For the same reasons, live turtles and carcasses must be moved in special tubs (e.g. plastic bowls with a waterproof mat for live animals) so that they can be cleaned and disinfected. Samples (e.g. digestive tracts) will be packed into watertight bags and if possible, put in a cool-box for transport to avoid any contamination of the vehicle and also to restrict the process of autolysis*[7] of the tissues (decomposition). After external examination of a dead turtle, or an autopsy, there are several options for eliminating the carcass or remains according to national rules where the operations are being carried out. If the turtle is examined at the site of the stranding and must be got rid of by municipal workers, for example, or by slaughterhouse workers, it is always preferable to wrap the carcass in a closed, hermetically sealed double bag and inform the agents who are taking over of the precautions to be taken.

23. All soiled elements, gloves, protective clothing, absorbent paper and disposable instruments must be thrown into the bag before it is closed if an incineration is anticipated, or special bins that will be treated in a way that suits this type of organic waste. Finally, it is understood that the ideal conditions for the external and internal examination of a turtle, and for the taking of samples, are those found in a laboratory. For dead turtles, it is recommended that there be a case-by-case study of the possibilities of carrying out the dissections*/necropsies in premises that are well-equipped and with competent technical staff. This means, particularly, veterinary analysis laboratories or scientific research laboratories. As regards live turtles, the examination is usually done in a care center or a veterinary surgery, where these precautions are already respected.

3.1.3 Preparing the premises, equipment and instruments

24. Before carrying out the operations of dealing with specimens, and storing or taking samples, and analyzing them, it is necessary to prepare the premises, equipment and instruments that are to be used. The elements that are useful for this preparation are summarized in Annex III to the present document.

25. If the examination and dissection cannot be done in laboratory conditions, it is recommended that an action zone be marked off and material prepared somewhere near the carcass, with a toolbox in which soiled instruments will be placed at the end of the operation to be cleaned later, and two big bin bags to receive the carcass to be got rid as well as disposable sharp things. If the examining and opening up of the carcass is done after moving it to the premises, these must at least have a water tap, an examination table and material that can be washed down (metal), if possible, fitted with a drainage canal, under which a bin will be placed to receive the tissues and non-sharp things to be thrown away at the end of the operation.

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[7] The glossary (Annex I) contains the definition of terms used in the protocols, marked in the text with an asterisk

3.1.4 Preparing the team, distributing roles

26. For reasons of hygiene (see above), it is recommended that at least two people are involved in the operations: one to operate, protect himself and handle the soiled objects; the other to take photos, note information etc. The second person can assist the surveyor by wearing two pairs of gloves, one of them being changed for writing. For surveyors, cut-resistant pair of gloves must be worn below the two pairs of gloves, one of them being changed for touching materials to keep clean or in case of cutting the first pair.

3.1.5 Size of marine litter considered

27. The new Commission Decision (Decision 2017/848 of the 17th May 2017) provides the different sizes of marine litter for D10C3 "primary" criteria as litter (>5mm) and micro-litter (<5mm). For the D10C3 "secondary" criteria, both marine litter and micro-litter are quantified. The MSFD Technical sub-group on Marine litter (MSFD TG-ML, 2013) recommends, for practical reasons, to consider micro-plastics between 1 and 5 mm when it is impossible to characterize chemically or physically the type of smaller microplastics. Consequently, the micro-litter size range for this criterion is considered at 1-5mm, for practical reasons when visual observations is the only possible method of characterization.

28. GESAMP (2016) provides the definition of micro-plastic as any plastic particle < 5mm. Moreover, the categories meso-plastic (5-25mm) and macro-plastic (> 25mm) can be used.) For more precise definitions, a glossary is provided under Annex I to the present document.

3.1.6 Useful definitions

29. In order to ensure optimum harmonization during the collection of information, certain definitions must be clearly provided. Acceptance of certain terms may differ from one person to the other and thus may represent a source of bias. The glossary (Annex I) contains the definition of terms used in the protocols, marked in the text with an asterisk *. These concerns, inter alia, the anatomy of marine turtles, assessment of carcasses, impacts of litter on these species, types of litter and fishing gear* encountered, etc.

3.2. General Information on Live and Dead Specimens

3.2.1. First Notes on the Discovery Site

30. **Contact:** Note the name, contact (phone, mail) and institution of the observer(s) (data collector).

31. **On the individual:** Identify the species of the observed marine turtle:

- Cc (loggerhead *Caretta caretta*): 2 pairs of pre-frontals scutes, nuchal scale in contact with the 1st costal;
- Cm (green *Chelonia mydas*): 1 pair of pre-frontals scutes, nuchal scale not in contact with the 1st costal;
- Dc (leatherback *Dermochelys coriacea*): Absence of keratinized scutes, presence of 'leather' and ridges.

32. In case of doubt about the species identification, refer to identification guide (e.g www.cites.org). If the species cannot be identified, note NI (Non-identified) on the observation sheet.

33. **Tags:** If the examined marine turtle has been identified during egg-laying or a prior release, it may have one or two rings attached to one (two) flippers or an electronic chip that has been slid under the skin or into a muscle. To read the chip you need to have a transponder reader. In some relatively rare cases the turtle carries a telemetric monitoring device (tag) that can also help identify it, by contacting the provider or structure whose names appear on the tag. If pre-existing tag on the flipper, specify the tag number. Indicate the presence and code number of electronic chip. Otherwise, note NO.

34. **Animal Identification Code:** It is recommended to use a standard identification code. We propose noting: 2 letters for the country, 2 letters for the location (e.g. region or institution), the species, the year, the month, the day and the number of turtle per order of collection during the year, separated with "_". Example: "FR_GR_CC_2017_03_12_9" corresponds to the 9th loggerhead individual, found in by the center of Grau du Roi in France, the 12nd March 2017. Thereafter, it will be asked to specific the type of sample.

35. **On the site:** Note the **date of discovery** (dd/mm/yyyy), **the location of discovery** and ***the coordinates*** if available **(*X, Y***: *in decimal degrees, or specify the coordinate system).*

NOTE: Taking pictures of the animal before handling is very important to verify the circumstances of the finding and to *a posteriori* confirm or clarify information noted, in case there is doubt or difficulty in identifying the species, the lesions*, the state of the individuals and the elements responsible for the interaction*. Using a tape measure can show the order of magnitude in the pictures and it is important to refer to the identification code of the animal examined when storing the pictures. Please specify if pictures are taken in the column "Photo at finding" of the Excel file.

3.2.2. Description of the animal's body condition

3.2.2.1 Conservation status or decomposition level

36. Two cases are present: the turtle is alive, or it is dead. But it can also seem dead (very slow breathing) and just be in a coma, so it is useful to check by looking for reflexes (oculo-palpebral*, withdrawal reflex when the tail is pinched) before reanimation, if need be. Note the **status** according to these 5 levels presented under Figure 1, hereunder:

- Level 1: litter can be extracted from the analysis of faeces in rescue center.
- Levels 2 and 3: are adequate for litter ingestion analysis from necropsies.
- Level 4: allows to measure biometric data and assess the presence/absence of ingested plastic (for the evaluation of the frequency of occurrence of litter ingestion (or prevalence, FO%)) and entanglement*.
- Level 5: for which individuals have usually lost the gastro-intestinal material, the analysis of litter ingestion is not possible[8].

[8] Some tissues (muscle, etc.) can be collected and frozen at -20°C for further genetic analysis.

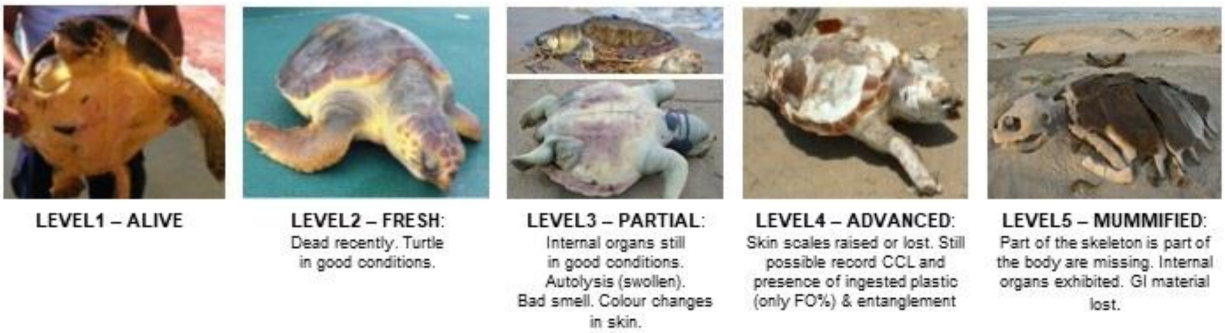

Figure 1: Conservation level or decomposition status

3.2.2.2 Discovery circumstances

37. Note the **circumstances** among the 4 categories:

- Stranding*: Animal found stranded on the beach or in the shoreline,
- By-catch*/Fisheries: Animal accidentally captured by fishermen (e.g. ingestion of a hook, trapped in a net, brought back by fishermen, etc.) during fishing operations,
- Found at sea: Animal discovered on sea surface,
- Dead at the recovery center: The animal arrived alive but died during its hospitalization.

3.2.2.3 Possible cause of morbidity and mortality, type of impact

38. If possible, the ***type of interaction with human activities and impact observed or suspected on dead or live stranded individuals*** should be deduced from external observations or organs observation during the necropsy* of dead individuals and complement with veterinarian examinations. Also, an inspection of the oral cavity should be conducted for the presence of foreign material. Then a choice among the 10 different categories should be made and the notes and remarks box should be completed with the help of the pathologist (if this is requested):

- Bycatch/Fisheries related: ingested hook, decompression sickness (diagnosable through X rays), individual trapped in a fishing gear, individual drowned in a fishing gear…;
- Entanglement in litter: entanglement in litter other than related to fishing activity. Please fill the column "Entanglement type" and "Litter causing entanglement";
- Ingestion of litter: digestive obstruction or occlusion, perforation or other impacts;
- Anthropogenic trauma: Collision with a boat or a propeller, individual beaten with knife, stick or harpoon, poaching…;
- Natural trauma: e.g., shark attack;
- “Natural disease” (=other symptoms): buoyancy trouble, cachexia, dermatitis, conjunctivitis, rhinitis…;
- Oils: Ingestion or external impregnation with oils;
- Unidentified: Impossible to know the cause of death/stranding, no remarkable damages, injury or disease;
- Other: Please specify in the column "Notes".

3.2.2.4 By-catch gear

39. If the animal has been found bycaught, specify among the 6 proposed categories, the ***by-catch gear***:

- Longline;

- Trawler;
- Nets;
- Fishing rod;
- Non-identified;
- Other: Please specify in the column "Notes".

40. Please also specify if possible, in the column "Notes" the distance from the coast and the duration of the deployment before the gear was brought aboard.

3.2.2.5 Health status

41. Note the ***health status*** according to the level of body condition (Fig. 2).

Figure 2: Health status from visual observation of plastron shape (from Thomson et al., 2009)

3.2.2.6 Main injuries

42. In case of injuries, the ***main type of injury*** (fracture, amputation*, sectioning, abrasion or other) should be reported according to Fig. 3 hereunder presented. For other type, please specify it in the column “Notes”.

Figure 3: Typology* of the most frequent injuries observed in sea turtles

3.2.2.7 Affected body part

43. If the animal presents an injury, the ***affected body part*** should be reported:

- RFF for the right front flipper;
- LFF for the left front flipper;
- RRF for the right rear flipper;
- LRF for the left rear flipper;

- Neck;
- Carapace;
- Plastron;
- Head;
- Several (if several parts of the body are impacted) or other (please specify in the column "Notes").

3.2.2.8 Litter causing entanglement

44. If the individual has been found entangled in litter, the ***type of material in which the sea turtle has been found entangled in*** should be specified, according to the following categories:

- Pieces of net (N),
- Monofilament line (nylon) (L),
- Rope or pile of ropes (R),
- Plastic bag (Pb),
- Raffia (Rf),
- Other plastics (Ot),
- Multiple materials (Mu),
- Unknown (Unk).

3.2.2.9 Other descriptive parameters

45. Visual inspection of the animal's ***fat reserves*** at the neck is recommended. For dead individual, this can be verified when opening the plastron* according to the quantity of fat recovering the abdominal muscles (see below, Fig. 6c). Choose among the 3 categories:

- Thin (sunken neck);
- Fat;
- Normal.

46. If possible, the ***sex*** (Male or Female) should be noted, which can be determined by gonads analysis or, in adult individuals from the observation of secondary sexual characters (Fig. 4), according to the length of the tail and of the claw in the front flipper. This may be confirmed through a visual observation of the genital apparatus during the necropsy for dead individuals. Otherwise, specify by NI (for Not identified).

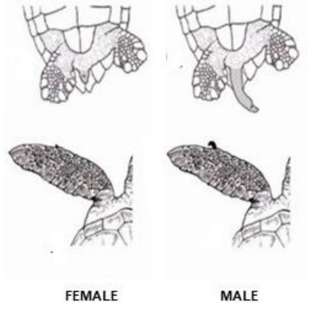

Figure 4: Example of determination of the sex of loggerhead turtle (from Wyneken, 2001)

3.2.2.10 Biometric Measurements

47. Following Fig. 5, several basic and *optional* body lengths can be measured (in centimeters, precision 0.01 cm), as well as the ***Weight*** (in kilograms, precision 0.01g). A measuring tape should be used to measure curved lengths and a sliding caliper for straight lengths:

- **Standard curved carapace length (CCLn-t or CCL)**
- ***Maximum Curved Carapace Length (CCLmax)***
- ***Minimum curved carapace length (CCLmin)***
- ***Curved carapace width (CCW)***
- ***Standard Straight carapace length (SCLnt)***
- ***Maximum Straight carapace length (SCLmax)***
- ***Minimum Straight carapace length (SCLmin)***
- ***Straight carapace width (SCW)***
- ***Curved plastron length (CPL)***
- ***Straight plastron length (SPL)***
- ***Curved plastron width (CPW)***
- ***Straight plastron width (SPW)***

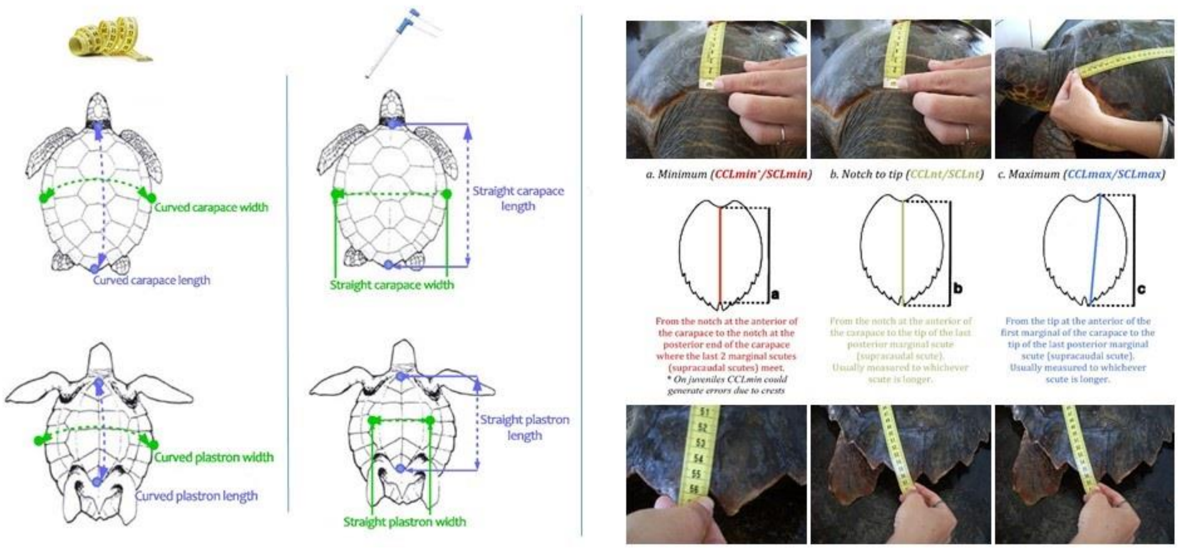

Figure 5: Biometric parameters (carapace and plastron lengths).

3.3. Sampling Marine Litter from Carcasses – Protocol for Dead Animals

48. In case of decomposed animal (status of Levels 3 and 4), the integrity of the digestive tract should be checked before carrying the turtle in laboratory. In any case (except status of Level 5), if the necropsy cannot be done immediately after the recovery, freeze the carcass at -20°C.

3.3.1 Turtle Necropsy

3.3.1.1 Opening of the carcass

49. The carcass should be placed on its back, trying to wedge it with an object so that it doesn't wobble from side to side. The plastron should be removed and separated from the carapace through an incision on the outside edge (yellow line) (Fig. 6a). The incision should be made with special attention, with the use of a short blade or by cutting with a horizontal tilt in order not to affect the integrity of the interior organs (Fig. 6b).

50. Once the inside of the plastron is accessed, cut the ligament attachment to the pectoral and pelvic girdle to pull back the plastron and reach the muscles and then the internal organs.
Report the ***Fat reserves*** of the animal (Fig.6c) according to:

- Atrophy of pectoral muscles (none, moderate, severe);
- Fat thickness in joint cavities and in coelomic membrane (abundant, normal, low or none);
- Then complete the fat reserves informing the trophic status* of the animal (thin, normal of fat).

Figure 6: Sequence of turtle necropsy: a) Ventral view of a dead turtle. Yellow line indicates the way to separate the plastron from the rest of the turtle; b) Horizontal cuts to prevent affecting the interior organs; c) Ventral view of the opened turtle (fat reserves (brown) can be observed on the muscles).

3.3.1.2 Extracting and preparing sections of the digestive tract

51. **Extraction of the Gastrointestinal System:** Expose the gastrointestinal system (GI) by removing the pectoral muscles and the heart of the animal (Fig.7a and 7b). The blood can be emptied from the abdominal cavity by carefully rolling the turtle onto a side. Clamp the oesophagus proximal to the mouth and clamp the cloaca*, the closest to the anal orifice. Remove the entire GI and place it on the examination surface. This operation is easier if done by at least 2 operators: one person keeps the animal lying on one side, while the other separates the ligaments of the different organs and membranes of the carapace, extracting the GI from the carcasse. Isolate the different portions of GI (oesophagus, stomach, intestines) by strangling and cutting between 2 clamps (see the blue solid lines in Fig. 7c) the gastro-oesophageal sphincter and the pyloric sphincter.

52. **NOTE:** If possible, record the **sex** of the animal through the observation of gonads.

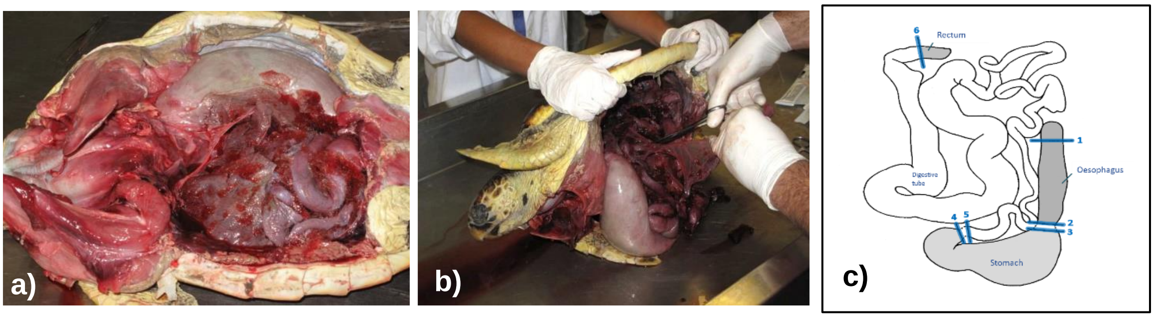

Figure 7: Sequence of extraction and preparation of sections of the digestive a) Remove the pectoral muscle and the heart; b) Extraction of the GI; c) Sketch of the entire GI. Blue lines indicate where clamps must be attached in order to separate the 3 different GI sections. (Drawing by V. Hergueta).

53. **Noting external lesions of the GI that can be attributed to litter:** Before opening up the digestive tube, examine the outer wall to observe possible perforations by foreign bodies or areas of necrosis. Also note secondary lesions, particularly a peritonitis following on a perforation of the

digestive tube, an invagination of the digestive tube, an occlusion*, etc. Photograph every lesion observed, taking care to get an overall view and a close-up (macro-lens). Pictures must be stored referring to the code corresponding to the animal examined, describing the lesion in the description of the subject.

3.3.2 Extraction of Gut Content

54. The three parts of the gastrointestinal system (i.e. oesophagus, stomach, intestines) should be removed by adding a second strangling at the cut edge to prevent spillage of the contents (Fig. 8a)[9]. Each GI section should be opened lenghtway using a scissor and slide the material directly out of the section onto a 1mm mesh sieve. The content should be cleaned with current and abundant tap water (Fig. 8b) to remove the liquid portion, the mucus and the digested unidentifiable matter[10].

55. The content for the presence of any tar, oil, or particularly fragile material, should be inspected and should be subsequently removed and treated separately. It should be then reported in the column "Notes" of the INDICIT-UN-MAP Excel file.

56. All the material should be rinsed collected in the 1mm sieve (Fig. 8b, c), and should be placesd in tubes or in zipped bags, reporting the sample code (individual code, respective GI section) and stored at -20°C, pending the laboratory analyses.

NOTE: At this stage, for the optional differentiation of litter and micro-litter, the material should be slid out of the section directly onto a 5mm mesh sieve superposed on a 1mm mesh sieve. Then, proceed with the rinsing and the storing of the material collected as described above, for both 1- and 5- mm sieves, reporting the samples code (individual code, respective GI section and size class (>5mm or 1-5mm)).

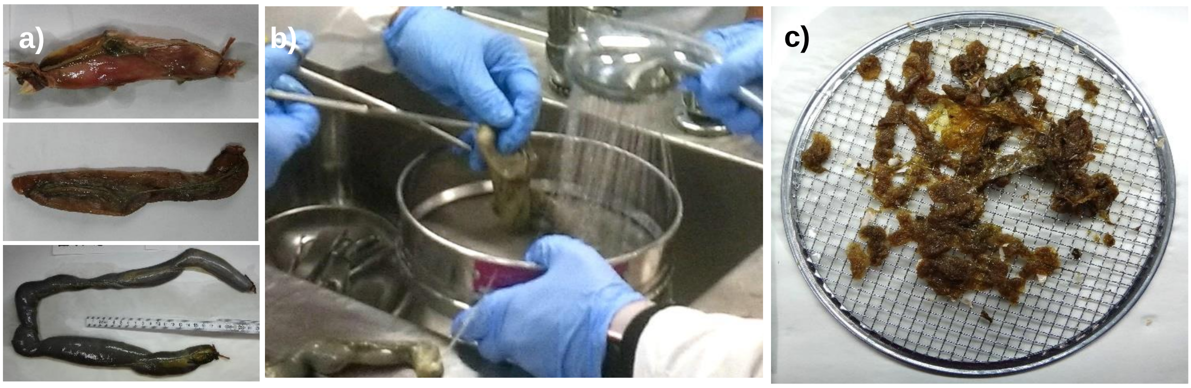

Figure 8: Digestive tract analysis: a) Separated GI sections: Oesophagus (up), stomach (middle) and intestines (down); b) Section opening and gut content lavage; c) Gut content extracted.

3.3.2. Extraction of Ingested Marine Litter and Other Elements from the Stored Gut Content

57. The gut contents should be defreezed the stored and both marine litter and other items should be removed manually by visual observation.

3.4. Sampling Marine Litter from Faeces – Protocol for Live Animals

58. **Collection of faeces:** For the homogeneity of approaches allowing the comparability of turtles and regions over time, the collected faeces will be analyzed only for the individuals remaining at least **1-month minimum** in the rescue center. The faeces should be collected **only after 2 months** from the

[9] The 3 parts of the GI (oesophagus, stomach, intestines) are analysed separately in order to assess possible differences in litter content per section and better assess the digestive transit of marine litter.

arrival of the individual. The turtle should be carefully rinsed with water to avoid contamination and the animal should be placed in an individual tank (Fig. 9a). A filter of 1mm should be disposed in all the discharge tubes of the tank (Fig. 9b). The water tank should be controlled daily by filtering through the 1mm mesh sieve according to the following methods:

- Collect the faeces manually with a 1mm mesh dip net (Fig. 9c);
- Put a 1mm mesh flexible collector in the drain tube (Fig. 9d);
- Place a 1mm mesh rigid sieve under the drain (Fig. 9e).

Figure 9: Sequence of faeces sampling. a) The turtle is disposed in an individual tank; b) A 1mm mesh sieve is disposed in discharge tubes; c) A 1mm dip net for handling faeces; d) Collector with 1mm mesh disposed in discharge tube for filtering water tank; e) An 1mm mesh rigid sieve down discharge tube for filtering water tank; f) Sample collected in a rigid sieve.

NOTE: Each sample which could not be analyzed directly can be conditioned in a tube or a zipped bag and identified with a permanent marker, e.g. with 2 letters for the country _ 2 letters for the region/Institution _ Species_Year _ Month _ Day _ N° turtle _ Type of sample.
Ex: FR_GR_CC_2017_03_12_9_Faeces corresponds to the faeces, excreted by the 9th loggerhead individual found by the rescue center of le Grau du Roi in France, the 12nd March 2017.
The sample is then stored at -20°C, pending the laboratory analyses.

59. **Collection of litter and other elements from faeces:** The sieves and collectors should be washed with abundant water above a 1mm mesh sieve (Fig. 9f). The collection of litter and other elements is conducted manually by visual observation directly from the 5mm and 1mm sieve.

NOTE: At this stage, for the optional differentiation of litter and micro-litter, the sieves and collectors should be rinsed above a 5mm mesh sieve superposed on a 1mm mesh sieve. Then, proceed with the collection of litter as described above, for both 1- and 5- mm sieves.

3.5. Marine Litter Analysis and Classification

60. **Litter and other elements classification:** The **protocol** that was used should be specified, between “Necropsy” or “Faeces”. For each GI section of the necropsied individual (Section 1 of this

document) or for faeces (Section 2 of this document), classify the litter and other elements according to the following categories (Tab 4., Fig. 10)[11].

Table 4: Classification of ingested litter and other elements for sea turtles content analysis.

CATEGORIES			CODE	DESCRIPTION
LITTER	PLASTIC LITTER	**Industrial plastic**	**IND PLA**	Industrial plastic granules, usually cylindrical but also sometimes oval spherical or cubical shapes, or suspected industrial item, used for the tiny spheres (glassy, milky...)
		Use sheet	**USE SHE**	Remains of sheet, e.g. from bag, cling-foil, agricultural sheets, rubbish bags…
		Use thread	**USE THR**	Threadlike materials, e.g. pieces of nylon wire, net-fragments, woven clothing…
		Use foam	**USE FOA**	All foamed plastics e.g. polystyrene foam, foamed soft rubber (as in mattress filling)…
		Use fragment	**USE FRAG**	Fragments, broken pieces of thicker type plastics, can be a bit flexible, but not like sheet like materials.
		Other Use plastics	**USE POTH**	Any other plastic type of plastics, including elastics, dense rubber, balloon pieces, soft air gun bullets… Specify in the column "Notes".
	Litter other than plastic		**OTHER**	All non-plastic rubbish and pollutant e.g. cigarette filters…
OTHER ELEMENTS		**Natural food**	**FOO**	Natural food for sea turtles (e.g., pieces of crabs, jellyfish, algae…)
		Natural no food	**NFO**	Anything natural, but which cannot be considered as normal nutritious food for sea turtle (stone, wood, pumice, etc.)

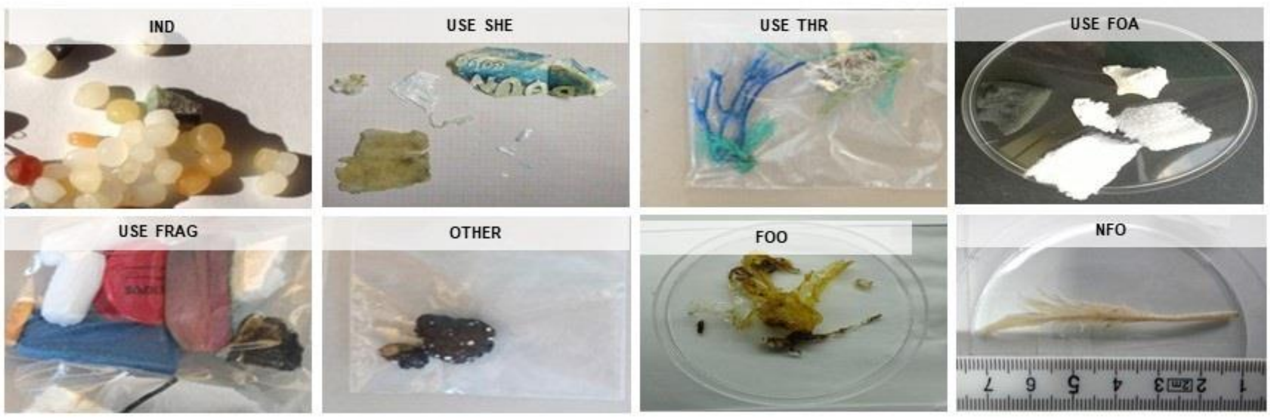

Figure 10: Examples of ingested litter and other elements categories established for marine turtle ingestion.

61. **Collection of data:** For each GI section of necropsied individuals or for the whole faeces' samples of live individuals, marine litter items and other items should be shorted into the different categories presented under Table 2. In additional the following parameters should be recorded:

- Record for all categories (litter and other elements): The **dry mass** (grams, precision 0.01 g) of each category: dry the sample at room temperature during 24h minimum or in a stove at 35ºC during 12h.

[11] The classification of the litter and other elements was adjusted by the INDICIT consortium, based on the MSFD guideline (MSFD TG-ML, 2013) and the INDICIT partners and collaborators (e.g. rescue centers and stranding networks) feedbacks. The different plastic categories can be identified visually and possibly confirmed by stereomicroscopy.

- Record for litter categories only: The **number of fragments** in each category**:** a fragment is a piece of litter that can be identified. The ***number of items*** in each category: an item is a set of fragments that seem to originate from the same piece of litter
- Record for the plastic litter categories only: The ***total volume of plastic litter*** (milliliter, precision 0.01 ml): **m**easure the volume of all plastic litter in a graduated beaker and record the water variation (Fig. 11). Push the floating plastic in the water thanks to a rod or a decimeter. The ***total number of plastic fragments per colour category:***
  - *Total number of white-transparent plastic fragments*;
  - *Total number of dark coloured plastic fragments (black, blue, dark green…)*;
  - *Total number of light coloured plastic fragments* (cream, yellow, pink, light green…).

NOTE 1: In the case where litter and micro-litter were differentiated, proceed with the data collection as described above, but distinguishing both size classes (>5mm and 1-5mm).

NOTE 2: The optional parameters recorded for plastic litter categories can be collected per GI section and per category, for practical and organizational reasons, but it is the total of all the GI – all plastic categories included – that will be noted in the Observation sheet.

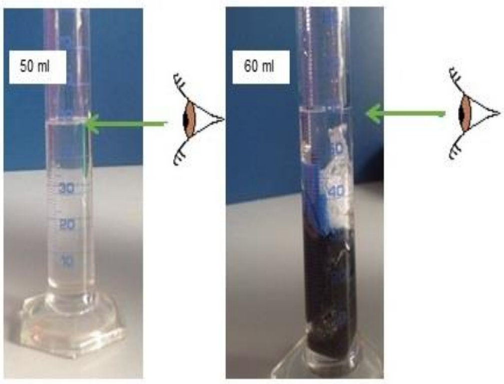

Figure 11: The volume of the plastic litter corresponds to the difference between the volume with (right) and the volume without (left) the plastic litter. The volume is read by considering the bottom of the meniscus formed by the surface water.

4. References

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ANNEXES

ANNEX I
GLOSSARY

GLOSSARY

Amputation (of a member). For a marine turtle, the loss of a flipper by being cut off, which may result from constriction* or strangling.

Autolysis. Destruction of tissues by their enzymes.

Necropsy. Examination of a carcass to study the causes of death.

By-catch. The accidental catch of a non-target species (of marine turtle, for example).

Cloaca. (Common) orifice of the urinary and genital passages in birds and reptiles.

Constriction. Action of squeezing, pressing around; when this happens at the level of the neck it can suffocate the turtle; when around a member, the blood supply is slowed or even cut off, causing, after a certain time, necrosis and loss of the member.

Dissection (of a carcass). Opening up a carcass according to a defined protocol to study its structure and take samples. When looking for the causes of death, the term used is ‘necropsy’.

Entanglement. Accidentally caught by fishing gear during the fishing operation, or abandoned or lost.

Fishing gear. Material intended for catching marketable aquatic species, e.g. trawls, seine nets, nets, lines and longlines. According to circumstance, the entangling is due to:

- **Abandoned gear** (derelict). The gear is left where the fisherman has intentionally abandoned it;
- **Ghost gear** (e.g. ghost net). Gear left on the seabed and which continues to fish; referred to as ‘ghost fishing’;
- **Lost gear.** Gear unintentionally lost during fishing operations;
- **Wreck**. Object abandoned at sea, drifting or on the seabed;
- **Discarded gear or fishing material**. Old gear or material put aside and often thrown back into the sea; this gear must be collected in containers on land for recycling.

Impact. Effect of something.

Interaction. Reciprocal action that two or more systems exercise on each other.

Occlusion. Complete halt of the passing of matter and gases in one portion of the GI. The occlusion can have a mechanical cause (total obstruction by litter) and constitute a veterinary emergency.

Lesion. Modification of the structure of a living tissue under the influence of a disease, of a reason inducing a pathology.

Macro-litter or litter: artificial polymers (plastic) and “other litter” with a maximum size (or diameter) > 5 mm.

Meso-litter: artificial polymers (plastic) and ‘other litter” with size between 5 and 25mm.

Micro-litter: artificial polymers (plastic) and “other litter” with size < 5 mm.

Oculo-palpebral reflex. Reflex in which the eyelids spontaneously shut or blink if the lashes or the internal edge of the orbit are touched with a finger.

Plastron. The ventral part of a turtle’s carapace.

Stranding (of a marine turtle). Said of an animal, dead or alive, that has been washed up on the coast.

Trophic status. Nutritional state in which may be reflected by variable degrees of stoutness, presence of fats in the tissues.

Typology. Approach consisting of defining or studying a set of types; by extension, here it means the listing and describing of types of litter, lesion, etc. that allow the surveyor to classify observations in the correct category of data.

ANNEX II
OBSERVATION SHEET

UNEP

OBSERVATION SHEET - Entangling and litter ingestion

INDICIT

COLLECTOR | **LOCAL CODE**

INSTITUTION | **Contact**

Discovery circumstances:

SPECIES ☐ *Caretta caretta* ☐ *Dermochelys coriacea* ☐ *Chelonia mydas* ☐ Other

INDIVIDUAL TAG: Tag number: | Electronic chip nº:

DATE OF DISCOVERY / / (dd mm yyyy) | **INDIVIDUAL CODE** - - - - - (CC RR (Region) YY MM DD n°)

LOCATION | X CORD | Y CORD

CIRCUMSTANCES	BY-CATH ENGINE CAUSE	CAUSE OF DEATH / STRANDING
☐ Bycatch/Fishery	☐ Longline	☐ By-catch/Fisheries
☐ Stranding	☐ Trawl	☐ Entanglement in debris
☐ Dead at rescue centre	☐ Drift net	☐ Ingestion of litter
☐ Found at sea	☐ Fishing rod	☐ Antrophogenic trauma
☐ Other	☐ Other	☐ Natural trauma
☐ NR	☐ NR	☐ Natural disease
		☐ Oils
		☐ Healthy
		☐ Other
		☐ NR

ENTANGLEMENT TYPE: ☐ Active ☐ Passive ☐ NR

LITTER CAUSING ENTANGLEMENT
☐ Net pieces
☐ Monofilament lines
☐ Rope/s
☐ Raffia
☐ Plastic bags
☐ Other
☐ NR

PICTURES ☐ Yes ☐ No

Picture names:

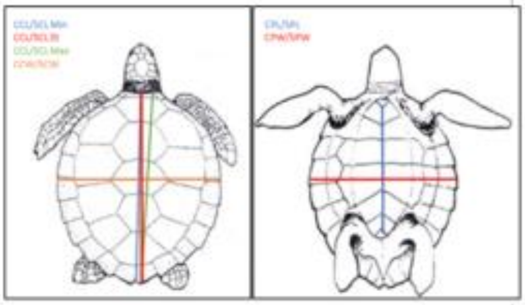
Animal body condition:

CONSERVATION STATUS	HEALTH STATUS (Plastron shape)	MAIN INJURIES	AFFECTED PARTS	FAT RESERVES
☐ 1- Alive	☐ Poor (concave)	☐ No injuries	☐ Flipper (	☐ Thin
☐ 2- Fresh	☐ Fair (plane)	☐ Fracture	☐ Carapace	☐ Normal
☐ 3- Partial	☐ Good (convex)	☐ Amputation	☐ Neck	☐ Fat
☐ 4- Advanced	☐ NR	☐ Sectioning	☐ Head	☐ NR
☐ 5- Momified		☐ Abrasion	☐ Plastron	
☐ NR		☐ Other	☐ Other	

Biometric measurements:

Curved measurements (0,01cm)		Straight measurements (0,01cm)	
CCLst	cm	SCLst	cm
CCLmax	cm	SCLmax	cm
CCLmin	cm	SCLmin	cm
CCW	cm	SCW	cm
CPL	cm	SPL	cm
CPW	cm	SPW	cm

WEIGHT (0,01kg):



Extraction of ingested debris:

INDIVIDUAL CODE:

PROTOCOL: ☐ **NECROPSY** ☐ **OBSERVATION OF FAECES**

Please describe:

VISCERAS STATUS (note the presence of any infection, suspect colour, fluid effusion, perforantion, presence of oil, etc.):

DIGESTIVE TRACT (note the presence of any infection, suspect colour, fluid effusion, perforantion, presence of oil, etc.):

ARRIVAL DATE	/ /
DEPARTURE	/ /
DEAD DATE	/ /

TURTLE BEHAVIOUR AND TREATMENTS:

Marine litter and other elements measurements:

	OESOPHAGUS			STOMACH			INTESTINES			FAECES		
	Dry mass (0.01g)	Number of fragments	Number of items	Dry mass (0.01g)	Number of fragments	Number of items	Dry mass (0.01g)	Number of fragments	Number of items	Dry mass (0.01g)	Number of fragments	Number of items
IND PLA												
USE SHE												
USE THR												
USE FOA												
USE FRAG												
USE POTH												
OTHER												
FOO												
NFO												

NUMBER of plastic fragments per colour	
white-transparent	
dark coloured	
light coloured	

NUMBER of plastic items per colour	
white-transparent	
dark coloured	
light coloured	

VOLUME of plastic litter ______ ml

NOTES AND REMARKS (Necropsy, faeces collection and debris measurements):

ANNEX III
LIST OF MATERIAL

LIST OF MATERIAL

For the take-over of the animal and the collection of samples at the discovery site:

Rope (to mark-off the zone)

Integral protective suit

Glasses and protective mask or shield

Cut-resistant gloves

Gloves

Boots

Camera

Measuring tape

Pen

Observation sheet

Bottle/zipped bags

Cooler

Permanent marker

Transport bins or containers for the turtle

Garbage bag

For the collection of samples on dead individuals in laboratory and the extraction of the ingested litter from the digestive tract:

In the laboratory room
Cold chamber or chest freezers (-20°C) with large storage capacity
Proofer (not mandatory)
Garbage bags
For surveyors
Integral protective suit
Glasses and mobcaps
Protective mask or shield
Cut-resistant gloves
Gloves
Boots
For notes and report
Camera (+ scale decimeter)
Pen
Observation sheet
Permanent marker
For the necropsy and the collection of the GI content
Clamps (at least 6) or roast wire
Scalpel
Scissors
Clips with claws
Metal containers
Metal spoon
Containers for samples (Bottle/zipped bags)
For the collection of samples
Sieve with 1 mm mesh

Sieve with 5 mm mesh

Measuring cylinders (2 L, 1L, 50cL; precision 0.1L)

Measuring decimeter

Precision balance (capacity 4kg, precision 0.01 g)

For the collection of samples on live individuals in rescue centers and the extraction of ingested litter in the faeces:

In the laboratory room
Freezers (-20°C)
Proofer (not mandatory)
Garbage bags

For surveyors
Glasses
Protective mask
Gloves
For notes and report
Camera (+ scale decimeter)
Pen
Observation sheet
Permanent marker
For the collection of samples
Containers for samples (tubes/zipped bags)
Metal spoon
Sieve with 1mm mesh
Sieve with 5mm mesh
1mm mesh rigid sieve
1mm mesh flexible collector (drain tube)

For the analysis of the ingested litter:

For surveyors
Glasses
Protective mask
Gloves
For notes and report
Camera (+ scale decimeter)
Pen
Observation sheet
Permanent marker
For the analysis of the ingested litter
Measuring tape
Decimeter

Precision balance (capacity 1kg; precision 0.01)

Measuring cylinders

Metal spoon / clamps

Binocular (*optional*)

ANNEX IV
REFLEX SHEETS

A. FIRST NOTES ON THE DISCOVERY SITE

***Note**: The loggerhead sea turtle (Caretta caretta) is a protected species in some countries, therefore only authorized people can handle live and dead animals or parts of them. Upon finding the animal, its management and recovery should be reported and coordinated with the responsible Authorities. A CITES permit is asked if a specimen or sample has to be sent/received.*
Sanitary precautions must be paid for the handling of dead or live wild animal to minimize risks of infectious diseases such as zoonosis. The intervention zone must be marked-off from the bystanders and handling necessitates to wear a protective suit with glasses, gloves and rubber boots, then carefully separated and disinfected or thrown. Ideally, a cut-resistant pair of gloves can be worn below two pairs of gloves, one of them being changed for writing or in case of cutting.

On the discovery site, note the following information on the observation sheet:

1. **General information:**
   - Contact information of the observer/collector of the animal;
   - Species;
   - Presence of pre-existing tags/electronic chips/telemetric monitoring devise;
   - New numbers of tag and electronic ship, when it applies;
   - Animal’s identification code;
   - Date and location of discovery;
   - Coordinates (*optional*);
   - Pictures/Videos.

2. Animal's body condition:

- Conservation status or decomposition level;
- Discovery circumstances;
- Probable cause of death/stranding (optional);
- By-catch gear (optional);
- Health status (optional);
- Main injuries (optional);
- Affected body parts (optional);
- Entanglement type (optional);
- Litter causing entanglement (optional);
- Other descriptive parameters (optional);
    - Fat reserves
    - Sex
- Biometric measurements.

B. EXTRACTION OF MARINE LITTER FOR DEAD ANIMALS: Necropsy protocol

1. Turtle's necropsy:

- Open the carcass by removing the plastron;
- Note fat reserves;
  Thin / Normal / Fat;
- Expose the gastrointestinal system (GI);
- Clamp the esophagus and the cloaca;
- Remove the GI from the carcass;
- Note external lesions on the GI and specify when attributed to litter.

2. Extraction of gut content and collection of ingested litter:

- Separate the 3 sections of the GI (oesophagus, stomach, intestines), and for each section:
- Rinse all the material collected over a 1mm mesh sieve (or superposed 5- and 1-mm mesh sieves – *optional*)
- Inspect the content and separate marine litter from other elements
- Collect marine litter and other content in separated zipped bags or bottles, noting the animal's identification code, the GI section (and optionally the litter class size (1-5, >5))
  Example: FR_GR_2017_03_12_9_Oeso
- Freeze at -20°C if analyses cannot be performed successively.

C. EXTRACTION OF MARINE LITTER IN LIVE ANIMALS: Faeces protocol

***Note**: Collect faeces from individual remaining at least 1 month in the rescue center only and up to 2 months after the individual's arrival*

1. Collection of the daily faeces:

- With a 1 mm mesh dip net;
- From a 1 mm mesh flexible collector disposed around the drain tube;
- From a 1 mm mesh rigid sieve disposed under the drain.

2. Collection of marine litter:

- Rinse the sieves and collector with abundant water above a 1mm mesh sieve (or superposed 5 and 1 mm mesh rigid sieves – optional);
- Inspect the content and separate marine litter from other elements;
- Collect marine litter and other content in separated zipped bags or tubes, noting the animal's identification code, the protocol (and optionally the litter size class (1-5, >5));
  Example: FR_GR_2017_03_12_9_Faeces
- Freeze at -20°C if analyses cannot be performed successively.

D. MARINE LITTER ANALYSIS

1. Litter and other element classification:

CATEGORIES			CODE	DESCRIPTION
LITTER	PLASTIC LITTER	**Industrial plastic**	**IND PLA**	Industrial plastic granules, usually cylindrical but also sometimes oval spherical or cubical shapes, or suspected industrial item, used for the tiny spheres (glassy, milky...)
		Use sheet	**USE SHE**	Remains of sheet, e.g. from bag, cling-foil, agricultural sheets, rubbish bags…
		Use thread	**USE THR**	Threadlike materials, e.g. pieces of nylon wire, net-fragments, woven clothing…
		Use foam	**USE FOA**	All foamed plastics e.g. polystyrene foam, foamed soft rubber (as in mattress filling) …
		Use fragment	**USE FRAG**	Fragments, broken pieces of thicker type plastics, can be a bit flexible, but not like sheet like materials.
		Other Use plastics	**USE POTH**	Any other plastic type of plastics, including elastics, dense rubber, balloon pieces, soft air gun bullets… Specify in the column "Notes".
	Litter other than plastic		**OTHER**	All non-plastic rubbish and pollutant, e.g. cigarette filters
OTHER ELEMENT		**Natural food**	**FOO**	Natural food for sea turtles (e.g., pieces of crabs, jellyfish, algae…)
		Natural no food	**NFO**	Anything natural, but which cannot be considered as normal nutritious food for sea turtle (stone, wood, pumice, etc.)

2. Collection of data for >5mm and 1-5mm

For each GI section of necropsied individuals or for the whole faeces samples of live individuals, sort litter and other elements into the different categories exposed above (Tab. 1) and record the following parameters:

- **For all categories (litter and other elements):**
  - Dry mass (grams, precision 0.01g) of each category.
- **For marine litter only:**
  - Number of fragments (i.e a piece of litter that can be identified in each category);
  - Number of items (i.e. a set of fragments that seem to originate from the same piece of litter) (*optional*).
- **For plastic litter only (*optional*):**
  - Total volume of plastic litter fragments;
  - Total number of plastic fragments and/or items per colour category:
    White-transparent / Dark coloured / Light coloured

Note*: In the case where litter and micro-litter were differentiated, proceed with the data collection as described above, but distinguishing both size classes (>5mm and 1-5mm).*

Appendix X

UNEP/MED WG.467/16
Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species

UNITED NATIONS

EP

UNEP/MED WG.467/16

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

UNEP

8 August 2019
Original: English

7th Meeting of the Ecosystem Approach Coordination Group

Athens, Greece, 9 September 2019

Agenda Item 8: Monitoring Protocols for IMAP Common Indicators related to Pollution and Guidance on monitoring concerning IMAP Common Indicators related to Biodiversity and Non-Indigenous Species

Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species

UNEP/MAP
Athens, 2019

Note by the Secretariat

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.

The agreed common indicators related to biodiversity and non-indigenous species cluster include:

1. common indicator 1: Habitat distributional range (EO1) to also consider habitat extent as a relevant attribute;
2. common indicator 2: Condition of the habitat's typical species and communities (EO1);
3. common indicator 3: Species distributional range (EO1 related to marine mammals, seabirds, marine reptiles);
4. common indicator 4: Population abundance of selected species (EO1, related to marine mammals, seabirds, marine reptiles);
5. common indicator 5: Population demographic characteristics (EO1, e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine mammals, seabirds, marine reptiles);
6. common indicator 6: Trends in abundance, temporal occurrence, and spatial distribution 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).

During the initial phase of the IMAP implementation (2016-2019), the Contracting Parties to the Barcelona Convention updated the existing national monitoring and assessment programmes following the Decision requirements in order to provide all the data needed to assess whether the ''Good Environmental Status'' defined through the Ecosystem Approach process has been achieved or maintained.

Decision IG.23/6 on the 2017 MED QSR (COP 20, Tirana, Albania, 17-20 December 2017) agreed, as general directions towards a successful 2023 Mediterranean Quality Status Report (2023 MED QSR), the following main recommendations:

(i) harmonization and standardization of monitoring and assessment methods;

(ii) improvement of availability and ensuring of long time series of quality assured data to monitor the trends in the status of the marine environment;

(iii) improvement of availability of the synchronized datasets for marine environment state assessment, including 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 Info-MAP System is operational and continuously upgraded, to accommodate data submissions for all the IMAP Common Indicators.

The present document outlines the monitoring guidelines of the agreed common indicators 1 and 2 related to marine habitats, common indicators 3, 4 and 5 related to marine mammals, marine turtles and seabirds, and common indicator 6 related to non-indigenous species.

These guidelines were discussed and reviewed by the Meetings of the Ecosystem Approach Correspondence Group on Monitoring (CORMON), Biodiversity and Fisheries (Marseille, France, 12-13 February 2019 and Rome, Italy, 21 May 2019) and the 14th meeting of the SPA/BD thematic Focal points (Portoroz, Slovenia, 18-21 June 2019). All the comments and suggestions received from the Contracting Parties were considered and included in this version of the document.

This document is submitted to the 7th Meeting of the Ecosystem Approach Coordination Group (Athens, Greece, 9 September 2019) for information and final approval.

Table of contents

A. Guidelines for monitoring Cetaceans in the Mediterranean Sea

Table of Contents

List of Tables

1. Introduction

1.1. Background

1. The Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) have adopted the Ecosystem Approach (EcAp) in January 2008. This strategy allows all aspects of marine ecosystem to be taken into account. It includes management of coast, sea and living resources that promotes conservation and sustainable use in an equitable way, in order to respect interactions in the ecosystems. Indeed, it recognizes ecological systems as a rich mix of elements that interact with each other continuously. This process aims to achieve the good environmental status (GES) through informed management decisions, based on integrated quantitative assessment and monitoring of the marine and coastal environment of the Mediterranean. EcAp is also a way of making decisions in order to manage human activities sustainably. It recognizes that human's activities both affect the ecosystem and depend on it.

2. In February 2016, the Contracting Parties to the Barcelona Convention have also adopted an Integrated Monitoring and Assessment Programme and related Assessment Criteria (IMAP). This text describes the strategy, themes and products to deliver by Contracting Parties over the second period of the implementation of the EcAp (2016-2021). The main goal of IMAP is to build and implement a regional monitoring system gathering reliable and up-to-date data and information on the marine and coastal Mediterranean environment. Mediterranean countries committed to monitor and report on 23 common indicators, articulated on 11 ecological objectives and covering topics related to pollution, marine litter, biodiversity, non-indigenous species, coast and hydrography.

3. One of eleven ecological objectives is “Biodiversity is maintained or enhanced” (EO1). Three determining factors are used to quantify the conservation:

- no further loss of the diversity within species, between species and of habitats/communities and ecosystems at ecologically relevant scales;
- any deteriorated attributes of biological diversity are restored to and maintained at or above target levels, where intrinsic conditions allow;
- where the use of the marine environment is sustainable.

1.2. Aim

4. These guidelines aim at helping managers and decision makers to understand and implement a strategy of long-term monitoring for cetaceans, in deciding what kind of method to choose at regional and national level to answer the indicators 3, 4 and 5. This document aims at presenting a global overview of methods, with the main advantages and disadvantages, the human resources and material requested in order to better estimate the investment needed and other practical points. For more details on one specific method, please follow the bibliographic references.

5. A lot of scientific papers, or guidelines exist on the subject and on all those methods that are recognised as standard. Some explain in detail the steps of implementation, the scientific background, highlight also pro and cons, advantages and disadvantages. A list of some of these documents are listed at the end and should be considered for further details.

6. This document focuses more on the techniques at sea than on the consequent and associated analyses. It has to bear in mind that analyses need expert’s time and skills and has a certain cost related in order to be properly done. A lot of models and types of analyses exist and are well described in many scientific papers. What should be stressed is that powerful analyses can be led only with reliable data that have been collected in a standardised and recognised manner. So, to be sure data will be useful, comparable and used, the decision

and implementation of rigorous methods should be the first step, following standard monitoring methods here highlighted.

1.3. Indicators 3, 4, 5

7. In the context of the Barcelona Convention, a common indicator is an indicator that summarizes data into a simple, standardized, and communicable figure. It is able to give an indication of the degree of threat or change in the marine ecosystem and can deliver valuable information to decision makers.

8. Among five common indicators related to biodiversity (EO1) fixed by IMAP, three are about marine mammals:

- Indicator 3 - Species distributional range

This indicator is aimed at providing information about the geographical area in which marine mammal species occur. It is intended to reflect the species distributional range of cetaceans that are present in Mediterranean waters, with a special focus on the species selected by the Parties. The main outputs of the monitoring under this indicator will be maps of species presence, distribution and occurrence. Resulting analysis can lead also to identification of important habitat and core areas for the species. The aim is to detect any important changes in the distributional pattern of the cetaceans.

- Indicator 4 - Population abundance of selected species

As cetaceans are highly mobile and distributed mainly over vast areas, this indicator refers preferably also to an area-defined abundance of selected species (in a specified area in a given timeframe). Resulting analysis led to absolute abundance, density maps or indices of abundance. The aim is to detect any important changes in those numbers. Methods for estimating density and abundance are generally species-specific and ecological characteristics of a target species should be considered carefully when planning a research campaign. The main limitation of some implementation of monitoring method is relates to how representative the results are in terms of the relevant population. So, it needs first to define which population is targeted.

- Indicator 5 - Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates)

This indicator required to demographic parameters as the age structure, age at sexual maturity, sex ratio and rates of birth (fecundity) and of death (mortality). These data are particularly difficult to obtain for marine mammals and to monitor but are important to understand and collect. Monitoring effort should be directed to collect long-term data series covering the various life stages of the selected species. This would involve the participation of several teams using standard methodologies and covering sites of particular importance for the key life stages of the target species. Results are in terms of numbers or rates. The aim is to detect any important changes in those numbers or ratio. One of the main limitations of some implementation of monitoring method is relates to how representative the results are in terms of the relevant population. So, it needs first to define which population is targeted.

2. Species concerned

9. IMAP fixes a reference list of species and habitats to be monitored. All cetacean species occuring 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*).

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

10. The decision to monitor additional species among these should not hinder the monitoring of the standard species set, as these are being monitored at wider scale (e.g., whole Mediterranean region), and the data that will be obtained at national or local scale would add a very high value.

11. Monitoring is needed on a consistent scale for each population studied. The Contracting Parties, while updating their national monitoring programmes, shall make every effort to identify the list of species and if possible, population to be considered. The choice will have to take into account on the specificity of their marine environment and biodiversity, and also on the number of animals occurring in the Contracting Parties' waters and how many there are in relation to total populations size to warrant investigating one or more of the indicators.

3. Monitoring methods

12. Before embarking upon a monitoring programme, the most important is to identify the objective, determine the appropriate indicator(s) in principle, then determine precisely what information can be gained and what are the limitations. Then a cost-benefit analysis of the various options available should be conducted. The type of platform, level of sophistication of survey, and detection method should be considered in each case, and the most appropriate ones identified, relying upon if the indicator can be monitored to be able to robustly detect changes should they occur given certain levels of effort (sample size).

13. Thus, when being in the process to decide which monitoring method to be implemented, it is important to consider several issues, that will be synthetized in different tables to get a global first overview. General consideration will give some advices considering on unifying data collection protocols and the statistical requirements on data and samples, and also the complementarity of methods at different spatial and temporal scales, as no single method will be enough to monitor all parameters and all species. The other chapters will present more in details the different methodologies.

14. Methods for estimating density and abundance are generally species-specific and ecological characteristics of a target species should be considered carefully when planning a research campaign. Furthermore, as cetaceans have no frontiers and their conservation should be thought at the Mediterranean level, it is recommended to promote the implementation of transnational and coordinated monitoring on a standard way.

3.1. Synthesis tables

15. Four tables synthetized the main information needed to take the decision on what method(s) to implement to elucidate indicator 3, 4 and 5 of the EO1 of the IMAP process:

- which method will give useful data to answer which indicator, depending on the target specie(s) and its characteristics. This is presented in a synthetic way in Table 1 for an overview;

- according to the method chosen, indications are presented concerning the time delay to get results, the cost associated, the difficulty in implementing the method, the constraints and limits associated and finally the compatibility with other method(s) (in order to optimize time and resources, as several methods can be used in parallel on the same platform during the same campaigns). Also, a column presents the metrics that can be obtain by the method.

- according to the method chosen, what will be the investment needed, in terms of material and human resources. Also, some indications are presented concerning the data storage volume and the time dedicated to process the analysis.

- according to the level at which there are designed for, population or individuals, and at which spatial scale they correspond the best (small or large area). In Table 4 each method has been designed to collect data to answer question at one of the levels and spatial scales, whereas some adaptation can be made to other level and spatial scale. Additionally, some methods are designed for large areas and the platform will have to move within the large areas. Whereas some methods, especially the one based on individuals, will be implemented in small areas and can give information on large areas in two ways: if the implementation is done in several places and built in a frame of a network (e.g., strandings, photo-ID), or by the nature of the parameter studied which can be extrapolate in a wider area if enough samples are available (reproductive status, genetic, telemetry).

16. Finally, as working at sea can be expensive and as marine environment and IMAP process deal also with other marine species,

17. Tableau 5 presents the monitoring methods for cetaceans and their compatibility with other marine species monitoring.

Table 1 - Synthesis listing different cetacean's monitoring methods recommended answering to indicators of IMAP process by cetacean species (legend: bold type = best suitable method; in bracket (less suitable method but can give interesting information) and in bracket and italic (*indication of limits*)). For the definition of the methods, see other chapters of the document.

	Baleen whales	Deep-diving cetaceans				Other toothed species		
	fin whale (*Balaenoptera physalus*)	**sperm whale (*Physeter macrocephalus*)**	**Cuvier's beaked whale (*Ziphius cavirostris*)**	**long-finned pilot whale (*Globicephala melas*)**	**Risso's dolphin (*Grampus griseus*)** also applies to killer whale (*Orcinus orca*)	**common bottlenose dolphin (*Tursiops truncatus*)** also applies to rough-toothed dolphin (*Steno bredanensis*),	**striped dolphin (*Stenella coeruleoalba*)** also applies to harbour porpoise (*Phocoena phocoena*),	**short-beaked common dolphin (*Delphinus delphis*)** also applies to harbour porpoise (*Phocoena phocoena*),
INDICATOR 3, species distributional range	**Visual Line transect "distance sampling" boat or aerial** Telemetry Acoustic line transect (or fixed point) (*presence/absence*) Land based method (*locally*)	**Visual Line transect "distance sampling" boat coupled to acoustic line transect** Photo-Identification Telemetry (Visual Line transect aerial)	**Visual Line transect "distance sampling" boat coupled to acoustic line transect** Telemetry and acoustic fixed point Photo-Identification (Visual Line transect aerial)	**Visual Line transect "distance sampling" boat or aerial** Acoustic line transect (or fixed point) (*presence/absence*)	**Visual Line transect "distance sampling" boat or aerial** Photo-Identification Acoustic line transect (or fixed point) (*presence/absence*)	**Visual Line transect "distance sampling" boat or aerial** Photo-Identification Acoustic line transect (or fixed point) (*presence/absence*) Land based method (*locally*)	**Visual Line transect "distance sampling" boat or aerial** Acoustic line transect (or fixed point) (*presence/absence*)	**Visual Line transect "distance sampling" boat or aerial** Acoustic line transect (or fixed point) (*presence/absence*)

INDICATOR 4, species population abundance	**Visual Line transect "distance sampling" boat or aerial** Acoustic line transect (*indices of relative abundance*) Photo-identification	**Visual Line transect "distance sampling" boat coupled to acoustic line transect** **Photo-Identification**	**Visual Line transect "distance sampling" boat coupled to acoustic line transect** **Photo-Identificatio n**	**Visual Line transect "distance sampling" boat or aerial** Acoustic line transect (*indices of relative abundance*)	**Visual Line transect "distance sampling" boat or aerial** **Photo-Identification** Acoustic line transect (*indices of relative abundance*)	**Visual Line transect "distance sampling" boat or aerial** **Photo-Identification** Acoustic line transect (*indices of relative abundance*)	**Visual Line transect "distance sampling" boat or aerial** Acoustic line transect (*indices of relative abundance*)	**Visual Line transect "distance sampling" boat or aerial** Acoustic line transect (*indices of relative abundance*)
INDICATOR 5, Population demographic characteristic s	Biopsy Stranding By-catch	Biopsy Stranding By-catch Photo-identification	Biopsy Stranding By-catch Photo-identification	Biopsy Stranding By-catch	Biopsy Stranding By-catch Photo-identification	Biopsy Stranding By-catch Photo-identification	Biopsy Stranding By-catch	Biopsy Stranding By-catch

Table 2- Synthesis for the different cetacean's monitoring methods concerning which indicators of the IMAP process they may help with, the time delay to obtain results, the type of results, their cost, the level of constraints associated, their limits or bias and an indication concerning the compatibility among methods. + = low, +++ = high.

Method	Indicator	Type of results	Rapidity of results	Compatibility with other methods	Costs	Constraints	Limits
Visual Line transect "distance sampling" **boat**	3- distributional range 4- abundance	3- distributional range : *presence/absence, spatial and temporal distribution, relative density* 4- abundance *absolute and relative, density*	Short-term	**acoustic line transect** (sometimes photo-Identification if approaching mode)	++++	+++	Bias due to responsive movements of animals; detectability to be assessed,
Visual Line transect "distance sampling" **aerial**	3- distributional range 4- abundance	3- distributional range : *presence/absence, spatial and temporal distribution, relative density* 4- abundance: *absolute and relative, density*	Short-term		++++	++++	For deep diving species the number of sightings will be too low to give reliable results.
Photo-identification	3- distributional range 4- abundance 5- demographic characteristics	3- distributional range: *occurrence, spatial and temporal distribution* 4- abundance: *absolute* 5- demographic characteristics: *ranging behaviour, migration patterns, body size or age class structure, sex ratio, fecundity rates, survival/mortality rates*	Can be medium-term but is far more reliable on long-term	**biopsy and telemetry** (sometimes line transect boat, depending if approaching mode)	++	++	Only applicable for species with long-lasting individual identifiable natural marks.

Method	Indicator	Type of results	Rapidity of results	Compatibility with other methods	Costs	Constraints	Limits
Land based method	3- distributional range 4- abundance	- distributional range: *presence/absence, locally temporal distribution* 4- abundance: *indices of relative abundance*	Short-term and long-term	acoustic fixed point, (photo-Identification depending on conditions)	+	+	Limited to small detection area and suitable coastal landscape.
Acoustic line transect	3- distributional range 4- abundance	3- distributional range: *occurrence index* 4- abundance: *indices of relative abundance*	Short-term	**visual line transect**	+++	+++	Relies upon animals being vocal.
Acoustic fixed point	3- distributional range 4- abundance	*3- distributional range: occurrence index* 4- abundance: *indices of relative abundance*	Short-term	land based method (if near coast)	++	+	Relies upon animals being vocal. Low spatial resolution or need a network of several hydrophone, and logistical problems with deployment.
Telemetry	3- distributional range	3- distributional range: *spatial and temporal distribution*	Short term Long-term	**biopsy and photo-Identification**	+++	++++	Only allows small samples resulting in much inter-individual variation. Invasive.
Biopsy	5- demographic characteristics	5- demographic characteristics: *sex ratio, fecundity rates*	Long-term	**photo-Identification, telemetry**	++	+++	Invasive method. Requires large sample size.
Stranding	3- distributional range (4- abundance) 5- demographic characteristics	3- distributional range: *occurrence index* 4- abundance: *indices of relative abundance* 5- demographic characteristics: *body size or age class*	Short- and long-term		+	+	Efficient if networking is implemented.

Method	Indicator	Type of results	Rapidity of results	Compatibility with other methods	Costs	Constraints	Limits
		structure, sex ratio, survival/mortality rates					
By-catch	3- distributional range 5- demographic characteristics	3- distributional range: *occurrence index* 5- demographic characteristics: *body size or age class structure, sex ratio, survival/mortality rates*	Short- and long-term		+	+	Efficient if special observers are involved, or a reporting well established program is implemented by Fisheries Agency
Unmanned Autonomous vehicle (drone and submarine AUV)	3- distributional range 4- abundance	3- distributional range: *spatial and temporal distribution* 4- abundance: *relative, (absolute if line transect)*	Short- and long-term		++++	+++	Method in development.
Pictures and video	3- distributional range 4- abundance	3- distributional range: *occurrence index, spatial and temporal distribution* 4- abundance: *relative, (absolute if line transect)*	Long-term	line transect aerial	++	+++	Method and technic in test, not standardised yet.

Table 3- Synthesis for the different cetacean's monitoring methods about the material and human resources involved, an indication about volume storage of data and time needed to process the analysis, and the level of skills needed (+ = low, +++ = high).

Method	Material needed Colour legend: in black "investment" ; in orange "operational "	Platform	Minimum n. Of persons needed	Data storage (volume)	Data processing and analysis (time))	Skills
Visual Line transect "distance sampling" **boat**	- binoculars - GPS, watch - instruments to estimate or measure the distance of the animals from the boat (reticulate binoculars, measuring stick) - observation forms or computer - corner quadrants or angle board	Vessel dedicated (like motor or sailing boat) or not dedicated ("fix line" like ferries or oceanographic vessels)	4	++	++	++
Visual Line transect "distance sampling" **aerial**	- observation forms computer with dedicated software a person to enter data in real time, and/or dictaphone - clinometer - GPS,	Airplane small, high-wing, that can fly slowly while remaining within the limits of safety, equipped with bubble windows (to allow the observer to look under it) and can carry at least three people (two observers and a data recorder).	3 + pilot	++	++	+++
Photo-identification	- observation forms or computer or mobile phone - GPS, - camera with lens	Vessel small or relatively small boat (outboard or an average zodiac boat) with a sufficiently low bridge over the water to take pictures at the correct angle.	1 (3)	+++	+++	+

Method	Material needed Colour legend: in black **"investment"** ; in orange "operational "	Platform	Minimum n. Of persons needed	Data storage (volume)	Data processing and analysis (time))	Skills
Land based method	- binoculars or telescopes - observation forms or dictaphone or computer - watch - theodolite or clinometer camera for photogrammetry - Compass or quadrant angles or angle boards	Land	1 (2)	+	+	++
Acoustic line transect	- binoculars - GPS, - observation forms - hydrophone coupled to stereo amplifier - sound-recording instrument and power source	Vessel Irrespective of the type, which is able to hold a constant speed and a course for use in transect. Preferably silent.	1 (2)	+++	+++	+++
Acoustic fixed point	- binoculars - GPS, watch - observation forms - hydrophone coupled to stereo amplifier - sound-recording instrument and power source	Beacon, buoy Or vessel	(1)	+++	+++	+
Telemetry	- beacon - crossbow or long pole	Vessel	1 (2)	+	++	++
Biopsy	- crossbow or gun and bolts - storage and cleaning material - freezer/frozen storage	Vessel small or relatively small boat (outboard or an average zodiac boat) with a sufficiently low bridge over	1 (2)	+	+++	++ Need specific skills

Method	Material needed Colour legend: in black "investment" ; in orange "operational "	Platform	Minimum n. Of persons needed	Data storage (volume)	Data processing and analysis (time))	Skills
		the water to shoot at the correct angle.				
Stranding	- stranding forms - camera - tape measure - sampling kit (knife, shears, packaging materials) - dedicated dress, safety gloves, safety glasses - freezers - fixing solution such as formalin, ethanol, DMSO	Land	1	+	+	++ Need to make sure this is handled by a trained and authorized scientist or veterinary
By-catch	- GPS, watch - observation forms - camera - tape measure - sampling kit (knife, shears, packaging materials)	Vessel	1	++	++	++
Unmanned Autonomous vehicle (drone and submarine AUV)	- drone or submarine AUV	Vessel	1 (2)	++	++	+++ Need specific skills
Pictures and video	- high resolution camera	Airplane	(1) + pilot	+++	+++	++

Table 4 – Characteristics of cetacean's monitoring methods in regard to indicator 3, 4 and 5 of the IMAP process : at which level they are implemented (population or individuals) and at which spatial scale they correspond the best (small or large area). The darker the colour, the best suited characteristics and the lighter the colour, the more adaptation you have to implement this method for that area or level. Method implemented on individuals can be designed (network, large samples size) in order to give results at the population level (for indicator 5). In cells is given an indication of the time frame and frequency of the campaigns implementing the described methods at the corresponding spatial scale.

Cetacean monitoring method	Population level	Individual level	Large area	Small area
Visual Line transect "distance sampling" **dedicated boat**			1 or 2 / 6 years	Yearly or seasonal
Visual Line transect "distance sampling" **dedicated aerial**			1 or 2 / 6 years	
Visual Fix line transect by ferry or oceanographic vessel	X		Yearly, seasonal or monthly	
Acoustic line transect			1 or 2 / 6 years	Yearly or seasonal
Dedicated observers on opportunistic platform			Yearly or seasonal	Yearly or seasonal
Photo-identification	X		(network) Yearly or several years	Yearly or seasonal
Telemetry				
Biopsy	X			
Land based method				Yearly or seasonal
Acoustic fixed point	X		(network)	Yearly or seasonal
Stranding	X		(network)	Seasonal, monthly
By-catch	X		(network)	Seasonal, monthly

Tableau 5 - Compatibility with other species monitoring for the indicator 3, 4 and 5 5 (X: method compatible with others; 0: method not compatible with other species)

Cetacean monitoring method	**Seabirds at sea**	**Turtles at sea**	**Sharks**	**Other big fish (tuna, sunfish, swordfish, ray)**	**Floating Marine Litter**
Line transect "distance sampling" **dedicated boat**	X	X	X	X	X
Line transect "distance sampling" **dedicated aerial**	X	X	X	X	X
Fix line transect "distance sampling" **by ferry or oceanographic vessel**	X	X	X	X	X
Dedicated observers on opportunistic platform *(line transect)*	X	X	X	X	X
Photo-identification surveys	X	X	X	X	X
Land based method	X	0	0	0	0
Acoustic line transect	0	0	0	0	0
Acoustic fixed point	0	0	0	0	0
Telemetry	X	X	X	X	0
Biopsy	X	X	X	X	0
Stranding	0	0	X	X	0

By-catch	X	X	X	X	X

3.2. General considerations

3.2.1. Scientific consideration on sampling and analysis

18. To ensure that the chosen method and the study design will be able to provide data to answer to the question posed with a useful level of precision, a power analysis should be run. It is useful to use existing data if any during this step. And the power analysis helps in indicating the ability of the statistical procedure and the available or planned data to reveal a certain level of change i.e. the ability to detect a trend of a given magnitude. Concretely the power analysis will help to plan studies to calculate the necessary sample size (e.g. the length of time series of abundance estimates), or the coefficient of variation (CV) of those estimates.

19. The use of existing software programs, as "TRENDS" (freely available at (https://swfsc.noaa.gov/textblock.aspx?Division=PRD&ParentMenuId=228&id=4740) helps greatly in the process. But as cetacean's species are highly mobile, spread over vast areas which led to difficulties to cover the whole population or their whole range, another method to increase power to detect trends is to design a trend-site survey design. This site is sought to maximize precision by focusing on a smaller area to survey and increased the effort in the chosen area. The smaller area could correspond to a representative part of the range of the stock or to a stock identified at a smaller spatial scale as demographically independent populations. Finally, one of the most common methods to increase our ability to detect precipitous declines are to increase survey frequency (annual for example). Other useful methods are tested, more during the analysis, as to change the statistical decision criterion.

20. Many of the methods here described work under certain assumptions (equal coverage, homogeneity of capture, detectability, etc) and a great care should be taken in dealing with these assumptions since the beginning of the implementation. Associated data should be collected in order to calculate the correction factors if needed.

3.2.2. Complementarity of monitoring methods

21. There is an interest in implementing several methods, as they can be complementary in spatial or temporal scales and for the different species. This should be defined case by case, according to the objectives, the species, the area and the means (human resources, platform and funds). As the objective of monitoring population of cetaceans is to detect trends over time, it has then to be considered to choose one or several methods and to plan to implement campaigns on a regular basis in order to get several results over time. Often, large-scale dedicated campaigns are more expensive than non-dedicated campaigns or small-scale campaigns. For example:

- **a large-scale** (the whole waters under national jurisdiction of a country at least, entire basin, entire seas) **visual line transect distance sampling dedicated survey** made with a vessel or an airplane will give you surface estimate of abundance and distribution of several visible and numerous species (whales and delphinids). In the meantime, if the campaign is boat-based, you can add a hydrophone to the vessel to collect **passive acoustic** data on abundance, distribution and presence/absence of deep diving species (sperm whale, Ziphiidae) and/or acquire data to correct availability bias for the deep diving species. As those large-scale dedicated campaigns might be one of the most expensive methods, they are often implemented at least once or twice per decade.

- In parallel **non-dedicated vessel - or aerial- based line transect surveys** should be implemented to get data and results on a yearly basis (with one or two samples a year for oceanographic campaigns, even one sample per month for ferry). This will allow you to know inter-annual variability (year with typical, rich or poor abundance) and to correct the results of your dedicated large-scale survey the year it is implemented.

- When an important or representative **smaller area** is defined (MPA, Important Marine Mammal Are, etc), based on the results of this/these previous large surveys, you can implement **visual and acoustic line transect**

distance sampling surveys in this small representative area. Ideally, seasonal monitoring programmes should be conducted at this scale (at least during winter and summer periods).

- And finally, you can focus on some species and launch **individual-based tracking**, implementing photo-identification, biopsy and/or telemetry programmes. Those methods are highly complementary to the previous ones.

3.2.3. Trained and qualified personal

22. These methods are rigorous and high quality designed, implementing standard protocols and awaiting standard data. So, people implementing one of these methods at sea should be trained to acquire the requested skills and knowledge to do it in the correct way. If necessary, funds for training must be included in the program's budgets.

3.3. Standard Monitoring methods of living animals

3.3.1. Visual monitoring method

23. For visual surveys, it is important to consider observer skill and experience. Observers may vary in sighting efficiency; hence, training is important to obtain consistent results in species identification, counting of individuals and measuring information (distance, angle, time of diving…). An observer training must be scheduled upstream to visual monitoring campaigns.

3.3.1.1. *Line transect "distance sampling" method*

24. In line transect "distance sampling", a survey area is defined and surveyed along a sampling design of pre-determined transects ensuring equal coverage of the area. The perpendicular distance of each detected animal to the transect is measured and consequently used to obtain a detection function, from which an estimate of the effective width of the strip that has been searched can be calculated. Abundance is then calculated by extrapolating estimated density in the sampled strips to the entire survey area by means of dedicated software. The calculated number is therefore an estimate of surface abundance in a defined area at the time of the study. Assumptions relating to specimens' detectability and observer perception (availability and perception biases) need to be addressed and various methods (respectively telemetry data and two-platforms surveys) have been developed to accommodate these.

25. This method, either boat- or aerial-based, is mainly used to collect data in order to answer to abundance and distribution questions on cetaceans (indicator 3 and 4). When the platform is dedicated to the mission of collection of data on cetaceans, the whole process of implementation is better robust, namely quantity of effort, equal coverage probability with dedicated sampling design, bias on detectability, etc. When observers go aboard a non-dedicated platform, the data collection are not designed and can not provide all necessary data to ensure a robust results and data to detect trends, Finally, observers on opportunistic platform collect complementary data that could be less robust to answer to the indicators. But this has to be assessed in a case by case cost-benefice study, as in several occasions, something interesting can be launch with existing platforms and analysis exist taken into account the heterogeneity in the effort.

3.3.1.1.1. Dedicated boat-based survey

Principle

26. Systematic surveys carried out from a boat constitute a powerful method primarily aimed to estimate the surface abundance and distribution of cetacean species over large areas. The boat follows a path corresponding to a predefined sampling plan, which covers the area of study as homogeneously as possible and records all cetacean sightings. The minimum amount of effort required to perform the analysis depends on the density of animals in the study area. The amount of effort can be calculated before designing the sampling plan. Often it is required that at least 40 sightings of one species is needed to get reliable results with lower uncertainties depending on the species and the area investigated. To cope with assumptions (perception, availability and responsiveness), often a two-platform surveys is implemented,

corresponding to two different teams of observers working independently of each other on the same platform. Comparing their specific data helps in correcting the perception bias.

Human resources

27. The Line transect method required that 180° in front of the vessel is continuously observed during all daylight hours. This required that at least two trained observers are watching at all time, and to allow resting and mealtime, it is required at least two teams rotating each two hours. So, for long lasting mission, a team of 4 trained observers is a minimum, the best option is at least 3+3 allowing a better coverage and a person also dedicated to record the sightings and all associated information. For double platform then, a supplementary team of 3 observers is requested.

Material needed

28. The equipment needed are as follows:

- A boat with the required characteristics (adequate height, speed…) to carry out the mission for the planned duration, the survey area and the desired collection protocol.

- Binoculars (and for double-platform, a high-power ("big eyes") binoculars on a tripod or other support).

- Compass or angleboard.

- Instruments to estimate or measure the distance of the animals from the boat (reticulate binoculars or a video camera for photogrammetry, or measuring sticks or ruler, etc.).

- Observational forms and a computer with a dedicated software for data (both navigation and sightings) storage.

- A watch.

- A GPS.

Implementation

29. The first phase is the preparation of the campaign, with training of people if needed, design the sampling scheme according to densities of cetaceans (if known) and habitats. Also, everything concerning authorization request and logistic should be considered largely before.

30. Effort should be precisely known, so start and end are recorded (hours and geographical positions). During effort, observers scan the water for cetaceans while the vessel steams along predetermined transect lines at constant speed and heading. Often the speed is at 10 knots for large vessels, but it can be 8 or 6 knots for smaller vessels. When cetaceans are seen, the observers record data such as the species, location (latitude and longitude) of the encounter, general behaviour of the animals, estimates of the number of cetaceans in the group, measure the distance from the observation point and calculate the angle from the bow. The sighting data are later analysed using distance sampling statistical models and imported into a Geographical Information System (GIS) for further spatial analysis.

31. This method is reliable when wind, sea state and visibility are adequate to detect small dolphins, and the limit if often put to Beaufort wind less or equal to 3. Also, Douglas sea state (from 4) can be a limitation to detect small delphinids.

This type of monitoring may require some authorizations procedures, depending on study area (environmentally protected zones, cross border areas).

Advantages

32. the advantages are:
- Allow representative coverage of areas.

- Different types of sample designs are available according to the characteristics of the study area and the census itself. The design of the sampling plan can be done using software DISTANCE (http://www.**distancesampling**.org).

- Protocols for data collection are standard and widely used; they are tested and improved continuously.

- Analytical methods are also standard, tested and constantly improved in order to minimize the influence of potential biases.

- Often, large vessels are required to cover large areas (vessels can remain at sea for many days, which can stay on course and maintain speed regardless of the sea state and can board enough personnel to allow rotation of the observer teams and secretaries). However, this method can also be applied to small areas with smaller boats (sailing vessels, motorboat).

Limitations

33. Limitations are:
- This method is expensive, labour intensive and give little spatial coverage.
- Responsive species movement prior to detection (i.e. attraction to, or avoidance of, the vessel) is difficult to predict but can generate substantial bias in estimates of abundance if it occurs. It must then be tested and calculated during the analysis.
- Theoretically, the line transect should not be interrupted: the boat must be in "passing" mode, that is to say, it does not stop or turn away, which could lead to potential biases. Therefore, species identification and counting of individuals in groups can sometimes be difficult and it is incompatible with the collection of ancillary data, such as photographs for photo-identification, biopsies. It may be possible to make a part of the sampling plan in the "closing" mode where groups of easily identifiable and countable cetaceans are then approached on "off effort" before resuming the transect path in "on effort". In this case, it is important to estimate the bias introduced in the protocol by this manoeuvre and preserve it for conditions with real difficulties.

3.3.1.1.2. Dedicated aerial-based survey

Principle

34. Working by aerial means (airplane) is a powerful method, primarily aimed at assessing the abundance and distribution of marine species over large areas or areas inaccessible by boat (far offshore area, harsh weather conditions, etc.). The platform used in most cases is a small airplane with two observers aboard and a data recording. The airplane follows the path of a predetermined sampling plan to cover a large area according to the equal coverage probability, noting all cetacean sightings.

Human resources

35. At least 3 trained “aerial” observers should constitute the team in one airplane, 2 observers and 1 real time data recorder. In case of the double platform two more researchers are needed

Material needed

36. Material required are as follows:
- A small, high-wing airplane with two motors, that can fly at 90 knots while remaining within the limits of safety. The airplane must be equipped with bubble windows (to allow the observer to look under the plane) and can carry at least three people (two observers and a data recorder) beside the pilot.
- Observation forms and a computer with a person to enter the data reported by observers in real time, or a dictaphone.
- Two clinometers, one for each observer.
- printed angleboards
- A GPS
- A computer with dedicated maps and software.

Implementation

37. The first phase is the preparation of the campaign, with training of people if needed, design the sampling scheme according to densities of cetaceans (if known) and habitats. Also, everything concerning authorization request and logistic (localisation of airports, availability of fuel) should be launch largely before.

38. The pilot of the plane is in charge of following the flight plan defined and surveyed along pre-determined transects. Two observers sit at the rear seats equipped with bubble windows on the left and right side of the plane scan the water for cetaceans. The third scientist, the navigator, sit in the front at the co-pilot seat, is responsible for the flight plan too, entering effort data, environmental conditions and sightings data in real time into a laptop during the flight. When cetaceans are seen, the observers record data such as species, estimated group size and declination angle when animals are abeam (the angle between the observation's point and t the vertical line between the sea surface and the plane). The sighting data are later analysed using distance sampling statistical models and can be imported into a Geographical Information System (GIS) for further spatial analysis.

39. This type of monitoring required a lot of authorization procedures specifics to aviation, in particular in cross border areas and also concerning airport use and fuel availability.

Advantages

40. The main advantages are:
- This technique is usually more profitable than large surveys over large areas, which would be conducted from the boat.

- Large areas can be covered in a short time and remote areas are reached quickly to study them (although the distance depends on the autonomy of the aircraft).

- Some sea conditions, such as waves, interfere much less when working from the airplane than from a boat.

- Provide opportunities to detect wildlife in real time and refine species identifications and group size count using a circle-back approach.

- The movement reaction issue (avoidance or attraction) is generally non-existent (if the aircraft is high enough and passes only once).

Limitations

41. Main limitations are:
- Visibility must be excellent (good sea conditions, clear sky, no glare, etc.).

- There are difficulties in identifying some species and counting large aggregation of cetaceans, merely small delphinids, due to the altitude and / or speed of the aircraft, which allow only few seconds to the observers to collect all the data. Pictures or video can help for those points.
- Sometimes the availability of appropriate aircraft characteristics (slow flight, high wings, sufficient autonomy, etc.) or fuel for such kind of aircraft, is rare.
- Data collection by air is expensive, particularly in remote regions away from airports.
- Aerial surveys are logistically difficult to implement and incur high costs from aircraft hire and staffing and can be limited by flight regulations and safety considerations.
- This technique is not the best one to study deep diving species like sperm whale or beaked whale, staying a long time not visible at surface or subsurface; nevertheless, data collected for deep divers can be corrected with the data on the proportion on time the animals are unavailable to be seen.

3.3.1.1.3. Not dedicated boat-based survey, or Fix line transect "distance sampling" by ferry or regular oceanographic vessel's campaigns

Principle

42. Surveys are conducted along fixed transects using passenger ferry or oceanographic vessels as platform of observation. Teams of trained marine mammal observers (MMO) board either a passenger ferry which conducted almost identical transects from month to month or an oceanographic vessel conducting regularly the same design over the same area (for example yearly national small pelagic fish stock assessments campaigns). Data collection of occurrences of marine mammals are conducted on "passing" mode, that is to say, it does not stop or turn away. The method implemented is the line transect and the purpose of the method is to repeat the same transects in the long-term.

43. On those kind of vessel, reliable data on distribution and abundance can be collected, depending on the type of routes and regularity of crossing. For example, in the Pelagos Sanctuary, the ferries run almost all year round, on numerous routes crossing part of the area, ensuring a good temporal coverage. Also, oceanographic small fish stock campaigns often follow a tied coverage of their area of interest. Those data may be of great interest to answer to indicator 3 and 4 in those conditions.

Human resources

44. The Line transect method required that 180° in front of the vessel is continuously observed during all daylight hours. This required that at least two trained observers are watching at all time, and to allow resting and mealtime, it is required at least two teams rotating each two hours. So, for long lasting mission, the number of 4 trained observers is a minimum, the best option is at least 3+3 allowing a better coverage and a person also dedicated to record the sightings and all associated information.

Material needed

45. The needed materials are:

- Passenger ferry using fixed lines allowing repetitions or oceanographic vessel implementing on a regular basis the same (or equivalent) design in the same area
- Binoculars
- Compass or angleboards
- Instruments to estimate or measure the distance of the animals from the boat (reticulate binoculars, measuring sticks and clinometer).
- Observational forms and a computer.
- A GPS.

Implementation

46. Observer's team conducted the survey from the deck of engine control room of the vessel or outside in a free of obstacle's observer point. They are divided on each side of the ferry/oceanographic vessel and collect data of cetacean's occurrence continuously on both sides. When "on effort", they scan carefully the area (with a focus on the 180° to the front of the boat) by eye and using binoculars, so as to detect visually cetaceans present on surface.

This type of monitoring required some agreements with ferry companies/oceanographic/fishery institutions.

Advantages

47. The advantages are:

- This method, in a representative sector, gives relevant indicators of what occurs surroundings (in terms of distribution and indices of abundance).
- It is a cost-effective means of providing wide coverage over protracted periods. Furthermore, the use of these platforms allows to realize a monitoring all year round or yearly and at a lower cost.
- The regularity with which the crossings are made allows to repeat the operation as much as desired to refine a study.
- in some areas, ferry routes make a kind of sampling design relatively tied, allowing a good coverage of the area (ex.: Pelagos Sanctuary), and also oceanographic small fish stock campaigns often follow a tied coverage of their area of interest.

Limitations

48. The limitations are:

- The major limitations are that there is rarely any control over the routes taken which are already designed, nor the speed of the vessel, and the vessel typically cannot divert from its track to confirm species identity or group size.
- Sometimes the required number of even only 2 observers cannot be allowed aboard, depending on the size of the vessel
- The application of this method is strictly speaking incompatible with the collection of ancillary data focusing on individual animals, such as photographs for photo-identification or biopsies.

3.3.1.1.4. Dedicated observers on opportunistic platform (military, custom, navy, whale-watching boats)

Principle

49. One or more observers board an opportunistic platform and benefit from the platform route to make observations without logistical implementations. Platforms can be boat-based or aerial-based.

50. Ideally, the effort should be significant to obtain a large number of observations and cover as homogeneously as possible the different values used in the environmental variables' analysis. So, the platform should go at sea on a regular basis, and within the same area to be of some interest in monitoring objective of distribution and indices of abundance. So, military or custom's vessel, airplane or helicopter can be targeted, as well as whale-watching boats.

51. This method, not dedicated to cetaceans studies, are less robust to answer to the assumptions needed to get reliable and precise results in terms of indicator 3 and 4. Nevertheless, the fact that the same area is regularly sampled in the same way, allows to gain knowledge on occurrence, presence and to compare these results between seasons and years.

Human resources

52. Depending on method implemented, size and authorization of the platform, at least 1 trained observer is required, and the higher the number of observers, the higher the quality of visual coverage and data recording.

Material needed

53. The needed materials are:

- Binoculars.
- Compass or angle-boards
- Instruments to estimate or measure the distance of the animals from the boat (reticulate binoculars, measuring sticks, clinometer).
- Observational forms and a computer.
- A watch.
- A GPS.

Implementation

54. Observers team conducted the survey and scan carefully the area, with a focus on the 90° to the front of the boat, and with a focus below and perpendicular to trackline for aerial platform. Searching visually cetaceans present on surface has to be done by eyes and binoculars are used to precise parameters such as species, numbers, etc. During every observation period they record the begin and end of effort, the environmental condition and sightings data such as species, estimated group size, behaviour GPS location. Depending on the platform and its mission, ancillary data may be possible to collect. This type of monitoring required some agreements with other structures.

Advantages

55. The avantages are:

- Platforms of opportunity are often used to survey areas at low cost. In some cases, costs may be relatively small because boats and equipment can be minimized without compromising the reliability of the results of a simple, but adequate data collection protocol.
- Data collected from an opportunistic platform can still be used to assess habitat use and to estimate the abundance of animals through spatial modelling. In addition, the use of environmental characteristics to estimate abundance or relative abundance can potentially increase the accuracy of results. Finally, some platforms allow photo-identification or acoustic data to be taken.

Limitations

56. The limitations are:

- The major limitations are that there is rarely any control over the routes taken, the speed of the vessel, the ability of vessel to divert from its track to confirm species identity or group size and even to take ancillary data (photo-identification). But this may vary greatly depending on the type of platform and mission.
- Monitoring implementation can be a low priority in initial objectives of the platform.
- The use of this kind of data should be done carefully, because there might exist a lack in the sampling design with uncovered area, heterogeneity in effort coverage across the range of values for the explanatory variables, etc.
- area covered might be small and unrepresentative for cetaceans

3.3.2. Passive acoustic monitoring

57. All cetaceans produce sounds like "clicks" for echolocation or "whistles" (frequency modulated sounds) for intraspecific communication. Passive acoustic methods allow the near-continuous detection and monitoring of those sounds. The monitoring of these sounds allows for the collection of information on spatial and temporal habitat use, as well as estimation of relative density for some species and even abundance for sperm whale.

3.3.2.1. Passive Acoustic "line transect" (towed hydrophone)

Principle

58. One array with at least two hydrophones are towed by a moving boat. Listening and recording can be continuous or by samples. The array enables to determine angle at perpendicular distance, which is the base of the analysis of the "line transect" method. The trajectory of the boat should be constant in speed and heading, following a predefine design or random transects.

59. The area covered is bounded by the probability of detection by the hydrophone and the frequency and power of the sound made by the animals.

60. This is the most effective method to survey sperm whale, as they are long-deep diving species, and they use "clicks" during the entire duration of their dives. Acoustic data from sperm whales can be used to assess both relative and absolute abundance and also distribution, provided that the appropriate equipment and survey design is followed. For other species, acoustic results might be complementary to visual for indicator 3, but not for indicator 4 as methods to relate sounds to abundance of animals are not efficient yet.

Human resources

61. At least one passive acoustic operator is needed, or more for a 24 hours work.

Material needed

62. The needed materials are:

- A boat, motor or sailing one, which is able to hold a constant speed and heading for a transect and be silent or can stop the engine often (for sampling).
- A whole acoustic acquisition chain:
    - hydrophone array composed of at least two hydrophones (even two arrays of hydrophone) coupled to stereo amplifiers and which is within a pipe that can be towed.
    - A DAQ system (convert the signal from analogue to digital format and convert in quantization)
    - A computer with a software analyzing sounds.
    - and a power source to power the system

- The relevant data forms.
- A GPS.

Implementation

63. The first phase is the preparation of the campaign, with training of people if needed, design the sampling scheme according to densities of cetaceans (if known) and habitats. Also, everything concerning authorization request and logistic should be launch largely before.

64. An acoustic acquisition chain is setup, comprising a tow cable into which is incorporated a linear array of two pairs of hydrophones, a deck cable that connects to the tow cable and carries signals to wherever the PAM station is set up. The electronic equipment at the PAM station provides power to the system, amplifies and digitises signals before feeding signals to one or more PCs that provide the user interface (software) and store the data. If continuous acoustic detection is chosen, the vessel starts the transect with the acoustic acquisition chain in position. The start of the effort is when the acoustic detection of animals is launch.

65. If sampling procedure is used, that means that regularly a listening period is implemented. For example, the standard is to listen for 2 minutes during each 15 minutes. Often, the speed of the boat is decreased at minimum in order to reduce engine noise and noise of the water flowing on the hydrophone. Using hydrophone at sea is often linked to special authorizations to acquired.

Advantages

66. The advantages are:

- This method is cost-effective, autonomous and it provides valuable information without disturbance to wildlife or their habitats.
- The detected radius can be very large for some species: most Mysticeti can be detected at tens or hundreds of kilometres. Depending on the equipment used, the ambient noise and the characteristic of the water for acoustic propagation, dolphins can be detected at distances up to 3 km in good conditions.
- The acoustic approach potentially detects the presence of a cetacean that is not visually observable because it is too far, it remains underwater, it moves at night or the weather conditions deteriorate. This method offers a valuable alternative for monitoring biodiversity when traditional (e.g. visual) surveys are impractical or impossible.
- Acoustic work can easily be done on a great type of vessels, from small boats or even opportunistic platforms to large vessel.
- This technique is not intrusive, and the necessary equipment is not particularly expensive.
- This approach records sound for documentation or future analysis and it is easier to standardize and automate data collection.
- A key benefit of active acoustic methods lies in their fine spatial resolution and their ability to collect data on multiple species simultaneously and nearly continuously from a moving vessel.
- Acoustic data are largely independent of collection error and inter-observer bias.
- A mobile approach grants larger geographic coverage.

Limitations

67. The limitations are:
- This method relies upon animals being vocal.
- Methods to relate sounds to abundance of animals are not well developed. In case of numerous animals, it is impossible to know which individual emits the sound and it is very difficult to know the number of animals in a group.
- Difficult identification for close species, mainly small dolphins (e.g. striped dolphin and common dolphin)
- Acoustic behaviour depends on the activity of a group, not necessarily the number of individuals, which can move without making any sound.
- Ambient noise and the noise generated by the research vessel can make the acoustic detection of an animal difficult. Detection probability is also a function of background noise, with acoustic interferences such as masking potentially species identification and group size estimation.
- Requires specialist data collection equipment.
- The volume of data typically generated by passive acoustic methods is enormous and requires significant investment in storage and after in post-processing.
- Small towed hydrophones are not suitable for the detection of low-frequency and infrasonic sounds simply because the vibrations and movements of hydrophones mask these sounds.
- Almost all hydrophones are sensitive to frequencies from a few hertz. This is why, it is often necessary to use a high-pass filter to remove low-frequency noise.

3.3.2.2. Fix passive acoustic

Principle

68. One (or more) hydrophone(s) is installed in one (or more) fixed strategic sites, either on the ground, or on a boat or a floating platform. Opportunistic or non-dedicated platforms or stations can be used. Sound recording is done continuously or at a regular frequency (sampling). Positioning at least three hydrophones also allows triangulation to precisely locate the animal emitting the sounds. The more hydrophones, the larger the area covered. So, network of several hydrophones is necessary to increase the interest of such tool for monitoring the presence and indices of abundance of several species.

Human resources

69. At least one acoustician should build the acoustic acquisition chain. Then, depending on the situation (coastal or at sea), a ship with pilot should be needed and one diver will setup the system out at sea. The same people might be needed when the equipment has to be changed (batteries if any, hard drive when it is full…).

Material needed

70. The needed materials are:
- A stereo hydrophone amplifier coupled to a transmission cable, a DAQ converter (digital and quantization of the signal), a hard drive to store data, a power source to power everything and finally a protection unit and fixations to install all equipment.
- A thermometer and a probe coupled to the sub-sea installation to enrich the data.

Implementation

71. The site is identified, the type of fixation is defined (depending on ground type, currents, etc) and the hydrophone system is installed. An existing underwater structure can be used, but caution should be made on the noise made by the structure, the more silent the better. Divers may install the acoustic system which will collect data for a predetermined period, mostly depending on capacity storage or power supply of the batteries. Then records (data) are being recovered for analysis. The system can stay for short, medium or long period. The recovering of the data and the changing of the batteries can sometimes be done without removing the whole system. Using hydrophone at sea is often linked to special authorizations to acquired.

Advantages

72. The advantages are:

- Passive hydroacoustic is ideal in long-term monitoring programs and can run on continuous 24-hour cycles, independently of weather conditions. By recording all animals moving close to a given listening station, it is possible to study temporal variations, ranging from the annual scale, to the monthly and daily scale.
- This technique is non-invasive, and the cost of basic equipment is not very high.
- Acoustic data are largely independent of collection error and inter-observer bias.
- The system can be automated and requires no human presence on site. It is easier to standardize and automate data collection.
- Detection over 360° and in almost all weather and light conditions.
- If the installed system is permanent, detection and temporal coverage will work 100%.
- Depending on how the hydrophone is positioned, the material, the water characteristics of sound propagation and the ambient noise, the monitoring area for dolphins is about 3-6 km because there is no noise from the boat. Tracking sperm whales and the Mysticeti can be extended to tens of kilometres.
- The system can sample regularly or continuously areas that are difficult to access.
- Concerning the surface system on a floating platform:
  · It can be self-contained with a power supply from solar panels or wind turbines.
  · Data can be transmitted via VHF waves or Wi-Fi, allowing real-time application.
  · Settings can be changed easily by easily accessible instruments (gain, filters, etc.).
- Concerning the system deployed on the seabed:
  · Discreet and less vulnerable to surface activities.

Limitations

73. The mimitations are:

- Detection probability and receiver performance are also a function of background noise, with acoustic interferences such as masking potentially hampering species identification and group size estimation
- This method relies upon animals being vocal.
- In this fixed method, the coverage is limited to the “immediate” vicinity of the system.
- Corrosion, fouling, and damage from currents, tides, storms, or fishery operations can all affect the longevity and efficiency of acoustic instruments.
- Methods to relate sounds to abundance of animals are not well developed. When animals are in a group, it becomes difficult to identify the individual that issued the sound and how many animals are present. There is a risk of multiple detection of the same group.
- Areas subject to strong tidal currents should be avoided due to noise or risk of damage to facilities (current, debris, etc.).
- Noise near the coast can mask the acoustic detection of an animal.
- Acoustic behaviour depends on the activity of a group, not necessarily the number of individuals, which can move without making any sound.

- As part of a network of permanently installed hydrophones to detect all species, including those that emit very low or very high frequencies, the cost of the equipment required is very high.
- It is hard to differentiate between small dolphins' species
- Concerning the surface system on a floating platform:
  - Susceptible to all weather conditions on the surface;
  - Vulnerable to all activities taking place in the area (possibility of degradation or loss of the equipment) and preferably protected from free access of people.
- Concerning the system deployed on the seabed:
  - The power supply is complicated (cable? battery to change?);
  - Need to dive in the site to change settings, difficult access to instruments;
  - What type of data transmission: by cable or storage?

3.3.3. Monitoring based on focal tracking of individuals

74. The previous methods described work more at a population level. Some specific monitoring focus on individuals. When the samples are numerous, they can give results at the population scales. Most of these methods are complementary to the previous ones, providing information to help to define 'population' for example, apart for photo-identification that can produce population estimates directly, through mark-recapture. Biopsy provide valuable data to the indicator 5.

3.3.3.1. Photo-Identification (or photo-ID)

Principle

75. Scientists use the photo-identification to distinguish cetaceans from each other and recognize them. The technique relies on being able to obtain good quality photos of animals' body parts that constitute unique recognizable markings during their whole life. The animals are photographed and catalogued individually based on natural markings criteria (e.g., pigmentation on the body, shape of the dorsal fin) and personal markings (scores, notches and scars) that identify them. A number of assumptions are made, particularly relating to recognizability, representativeness of sampling and capture probabilities that should be homogeneous. When an already identified individual is re-sighted, or photographically re-captured, this can provide a response to various issues, such as: population size, site fidelity, distribution, movements, social structure, etc. This means that there is a need for sorting, storing pictures and associated data within a catalogue which should be regularly updated.

76. Photo-identification is a good method to estimate population size (indicator 4) through mark-recapture models, and for specific areas that populations or part of populations occupy during one or more seasons of the year. It is also one of the methods to provide population parameters e.g. survival and calving rate.

77. The standard software program for mark-recapture analysis is programme MARK (http://www.cnr.colostate.edu/~gwhite/mark/mark.htm), which includes a wide range of models to estimate population size, survival rates and allow to correct some of the bias against the assumptions.

Human resources

78. At least one trained observer/photograph will take pictures of the cetaceans and indicate to the pilot of the vessel how to move the vessel in order to ensure good photo-identification (speed, heading, position in comparison of the animals…). The post-treatment of pictures requests one skilled person at least, and is time-consuming, in order to get a final catalogue of photo-identified animals and the matrix of recaptures which is the base of any analysis.

Material needed

79. The needed materials are:

- A boat with a sufficiently low bridge over the water to take pictures at the correct angle.
- Observation forms and, ideally, a computer.
- A watch.
- A GPS.
- A camera with a lens (up to at least 200mm, ideally up to 300 or 400 mm). Digital cameras with high resolution (at least 6 megapixels) are highly recommended.
- a computer and a hard drive to store all the pictures and moreover the catalogue of photo-identified animals

Implementation

80. On the boat, researchers take pictures of natural markings on animals at certain angle and from certain parts of the body depending on the species (e.g. flanks for delphinids, tail for sperm whale) of all individuals encountered.

81. The analysis of the images is time-consuming and requires great concentration and attention to detail. Every individual is listed in a catalogue of photo-identification, allowing comparisons. Scientist has to compare the photo of an individual with all the photos which are in his database and update regularly his existing catalogue and the matrix of re-capture. In an attempt to facilitate the process of matching, some software has been developed to make the comparison automatically. The principle is that the software presents a number of candidates (possible matches) with a certain probability/similarity, which safes time to the researcher by not needing to go through the whole catalogue. Nevertheless, the researcher takes the final decision about a positive match.
Photography may require some specifics authorizations procedures as well as regional partnerships may require some agreements.

Advantages

82. The advantages are:
- Relatively easy data collection protocol.
- Non-intrusive method of "marking" animals.
- A systematic sampling plan is not always necessary but is preferable.
- Standard and tested analysis methods exist, that provide reliable results as long as the hypotheses are tested or the bias are well estimated.

Limitations

83. The limitations are:

- Only applicable for species with long-lasting identifiable natural marks.
- Natural marks must be unique, recognizable and not change.
- Heterogeneity of capture probability.
- The collected data is a photograph of a wild animal in motion; it is not easy to take a good quality photograph with targeted criteria without good relative experience.
- Required several captures. If there is not enough recaptures, analyses are difficult and sometimes give unreliable results.
- Require a large quantity of data and a long-term study and is time-consuming for the cataloguing part.

- Difficulty of application in low-density areas.
- This method generates mark-recapture estimates of the total number of individuals in the study area. However, the total size of the population may be greater if all the animals in the population do not frequent the monitored area.

3.3.3.2. Telemetry

Principle

84. There are two types: satellite telemetry (Argos) and radio wave (VHF) telemetry. This technique consists in attaching a transmitter to an animal and following its movements remotely by satellite or via a receiver VHF or acoustics which can be installed aboard a ship or a plane.

85. Thanks to the beacons which transmit every hour/day their signals to the satellites, scientists acquire knowledge on the localization of the animal. These techniques allow to study animals in their world and to obtain information on feeding behaviour, distribution, reproduction area and migratory routes. These beacons also allow to record other data such as temperature, pressure, luminosity, swimming speed and sounds.

86. Information on the movements and distribution of individual animals can help to identify important habitats (feeding areas), migration routes and to define boundaries between populations. So, these data can provide complementary results to the indicator 3 at least and help to define the study area to monitor a population in the frame of the indicator 4.

Human resources

87. At least at sea, one person should have skills to attach/deploy the system on the animals. To detect the animal, and follow with VHF, at least 3 people are needed.

Material needed

88. The needed materials are:
- transmitters (Argos or VHF)
- small or relatively small boat (outboard or an average zodiac boat) with a sufficiently low bridge over the water to approach correctly the animal.
- beacon, crossbow or long pole
- In case of radio telemetry, a receiver VHF or acoustics to set up on a platform (vessel, aircraft) that follows the animal tagged.

Implementation

89. An animal will be detected and approached nearby, in order to attach (suction cup) or deployed the transmitter. Usually suction cups are pressed on the body using a pole, meaning to approach the animal to touch its body, whereas for Argos transmitters it is deployed in pulling on the animal with a crossbow a device with a clip that will be embedded in the subcutaneous fat of the animal.

90. For coastal species the approach can be made from a rubber boat directly, and for more pelagic species a large vessel can act as a base and a rubber boat can be towed and be used to approach the animals. For a device using VHF, the vessel will follow the animal at distance in order not to interfere with its behaviour and also in order to recover the device when it will naturally get off the animal.

Because this method has a direct impact on cetaceans, it requires request of authorization prior to implementation.

Advantages

91. The advantages are:

- These instruments allow to collect a lot of information not allowed by other methods (behaviour, movements) and without human interference.
- This method allows to study movements of animals on a large distance, in isolated area and under the water surface.

92. For satellite telemetry:

- Operate on a very vast area and allows to study movements of animals on a large distance;
- Independent from weather conditions;
- Possibility to obtain additional information;
- No need of an observation platform following the animal at sea;
- Allows to know species presence in an unexplored area;
- Allows to obtain information summaries about the animal's activities during long periods.

93. For radio telemetry:

- Relatively low-cost;
- Small-sized system and relatively non-invasive system;
- Operate on a wide area;
- Relatively independent from weather conditions.

Limitations

94. The limitations are:

- This method is intrusive, either by its approach nearly to touch the animal but also through the system to attach the device (mainly satellite transmitters) to animal body
- Information is obtained on few individuals and depend on performances of equipment used, as well as the accessibility of mammals. A lot of individuals must be tagged to draw any general conclusion, and this is often not possible
- The implementation of this method requires important logistical support because it requires an installation directly on the animal, which is a particularly difficult operation for rare and fast animals.
- This method is intrusive for animals, with infection risks.
- Only animals which can be correctly approached are equipped and required that the animal is at the surface for the data transmission

95. For satellite telemetry:

- Expensive method;
- Limited support of non-intrusive mechanism on animal and limited time-life.

96. For radio telemetry:

- Required to maintain a platform following the animal at close distance;
- limited autonomy;

3.3.3.3. Biopsy

Principle

97. This method consists in collecting on living animals at sea a fragment of skin and blubber. This can be done by throwing with a crossbow darts with tip, dart gun, riffle or even a pole with biopsy tip or skin swabbing when dealing with bow riding animals for example.

98. Such samples allow to gather information on biodemographic parameters (indicator 5):

- To determine the sex of the animal
- To determine the genetic specificity of individuals (fragment of DNA) of the same species. Based on that, analyses of kinship, matrilinear links, and social structure can be run.
- To obtain information on the reproductive status of individuals (e.g., pregnancy for females) based on the level of hormones.

99. Other information can be gain:

- on feeding level (isotope)
- on level of contamination in heavy metals and other pollutants (such as organochlorine contaminants)

100. Several parameters included in the indicator 5 can be obtained through the analysis of the skin and blubber collected with the biopsy method: sex ratio, pregnancy rates. Also, the genetic structure of the animals allows to better determine the limit of a "population", or a sub-population, which helps to know when looking for the distribution or abundance of this population.

Human resources

101. At least one pilot, one shooter and it is highly recommended to have a photographer to be able to identify the animal sampled, which may provide the opportunity, for instance, of monitoring the healing process. A fourth person can take care of the samples when the biopsy has succeeded.

Material needed

102. The needed materials are:

- A small or relatively small boat (outboard or an average zodiac boat) with a sufficiently low bridge over the water to shoot at the correct angle.
- Crossbow or gun and bolts, darts with tip.
- Storage and cleaning material (products)
- Freezer or storage frozen.

Implementation

103. Animal targeted should be approached nearby. Biopsies are realized by means of an arrow (pulled by a crossbow or an airgun) which, pulled with some force, take a piece of skin and fall into the water where it is then recovered with the sample. In the same time, a photo allowing to identify animal is taken to obtain a complete documentation for each animal. It should be noticed that the material (skin and blubber) is right away stored following a strict protocol which can differ depending on the planned analyses (genetic, hormone, isotope): alcohol in one case, freezing in another.

104. As for photo-Identification, for coastal species the approach can be made from a rubber boat directly, and for more pelagic species a large vessel can act as a base and a rubber boat can be towed and be used to approach the animals whereas the large vessel stays away.

Because this method has a direct impact on cetaceans, it requires demands of previous authorization applications.

Advantages

105. The advantages are:

- Give access to information very difficult to obtain in another way (genetic, hormones, isotope)

- Biopsy sampling tends to be relatively affordable and can be easily paired with additional methods to maximize data collection opportunities.

Limitations

106. The limitations are:

- A strong disadvantage of biopsy is that it is invasive because the animal will be approached very near and the biopsy itself (i.e. results in physical lesions), which restricts sampling to the size and age classes (and species) that can be ethically targeted under existing permitting restrictions.
- The lifestyle of cetaceans, which spend only some fractions of their life on-surface limit strongly options to collect tissue from alive animals.

3.3.3.4. Land based tracking

Principle

107. This method consists in collecting data from a fixed point on the coast, following individuals crossing the area watched from the point of observation. Ideally, the point of observation must be high. Such tracking allows studying distribution, behaviour, use of the habitat and movements of focal cetaceans, without impact of boat presence on the natural behaviour of animals. This method is suited for the study of a coastal resident population or migrations close to the coast.

108. This method is most efficient for coastal population or resident groups. It can give results on distribution and habitat use, in link with indicator 3.

Human resources

109. At least 3 persons should be in charge of the observation and measures. One can make the measures of the group/animal followed, the second record notes, and the third one observes other part of the sea to detect other animals.

Material needed

110. The needed materials are:
- Binoculars or a telescope on a tripod.
- Observation form or Dictaphone.
- Watch or clock.
- Compass or angleboard and an instrument to measure the distance between the animal and the observation post (e.g., clinometer camera for photogrammetry, theodolites).

Implementation

111. One or more observers position themselves at a strategic point of view (headland, cliff, strait, entrance of a bay) and collects data on animals and weather. Observations can be made with naked eye or with binoculars or telescopes but is dependent on a calm sea and on a good atmospheric visibility.
This type of monitoring does not require some special authorization procedures as long as the observation point is free of access.

Advantages

112. The advantages are:

- Land-based methods are non-invasive, enabling the monitoring of marine mammals without risks of observer-induced disturbance.
- This is the least expensive techniques (no costs due to platform navigating at sea) used. It can therefore be implemented often and so allow a long-term monitoring.
- The land-based method can be easily standardized and realized all year round, according to observation conditions.

Limitations

113. The limitations are:

- The field of study is limited to the area covered visually (naked eye or binoculars); the prospecting area is thus limited.
- Land-based methods are normally constrained to relatively conspicuous species that regularly come to the surface within sight of land.
- Investigations on fine-scale distribution are constrained by the difficulty in determining the precise geographical position of cetaceans. Theodolites are widely used in such studies, but there are limitations to their use. In particular, measurement readings can often be long, and the collection is made on a centre of gravity of a small group rather than on individuals. In addition, such groups can be spread over tens or hundreds of meters; a single position is rarely representative of all individuals.

3.4. Standard monitoring of strandings and by-catch animals

114. The monitoring of strandings and by-catch deal most of the time with dead animals. A lot of data can be collected which will be used in the three indicators: as a first step, the collection of strandings and by-catch information aids the construction of a species list of cetaceans present in the area (or surroundings for strandings) and a rough measure of status and seasonal variation in abundance. Then, the analysis of carcasses gives a lot of information on demographic parameters.

3.4.1. Stranding

Principle

115. Stranding is a monitoring method that is continuous all year round, with qualified people ready to go on each stranding event of cetaceans when it occurs and is detected. Parameters of the animals are measured, and biological samples are taken when possible and stored.

116. This method was the first one to be used by scientists as monitoring method, because strandings occur all the time and animals arrive on the coast, so they are easier to approach than living animals at sea.

117. Stranding of cetaceans represents an extremely precious scientific material for the knowledge of these species difficult to study in their natural environment. Study of carcasses, realization of autopsies and complementary analyses on biological samplings can supply information on the presence of a species, its distribution, demography of populations, feeding regime, health status of the animal (food, diseases, contamination), death causes, impact of anthropological threats (incidental catches, ship strike). These data will be used mainly for the indicator 5.

118. It is of crucial importance to fund this monitoring on long term and in a structured way. A network of referenced people localised all along the coast and working in the same manner, linked to a coordinator, is the base of an efficient monitoring network of strandings. An animation and steering committee would allow the network to function properly and guarantee the system's sustainability.

Human resources

119. People trained to do the measurements and take biological samples according to specific standard protocols, available to reach the stranded animals as soon as it is detected. Within the network there should be also veterinarians to examine carcasses, detect the causes of mortalities and place to store the biological samples (freezer).

Material needed

120. The materials needed are:
- Stranding forms
- Camera
- Tape measure
- Sampling kit (knife, shears, packaging materials)
- Refrigerated box and freezers network
- Dedicated dress, safety gloves, safety glasses
- Heavy equipment allowing to move carcass if necessary (bulldozers, rendering truck, car)

Implementation

121. When a cetacean stranding is reported, one or more person is on the scene to prevent the approach of people and animals to the carcass and take measures and biological samples. This method requires a specific training for participants. A warning procedure must to be established to be effective. A stranding network must be developed to be efficient and bring useful data.
Approaching and dealing with dead animals as well as protected species need special authorization.

Advantages

122. The advantages are:
- Stranding bring even frequently information, even if these are often limited and non-predictable due to their nature.
- Availability of the whole body and organs for analyses and conservation (tissue bank).
- Some species are known only by stranding and rarely observed at sea.

Limitations

123. The limitations are:
- Not predictable and intervention must be realized on short time for sanitary reasons and for autopsy to be exploitable from a scientific point of view, so require having an available person at the right time.
- Interventions on alive animals represent security and health risks for animals and rescuers. For animals, distress and stress engendered by stranding may cause unpredictable and dangerous behaviour. Also, sanitary risks and disease transmission between rescuers and the animal are real.

3.4.2. By-catch

Principle

124. Marine mammals are frequently captured in fishing gear. "By-catch" means cetaceans accidentally captured by commercial fishing, sometimes but rarely by recreational fishing. Scientific observers can be embarked on board professional fishing ships, to observe captures and fishing conditions, and to take measures and biological samples.

125. Analysis of the measures and samples collected on carcasses provide a lot of information on demography (indicator 5): size of animals, age at maturity, rate of pregnancy, sex ratio…

Human resources

126. People trained to do the measurements and take biological samples of cetaceans according to specific standard protocols. Often, they might take other measures on other species when going on a commercial fishing vessel as observer. One person might go on one vessel for a period. This means that the most vessels to be monitored, the most people trained and authorized to board.

Material needed

127. The needed materials are:

- GPS, watch
- observation forms
- camera
- tape measure
- sampling kit (knife, shears, packaging materials)
- freezer

Implementation

128. One observer embarked on board of a professional fishing vessel. His work consists in collecting scientific data relative to the operation of fishing. He intervenes when a cetacean is captured to take data on the animal. If possible, he takes biological samples, stored them and go back at land with them. To realize sampling on the individuals of marine mammals and bring them on land if useful and feasible, administrative authorization requests are necessary.

Advantages

129. The advantages are:

- By-catch bring crucial biological information on "healthy" animals (compared to strandings who include sick animals), even if these are often limited and non-predictable due to their nature.
- All the animals by-caught might be "fresh" as they were alive few days before and biological samples might be taken from all of them, insuring availability of good quality samples for analyses.
- An observer aboard a fishing vessel will bring data on species and number of animals that are by-caught, enabling to assess the impact of this threat for cetaceans (provide complementary information for indicator 3 and 4).

Limitations

130. The limitations are:

- The event of by-catch is rarely predictable, there might be no by-catch

- Difficulty in going aboard fishing vessel sometimes, because of willingness of fishing captains, size of the vessel or authorization,

- Difficulty in doing the measurements and taking biological samples in some small sized fishing vessel, and also in storing samples in a freezer.

- Intervention on a carcase in a moving vessel represents security risks for people. Also, sanitary risks and disease transmission between people and the animal are real.

3.5. Emerging Monitoring technologies

131. As technologies are improving fast, new studies using them are launch. As these are relatively recent, case by case tested and relying upon technology's capacities (namely pictures resolution, autonomy of AUV, artificial intelligence software to analyses thousands of images, etc.) no standard method is yet approved or define. But as this field is of growing interest and development, and as these technologies may be use within the standard methods already presented in terms of improvements or adding values, these technologies will be shortly presented in this document.

3.5.1. Unmanned underwater and aerial vehicles

3.5.1.1. Sampling from Drone (pictures, blow…)

132. Advances in aerial drone technology offer new opportunities for studying cetaceans remotely and noninvasively. These instruments are light-weight, portable platforms piloted remotely from the ground/deck of a vessel, and allowing surveys of remote, hard-to-reach areas within small time windows.

133. Drones or Unmanned Aerial Vehicles (UAVs) can be used to take pictures or videos by applying the line transects method (visual), to answer abundance and distribution questions. As survey by aircraft, the protocol consists to program to follow a flight plan defined and surveyed along pre-determined transects based on GPS waypoints to form a full coverage survey grid. The drone takes a collection of images with an overlap in coverage of the survey area, and records flight information such as GPS coordinates and altitude in the EXIF header of each image file.

134. UAVs are a promising tool for animal surveys. Indeed, this technology has many advantages:

- potential for carrying out relatively large-scale aerial image-based surveys at often a fraction of the cost of manned aerial surveys, and without many of the safety issues associated with manned aircraft;
- low cost of UAV systems compared to manned aircraft may also allow greater flexibility in survey design, for instance by flying two or more platforms at specific time lags rather than employing the circle-back maneuverer;
- ability to repeatedly collect high-resolution aerial imagery, with extremely low disturbance to animals;
- possibility to be used in areas where manned aerial operations are difficult and dangerous, and allows to survey sites with no airfields;
- may eliminate observer bias in the data collection phase;
- less subject to flight restrictions due to weather conditions;
- results are easily replicated and have minimal impact on the surrounding environment.

135. However, this technology has some limits:

- the longer manual data post-processing times still pose some challenges (in terms of efficiency and costs);
- environmental and survey-related variables, such as light conditions and wind, can affect detectability. Several studies are in progress to quantifying detectability and certainty in animal detections/identification using UAV technology;
- the majority of available UAVs is only useable over limited ranges (i.e. within line-of-sight), at slow speeds, and under small payloads;
- stringent and country-specific civil aviation regulations and complex permitting processes can limit their adoption for scientific applications;
- the covered surface is still lower than the one from a plane;
- impossibility to fly in high winds (wind speed must be less than 25 knots on the ground);

- depending on autonomy of the drone, a vessel can be needed as platform to take off and land, which increase the costs.

136. A drone can be also used as tool to approach an animal realized from a boat. It can allow to study behaviour by achieving better visibility or to take a sample such as in the blow of a whale. This system allows to non-invasively collect mucus microbiota samples safely and reliably, by minimizing external contamination such as air and seawater from outside the blowhole. This type of samples is used for hormonal analysis for example and can help for the indicator 5.

3.5.1.2. Marine AUVs and glider

137. An AUV is a marine craft pre-programmed to conduct underwater missions without constant supervision or monitoring by a human operator. They allow observations of species in their natural environment, with highly accurate vertical and horizontal geo-positioning and the ability to instantly react to the observed environment.

138. Ocean gliders are autonomous winged underwater vehicle that collects ocean data using buoyancy-based propulsion and can remain at sea for weeks to months at a time surveying over spatial scales from ones to hundreds of kilometres. Modern gliders can be fitted with cameras, mobile tracking systems, or acoustic loggers/echosounders. Some robots automatically detect those sounds, identify the species based on characteristics of the sounds, and report which species have been heard to scientists on shore via satellite in near real time.

139. Robots are powerful tools for accessing environments too dangerous or too remote for human exploration. They can complement conventional forms of sampling by providing long-term, fine-resolution coverage of areas that are impractical or too expensive to survey, without constraint from weather conditions or sea states. Some instruments can remain unattended for several weeks to months, offering an unsurpassed level of autonomy.

140. Their biggest drawbacks are their high costs, slow speeds, and limited dive times. Furthermore, their energy storage and power consumption are some limits.

141. AUVs and ocean gliders are valuable for generating long-term datasets in remote locations but can be challenging to deploy and recover.
Launching an AUVs or glider within the sea may be constrained by some authorizations.

3.5.2. Pictures and video

142. Digital cameras delivering stills and video feeds can be used as a support to observers in order to gain some precision if needed. For example, they can be used during a sighting to precise group size count or identification of species. Conducted in a more continuous way, they may help in enhancing encounter rates, although usually within a narrower search swath located immediately beneath the plane. These technologies are helpful in being used in parallel, to combine the advantages of human observations for scanning larger regions with the advantages of later re-analysis and reassessment of images and videos.

143. Several studies are in progress to test if those technologies alone could be used as monitoring methods. Tests are in progress to allow an automatic detection and determination of cetaceans, but methods are not yet operational. Aerial videography benefits from standardized methodologies that can be replicated, but is time-consuming and very costly, because the determination of cetaceans has to be done by an operator.
Taking pictures or video may be constrained by some authorizations.

Conclusion

144. Monitoring cetaceans is a hard task, based on the fact that they are highly mobile and spread in vast areas. Methods have been developed to collect data to follow the evolution, mainly of their distribution, their numbers and their demographic characteristics. Monitoring such parameters imply a lot of knowledge, skills and resources. Each method has its advantages and disadvantages, and approaches may frequently complement one another in providing a more complete picture of the status and distribution of a particular cetacean species.

145. A least strandings monitoring should be organized, with a strong network, everywhere for baseline data on cetaceans (distribution, presence, indices of abundance, genetic analysis). Then a first visual and acoustic survey should be organized over large scale for a knowledge about the global context, which could be repeated regularly several years later (6 to 10). Ferries and oceanographic vessels should be used as non-dedicated platforms if they cover an area on a regularly basis which can be important for cetaceans. Then more focused monitoring programme covering smaller, but representative or important areas should be launch on a yearly basis, including visual and acoustic with some biopsy and photo-ID.

146. Furthermore, the aim of the monitoring programmes is also to get a global vision of the situation at the Mediterranean level. So national programmes should ensure standardization, in method/platform/period with neighbouring countries as much as possible. Even, promoting the implementation of transnational and coordinated monitoring ensure a better effective conservation of cetacean's populations (Authier *et al*., 2017). Initiatives such as the ACCOBAMS Survey Initiative, or the existing "Fixed line transect Mediterranean network" coordinating protocols and database of the different teams working on ferries should be encouraged and supported. This kind of initiatives allows easily to merge all the data for further analysis at a regional or sub-regional level. Standard strandings networks and photo-identification catalogues should also be implemented at the sub-regional level, following the recommendations of Decision IG.23/6 on the 2017 MED QSR (COP 20, Tirana, Albania, 17-20 December 2017) concerning harmonization-standardization-synchronicity of monitoring and assessment methods and improvement of availability /accessibility of the datasets.

147. Before embarking upon a monitoring programme, it is prudent to determine precisely what information can be gained and what limitations exist. A lot of practical and operational adaptation can be found on a case basis. A lot of monitoring programmes already exist, being a source of advises that should be ask for in order to gain at quality, logistical and cost levels.

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B. Guidelines for monitoring Mediterranean Monk seal

<u>Table of Contents</u>

I. Introduction
1. Background

1. In 2008, the Contracting Parties to the Barcelona Convention - namely 21 Mediterranean countries and the European Union (EU) – decided to apply the ecosystem approach (EcAp) to the management of human activities that may affect the Mediterranean marine and coastal environment for the promotion of sustainable development (UNEP/MAP, 2007). It is an ecological strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way, with the aim to ensure that human use of ecosystems is kept within the limits of capacity of ecosystem. The ultimate objective of this approach is to achieve the Good Environmental Status (GES) through informed management decisions, based on integrated quantitative assessment and monitoring of the Marine and Coastal Environment of the Mediterranean.

2. In 2016, the Contracting Parties also agreed to design an Integrated Monitoring and Assessment Programme (IMAP) with a list of regionally agreed good environmental status descriptions, common indicators and targets, with principles and clear timeline for its implementation according to the 6 year-EcAp cycles structure. Building and implementation of a regional monitoring system is the main goal of IMAP to gather reliable and up-to-date data and information on the marine and coastal Mediterranean environment. By adopting IMAP, Mediterranean countries committed to monitor and report on Ecological Objectives (EOs) and their related common indicators (CIs), in synergy with the EU Marine Strategy Framework Directive (MSFD), covering three components: i) biodiversity and non-indigenous species; ii) pollution and marine litter; and iii) coast and hydrography.

3. One of eleven ecological objectives is "Biodiversity is maintained or enhanced" (EO1). The term 'maintained' is key to the quantification of GES for EO1. This condition has three determining factors:

a. no further loss of the diversity within species, between species and of habitats/communities and ecosystems at ecologically relevant scales;
b. any deteriorated attributes of biological diversity are restored to and maintained at or above target levels, where intrinsic conditions allow;
c. where the use of the marine environment is sustainable.

4. Among five common indicators related to biodiversity (EO1) fixed by IMAP, three are about marine mammals including the Mediterranean monk seal:

- Common indicator 3: Species distributional range;
- Common indicator 4: Population abundance of selected species;
- Common indicator 5: Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates)

2. Purpose and Aims

5. As top predators in the Mediterranean Sea, the monk seals are an important element of marine biodiversity. Their abundance and distribution are known to respond to various natural and anthropogenic drivers. Role of long-term monitoring programmes in assessing population states are widely recognized and several programmes covering the North-East Atlantic marine environment including plankton, fish, seabirds and marine mammals already in operation. Monitoring efforts of Mediterranean monk seals are regional due to their scattered distribution range. The largest subpopulation inhabits the eastern Mediterranean Sea in Greece and Turkey. The second largest aggregation located at Cabo Blanco. The third subpopulation inhabit the archipelago of Madeira and the small unknown number of seals might inhabit at the eastern Morocco therefore every working group has a different monitoring strategy regarding their regional differences.

6. The aim of this document is to provide guidance to monitor Mediterranean monk seal in relation to the IMAP common indicators, i.e distribution, abundance and population demographic

characteristics (i.e. Body size or age class structure, sex ratio, fecundity rates, survival/mortality rates) at the Mediterranean and national scale.

7. These monitoring guidelines are for the surveys to be conducted in the areas where the Mediterranean monk seal populations actively occur/inhabit.

3. Common Indicators related to Marine Mammals including the Mediterranean monk seal

8. A common indicator is built in the context of the Barcelona Convention and it "summarizes data into a simple, standardized, and communicable figure and is ideally applicable in the whole Mediterranean basin, or at least on the level of sub-regions, and is monitored by all Contracting Parties. A common indicator is able to give an indication of the degree of threat or change in the marine ecosystem and can deliver valuable information to decision makers (IMAP, 2017)".

9. Among five common indicators related to biodiversity (EO1) fixed by IMAP, three are about marine mammals:

- Common Indicator 3 - Species distributional range:
  This indicator is aimed at providing information about the geographical area in which marine mammal species occur. It is intended to determine the species range of cetaceans and seals that are present in Mediterranean waters, with a special focus on the species selected by the Parties. The main outputs of the monitoring under this indicator will be maps of species presence, distribution and occurrence.
- Common Indicator 4 - Population abundance of selected species:
  This indicator refers to the total number of individuals belonging to a population in a specified area in a given timeframe. Methods for estimating density and abundance are generally species-specific and ecological characteristics of a target species should be considered carefully when planning a research campaign. In this document, target species refers to the Mediterranean monk seal.
- Common Indicator 5 - Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates):
  This indicator aims to provide information about demographic parameters as the age structure, age at sexual maturity, sex ratio and rates of birth (fecundity) and of death (mortality). These data are particularly difficult to obtain for marine mammals. Monitoring effort should be directed to collect long-term data series covering the various life stages of the selected species. This would involve the participation of several teams using standard methodologies and covering sites of particular importance for the key life stages of the target species.

4. Monitoring methods

4.1. Monitoring strategy

10. Due to the very critical status of the Mediterranean monk seal, any type of monitoring activity of the species should be conducted under the supervision of the national authorized legislative bodies.

11. The Mediterranean monk seals spent most of their time in the water, however, monitoring them in the aquatic environment is a challenging job and provide little information on the population. On the other hand, they marine caves while haul out to rest and breed and this period is the best option to collect data on the species. The most suitable method to monitor the Mediterranean monk seals in their cave is to use non-deterring camera traps in order to minimize disturbance while monitoring.

4.2. Time, Place and period

12. In general, monitoring should be performed all year round. However, if there is any restriction to due to season, location of cave, camera trap availability, the effort should be concentrated in monitoring only the breeding caves during the breeding season, which almost exclusively takes place between August to December in the Eastern Mediterranean Sea. There are, however, not enough scientific evidences to propose that the breeding of the Mediterranean monk seals is strictly seasonal and could therefore show a regional difference elsewhere.

4.3. Equipment

13. The following is the basic equipment needed for cave monitoring

- A boat preferably and inflatable one is essential to reach the seal habitats
- Camera trap with PIR-based motion detector
- Silicone sealant to be applied to the camera traps for extra protection against excess humidity
- Waterproof dry bag and container to carry the camera traps and other electronic equipment
- Flash memory card (16 GB or higher)
- Personal Free diving equipment (ABC equipment)
- Underwater torch
- Hand hold GPS to record the position of the caves
- Photo-trap cave-wall mounter (preferably made of chromium, custom-built)
- Protective equipment as required (such as (life vest, helmet, etc.)

14. For land-based surveys a photo camera with telephoto-lens (200-400 mm) high magnification binocular may also be used

4.4. Maintenance of Equipment

15. The most important equipment of monk seal surveys is camera trap. It is not waterproof but is weather resistant. As camera-traps are deployed for long times in a cave environment that is extremely humid, additional protection should be applied such as sealing the joints of the body with silicon sealant. Placing a small umbrella like protection may be considered to prevent equipment from dripping water. Batteries of GPS and underwater torches are checked before every survey. Setup of camera-traps should also be set considering the status of the environment in which the camera traps are to be deployed. Metal (containing) equipment should be lubricated against corrosion after every use. After the camera trap recovery, memory cards and batteries should be removed from the traps and are cleaned to remove sea salt.

4.5. Monitoring methods

4.5.1. Primary monitoring methods

4.5.1.1. Cave survey and monitoring

16. As mentioned before, the best monitoring method of the Mediterranean monk seals is to observe them in their haul out habitats (i.e. marine caves). Within this scope, cave surveys should be conducted to identify caves that are suitable for monk seal use. Then, the caves that are actively used by monk seals are monitored by camera-traps in order to minimize disturbance while monitoring the population.

4.5.1.2. Surveys to explore resting/breeding habitats

i. In areas not surveyed before

17. Surveys should be conducted in areas not investigated before to explore caves which meet the requirements and descriptions of a Mediterranean monk seal cave (IUCN/UNEP, 1998). Active surveys should be carried out on coasts where the geography is suitable for cave formation. For that respect, karst steep topographies are of great importance. The surveys should be done using a boat manned preferably by four people; two swimming along the coast of interest in search of caves; one recording the data and one steering the boat. The monk seal cave might may have underwater entrance with very narrow passage and a long corridor, so it is not always easily recognizable from surface. The large and narrow openings, crevices and holes between the rocks should therefore be checked carefully. When an entrance is found, a team member should enter the cave with necessary precautions taken in order not to disturb the animals. Caves with underwater entrances should always be investigated by free diving. Noisy equipment, such as scuba diving equipment are not recommended for cave investigations as the disturbance created by the bubbles can deter the seals. If the entrance of a cave is too long to be enter on apnea, SCUBA equipment may be used only for exploration.

ii. In areas surveyed before

18. If the area has already been surveyed before and an available information about the marine caves are available to identify the caves to monitor, the procedures explained in the section above can be neglected. However, in any case, surveys are recommended to cover the whole area at least once as Mediterranean monk seals can also use protected and deep crevices for resting.

4.5.1.2.1. Cave Inventory

19. Information of newly explored caves should be recorded in both a field survey (Annex 1) and a cave inventory protocol sheets (Annex 2). The cave inventory protocol includes the coordinates of the cave and various characteristics of the cave related to the Mediterranean monk seal monitoring including number of entrances, resting platforms, air chambers, its photograph, total length, its sketch where possible etc. Each cave should also be classified according to the categories described by Gucu et al. (2004).

4.5.1.2.2. Selection of caves for monitoring

20. The height of the ceiling and width of the inner space of actively used caves are taken into consideration to evaluate the risk that the camera could be exposed to strong waves while selecting a cave for monitoring. In order to prevent loss of camera-traps, the caves that has ceiling lower than the maximum wave height are not used for monitoring. Combination of various factors such as the season, accessibility, cave type (potential, active or breeding) and cave characteristics, number of available camera traps is effective of selection of caves for monitoring. However, if year-round monitoring is not possible, then emphasis should be given to the breeding caves during the breeding season, as fecundity is utmost important population parameter to be monitored.

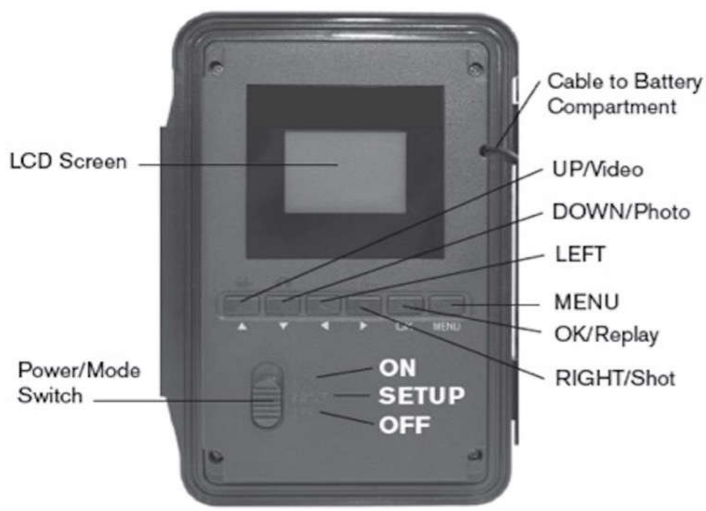
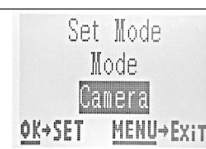
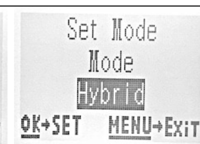
4.5.1.2.3. Camera trap set up, deployment, and recovery

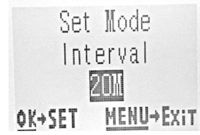
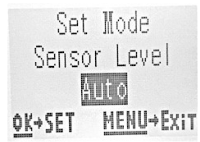
21. Commercially available camera traps have photograph, video and hybrid modes. The hybrid mode allows both still photos and videos to be captured at each trigger so may be good for data collection on behaviour. Camera image size should be in the highest resolution as high-quality photographs are needed for the photo-identification analyses. The length of the video captures should be set considering the duration of deployment, battery life and the size of the memory card.

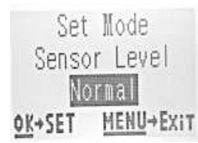
22. Data and time stamp of the camera-trap is crucially important for the data stored in the memory cards. The built-in clock should be set with care and stamp mode should be set on “ON”. Some camera-traps has built-in temperature and moon stamps, which may be useful to have more information about the in-cave seal behaviour.

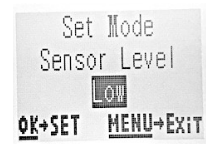
23. Most commercial camera-traps will take a photo (or record a video clip) automatically at your choice of time intervals to prevent the card from filling up with too many redundant images and to prolong battery life. The interval between two consecutive activations may be set at 20 minutes and longer in order to minimize disturbance (Gucu 2009). Sensor setting is set to auto or to normal/medium if the auto option is not available as in the case of some models. If the other fauna (bats, rats, etc.) is observed in the cave, a low sensitivity of sensor settings may be used to avoid unnecessary activation of the camera trap by this fauna (Table 1).

Table 1. The basic camera set-up for monk seal cave survey/monitoring

Basic camera trap set-up for monk seal cave survey/monitoring	
Front view	**Back view**
	
Settings	**LCD screen view**
Camara Mode	 
Camera image size	
Video length if hybrid mode is set	

<table>
<tr><td>Event interval</td><td>
</td></tr>
<tr><td>Sensor level</td><td>



or

</td></tr>
</table>

24. Location of the camera-traps is determined in order to get appropriate photos that cover the right location where the animal hauls out most of its time in the cave. The number of traps used in a cave changes based on size and morphology of the cave. The caves with wide inner space where the haul out platforms are larger than the camera view angle is monitored with sufficient number of camera traps.

25. Photo-trap cave wall mounter is placed to the suitable location by nailing its legs. When the suitability of location is assured, it is permanently fixed by covering the legs with white cement. After drying of cement, camera trap is fixed to the mobile arm of the wall mounter by using screws. At last, tilt angle of the trap is checked, the paper cover over the PIR sensor is removed and the trap get activated. The camera trap is strengthened with plastic cable ties.

26. Depending on combination of various factors such as the season, accessibility, cave type (potential, active or breeding) and cave characteristics, camera traps are left in caves for one to the maximum of three months. During recovery, camera trap used is usually replaced with a new one, as the camera trap used is usually worn out due to the conditions in the cave. However, the flash card is replaced only if there is no spare camera-trap available and previous one is going to be kept in the cave for the next survey.

4.5.2. Secondary monitoring methods

27. The methods below are used in the Mediterranean monk seal monitoring, but the output is usually very limited. So, these methods are considered as complementary to the primary monitoring methods.

4.5.2.1. Land based survey

28. Land based survey is conducted by a team of two observers during daytime at a high point on land where presence of the monk seal is confirmed or previously reported. During the observations, information is collected on date and start and end times of observation, name and coordinates of observation point, weather conditions (taken at hourly intervals or when it changes), time of seal sighting, seal morphology and behaviour. Photos/videos are taken when possible. Survey lasts over 1 hour and is stopped if a seal does not appear after 2 hours of observation or, when the sighted seal disappeared from sight. As well as during cave surveys and monitoring, weather conditions (sea state, wind force and direction, and visibility) are also factors limiting the land-based surveys.

4.5.2.2. Opportunistic monitoring

i. Dedicated observers on opportunistic platform (i.e oceanographic vessel)

29. Surveys are performed by dedicated observers during daytime while the vessel is in transit. An observer is placed on the bridge of the research vessel, searches for the presence of the

monk seal using both naked eye and binoculars. During the observations, information is collected on date and start and end times and coordinates of observation, weather conditions (taken at hourly intervals or when it changes), time of seal sighting, number of seals, morphology and behaviour. Photos/videos are taken when possible. These observations are carried out when the research vessel is cruising at speeds not greater than 12 knots and weather conditions are relatively fair.

ii. Stranding

30. Information on stranded animal is recorded including the ID number, observation date, stranding location, latitude and longitude coordinates, length and weight of the animal (where possible to measure), age class, sex, stranding condition (live or dead), and other observational comments, including evidence of injury or human interaction. Photos/videos are taken where possible. Morphological features are mapped to a seal identification sheet. Data on stranding contributes the mortality rate estimations while evaluation demographic structure of the population.

4.5.3. Synthesis tables

Table 2. A synthesis table listing the different monitoring methods that can be used to monitor each common indicator.

Related to common indicators				
Monitoring methods	**CI 3** Species distributional range	**CI 4** Population abundance	**CI 5** Population demographic characteristics	**What to survey/monitor**
Surveys to explore resting/breeding habitats	x	x	x	• Seal presence/absence • Seal habitats • Seal habitat use • Basic demographic
Cave monitoring	x	x	x	• Basic demographic structure, parameters and trends • Seal habitat use • Seal behaviour Individual identification • Monitoring the habitats • Low cost • Can be used for public awareness
Land based surveys	0	0	x	• Seal presence/absence • Seal habitats • Seal habitat use • Behaviour
Dedicated observers on opportunistic platform (i.e. a research vessel)	x	x	x	• Seal presence/absence • Seal habitats
Stranding	x	x	x	• Input to basic demographic structure (specifically mortality rates)

Table 3. A synthesis table listing the different data analyses methods that can be used for each common indicator. X: the method is relevant ; 0: the method is not relevant

Data analyses methods/ Related to indicators	CI 3 Species distributional range	CI 4 Population abundance	CI 5 Population demographic characteristics
Photo-identification	x	x	x
Demographic analyses	0	x	x
Population Viability analyses	0	x	x
Mark-recapture analyses	0	x	0

Table 4. Synthesis table listing the equipment for the different research methods. X represents the equipment is used, 0 respresents the equipment that is not used

	Primary monitoring methods		Secondary monitoring methods		
Equipment	Surveys to explore resting/breeding habitats	Cave monitoring	Land based survey	Opportunistic monitoring (from a vessel)	Opportunistic monitoring (stranding)
Research vessel/ Inflatable boat	X	X	0	0	0
GPS	X	X	X	X	X
Photo/video camera	X	X	X	X	0
Underwater torch	X	X	0	0	0
Personal free diving equipment (mask, snorkel and fins) (ABC equipment)	X	X	0	0	0
Camera trap with PIR-based motion detector	X	X	0	0	0
Flash memory card	X	X	0	0	0
Photo-trap cave-wall mounter (chromium, custom-built)	X	X	0	0	0
Silicone sealant	X	X	0	0	0
Waterproof dry bag and container	X	X	0	0	0
Life vest	X	X	0	0	0

Various tools (such as plastic cable tie, nails, pliers)	X	X	0	0	0
Binoculars	0	0	X	X	0

Table 5. Synthesis table listing the equipment for the different monitoring methods.

Monitoring methodology	Advantage	Disadvantage
Surveys to explore resting/breeding habitats	▪ Updating/Identification of habitats ▪ Updating/recording of habitat use	▪ High cost and logistic challenges
Cave monitoring (with camera traps)	▪ Recording of basic demographic; structure, parameters and trends ▪ Recording of natural behaviour individual identification ▪ No/minimal disturbance ▪ Monitoring the habitats ▪ Low cost ▪ Can be used for public awareness	▪ Equipment is prone to water and damage ▪ Medium quality population estimates
Land based surveys	▪ Updating/Identification of habitats ▪ Updating/recording of habitat use ▪ Input to basic demographic structure ▪ Low cost and challenges	▪ Poor individual identification ▪ Low quality of population estimates
Dedicated observers on opportunistic platform (i.e. a research vessel)	▪ Updating/Identification of habitats ▪ Updating/recording of habitat use ▪ Input to basic demographic structure	▪ Poor individual identification ▪ Low quality of population estimates
Stranding	▪ Input to basic demographic structure (specifically mortality rates)	▪ Poor individual identification

5. Data analyses

5.1. Photo-Identification

31. Estimation of the population size of the Mediterranean Monk seals has a critical importance to assess status of the species. However, it is very challenging job considering their small numbers and isolated nature, therefore, methods used in cetacean studies such as tagging or observation from boats are not applicable for this species. Photo-ID on the other hand is another commonly used method on numerous species which is a practical alternative for monk seal studies.

32. The Mediterranean monk seal has distinguishable unique pelage patterns, scars, natural marks, that can be identified through high-resolution photographs and video footages taken by camera-traps. Pelage colour is not used to identify seals as it is dark and shiny when the seal just hauls out and gradually turns light grey as the animal get dried during resting. Obtained photographs are sorted by date and time to be able to identify seals photographed at the same time. Captured images are controlled and photographed seals are grouped regarding their sex and the morphological categories based on Samarach and Gonzalez (2000), Dendrinos et al. (1999), Ok (2006). The details of the morphological categories are given below in section 3.2.1. Morphological features mapped to a seal identification sheet (Annex 1). These sheets include dorsal, ventral, lateral drawings of the seals which can be full-filled manually. Finally, the sheets compiled in an identification catalogue that involves basic characteristics of the identified individuals such as sex, name, morphological stage, date of the first sight and habitat information.

5.2. Demographic structure

33. The demographic structure of the population is explored by using the approaches explained below.

5.2.1. Minimum estimated age

34. The minimum ages of the individuals are estimated according to the method given by Gucu et al (2004). Estimated minimum age in years; Aest= (P-D)/365+X where

D: Date of the first sight.

P: Days transpired since the first sighting

X: the age of the individuals at the first sighting.

35. In order to estimate minimum age of an individual in years, the age of the individuals at the first sighting (X) is estimated by choosing one of the morphological categories described in Table 6.

Table 6. Modified morphological categories of the Mediterranean monk seal (taken from Ok, 2006).

Stage	Characteristics of the category	Period (years)	Photo/illustration Photos taken from Dendrinos et al. 1999 Illustrations taken from Samaranch and Gonzales, 2000
1	skinny (pup-premolted; pms)	0.00-0.03	
2	fat (pup-premolted; pmf)	0.03-0.08	

3	pwm moulting (pup-preweaned; pwm)	0.08-0.14	
4	pup-preweaned (pw)	0.14-0.33	
5	youngster- weaned (y)	0.33-2.50	
6	subadult (sa)	2.50-6.00	
7	adult female young (afy)	6.00-7.00	
8	adult male young (amy)	7.00-8.00	
9	adult female elder (afe)	8.00-20.00	
10	adult male elder (ame)	9.00-20.00	
11	senesce female (sf)	20.00- -	Not available

5.2.2. Fecundity

36. Fecundity of the population is calculated using the formula formed by Akçakaya et al. (1999)

Ft = Pt+1/At

Ft: Fecundity at time t.

Pt+1: Number of pups born at time t+1.

At: Number of parents at time t.

5.2.3. Annual birth rate

37. Annual birth rate of the population is calculated according to Gazo et al. (1999)

ABRt = Pt/ AFt

ABRt = Annual birth rate at time t

Pt = Number of pups born at time t

AFt = Number of sexually mature females (categories starting from 7 in Table 2) at time t

5.2.4. Survival and Mortality rates

38. Number of individuals and deaths (mainly stranded animals) are recorded for each year and used to calculate the annual mortality rate and subtract from one to obtain overall survival rate to the next year. Following formula of Akçakaya et al. (1999) summarizes the calculation:

$S_t = 1 - (D_{t+1} / N_t)$

S_t: Survival of the individuals at time t.

N_t: Number of individuals at time t.

D_{t+1}: Number of deaths at time t+1.

5.3. Additional Advanced methods

5.3.1. Population Viability Analysis

39. Population viability analysis is used to explore current and future status of the Mediterranean monk seals including the threats faced by species, risk of their extinction or decline, and their chances for recovery, based on species-specific data as described by Akçakaya et al. (1999). Various types of population models can employ depending on the structure of the population. A stage-structured stochastic population model is used as its groups individuals in a population according to their age or morphological characteristics, allowing vital rates (survival and fecundity) by age or stage-class to be integrated in the model (Akçakaya 2000). Model results are summarized in terms of population trajectories and risks of decline within different time durations and different parameters.

5.3.2. Mark-recapture Analyses

40. Data derived from photo-Identification is exploited in mark-recapture analyses. In this approach, re-sighting events of seals with distinctive markings are used to study the movement patterns, site fidelity, and population size (Karlsson, Hiby, Lundberg, 2005). More specifically, the marking recapturing index (Lancia et al., 1994) is used considering 2-sample closed population model of Lincoln-Petersen (Lincoln 1930). The first step is to capture and mark a sample of individuals. Marking methods depend on the species. In monk seals, identified individuals are assumed as marked individuals. The assumption behind mark-recapture methods is that the proportion of individuals identified in first control recaptured in the following period represents the proportion of identified individuals in the population as a whole.

6. Quality control

41. All the survey protocols filled are cross-checked between at least two members of the survey team. Photographs taken by camera-traps are scored by different researchers taking into account various factors such as image resolution, level of distinctiveness, visibility of natural marks. In order to test the accuracy of the photo-identification, the same set of photographs are assessed by different researchers. Each national monitoring group has its own quality control protocols. Although especially photo-identification methods used are similar, the selection, scoring, and matching of

images are varied greatly amongst research groups. Therefore, it is recommended that a common protocol in quality control should be developed between the contracting parties.

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Annex 1: Field survey protocol

Date:			Time start:					Time Stop:
Team:				Survey type:				
Weather Conditions								
Wind speed:	Calm	Medium	Strong					
Cloudiness:	Bright	Partl	Cloud	Rainy				
Sea Condition								
Wave direction:								
Wave strength:	Cal	Mo	Ro	Sto	Sw			
Turbidity:	Clear	Blui	Green	Brow				
Tide	Up tide	Normal	Low tide					
The Coastal	From:	To:	**GPS file:**					
Caves Discovered								
Cave	L	L	Remark					
Other survey remarks								
Event	Time	**Lat**	**Lon**					

Annex 2: Cave inventory sheet

Cave code	**Cave name**	**Discovered by**
Cave Info		
Latitude	Longitude	Photo frame

Total length in meters (opening to far end)	

Number of seal (s) :	Sighting Code :	Odor :
Number of chambers	With air:	Without air:

Cave entrance information

Entrance #	Surface	Underw	Land	Depth	Height	Width	Direction

Platform information

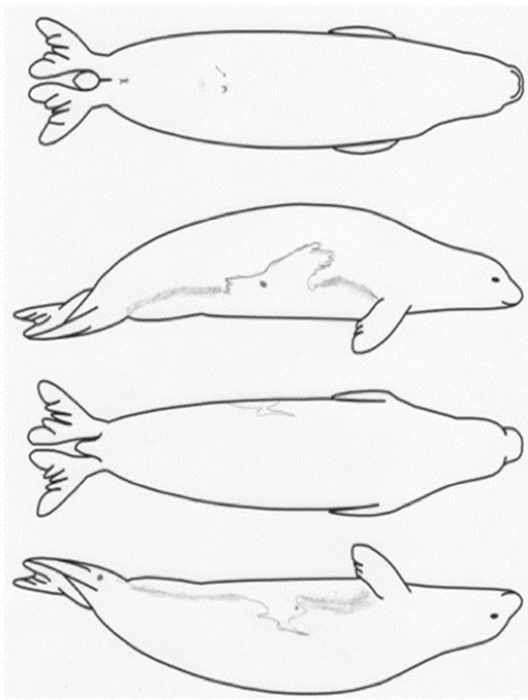
Platform	Positio	Length	Width	Texture	Suitabil	Feces	Fur	Track

Seal Evidence

Platform	Depression	Track	Fur	Feces	Other

Sketch of the cave

Annex 3: identification sheet



Code	: Y1
Sex	: Female (Youngster)
Sighted in	: Zafer Burnu
Cave(s) used	: Z1
Number of photos	: 20
Identification	: Ventral discoloration

C. Guidelines for monitoring sea birds in the Mediterranean

<u>Table of Contents</u>

Executive Summary

1. Conservation and wise use of marine ecosystems requires managing human activities. Sound scientific knowledge is needed to allow for adequate measures to be put in place. Monitoring and assessment of biological populations, and of the ecological conditions on which they depend, becomes essential to achieve the conservation objectives.

2. In the Mediterranean region, the UN Environment/MAP Barcelona Convention ***Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria*** **(IMAP)** defines the roadmap to deliver the implementation of the Ecosystem Approach Process (EcAp process), between 2016 and 2021, to assess the status of the Mediterranean Sea and coast, as a basis for further and/or strengthened measures.

3. In relation to seabirds, IMAP proposes to monitor and assess the following common indicators (CIs): **CI 3: Species distributional range** (EO1); **CI 4: Population abundance of selected species** (EO1); **CI 5: Population demographic characteristics** (EO1, e.g. body size, age class structure, sex ratio, fecundity rates, survival/mortality rates). IMAP recommends monitoring and assessing those common indicators for a selection of representative species, 11 in total, organised into 5 functional groups.

4. **Functional groups** aim to combine information on different species to illustrate the effect of common factors. Each functional group represents a predominant ecological role (e.g., offshore surface-feeding birds, demersal fish) within the species group. For the purpose of these guidelines, the most relevant functional groups are coastal top predators, inshore benthic feeders, offshore surface-feeders, inshore surface feeders and offshore (surface or pelagic) feeders.

5. It is recommended that competent authorities develop a **monitoring strategy**, detailing the species, data, methodology, sites and timeframe. It should also specify the uses of the collected data. Ideally, the monitoring strategy will be implemented through successive multi-annual work plans. It is advisable to keep things simple and aim for the long term; a few species monitored in a reasonable number of representative sites over many (20+) years is likely to provide more informative results than in the case of more ambitious approaches with a variable effort over shorter periods of time.

6. The choice of monitoring method will depend on the species and data being sought. Counting birds at colonies (**colony census**) is the single most effective way of obtaining numerical information on species abundance and population trends over time. The number of colonies, and their spatial distribution also provides information on species distribution range. Censuses should be carried out regularly every 5 – 10 years and must be done professionally to keep disturbance to a minimum.

7. Outside of the breeding colonies, **counting bird numbers** at particular sites where birds aggregate (for roosting, bathing, etc.) can provide a good indication of their abundance, especially if censuses are carried out simultaneously at several sites in a particular area. Birds' presence may be influenced by external factors, so good knowledge of local conditions and a large sample size can help improve accuracy of the estimates. Similarly, **shearwater rafts** at sea near the breeding sites can be used as a proxy for breeding numbers at those sites, but there is large variability in the size of those rafts, so they do not necessarily represent differences in population size at the site. This method can complement other techniques, but it is not recommended on its own to estimate bird abundance.

8. **Migration point counts** allow for the assessment of the total abundance of birds passing through narrow points at sea. This method can only be expected to provide reliable estimates at a few strategic points like the Strait of Gibraltar but may be less accurate elsewhere. Detectability can be an issue, but it could be improved using distance sampling methods. Counting birds at migration points does not allow to establish a link with national populations, so its use is limited.

9. **Ship-based surveys** in set transects at constant speed are a very effective method to monitor seabird distribution and abundance, particularly when the probability of detection is estimated at the same time using the method of distance sampling. Ideally, the surveying team should have free use of a vessel and control over its course of travel and speed. Seabird distribution can be heavily disrupted by the appearance and activity of the survey vessel; fishing boats are the least suitable for surveying, as they tend to attract a

large number of species. When surveying, it is recommended to record the activity of the own as well as other vessels, especially if they are fishing.

10. **Aerial surveys** are another effective method to study distribution and non-breeding abundance on a large scale but may not be a preferred method in the Mediterranean context. Plane time can be very expensive, and the distance and speed of the survey may limit the ability to detect or identify difficult species. It is important to record all events (e.g., presence of fishing boats) during the surveys. Distance sampling methods should be used to estimate density.

11. **Citizen science** (opportunistic observations) and **fishermen questionnaires** are supplementary methods to obtain additional information on seabird distribution. Effectiveness of these methods is limited; their value increases when boat-based observations are provided by regular collaborators and when the exact location (coordinates) is recorded.

12. **Capture–mark–recapture methods** are highly effective in providing robust estimates of demo-graphic variables, but they require adequate planning and long-term commitment (at least 5 years, ideally 10 or more), as well as highly specialised teams. This restricts the use of CMR methods to a relatively small number of sites and species. The team should also collect data *in situ* on the breeding biology of the species under study to allow for the development of population models.

13. **Tracking** methods are increasingly popular and may be extremely useful to unveil the movements and behaviour of a small number of individuals. However, those individuals may not be necessarily representative of the whole population, so sufficiently large sample sizes may be required. Tracking provides presence-only data at a medium to very high cost; their effectiveness to monitor bird abundance is limited, but they can help find/identify hotspots of seabird activity.

14. **Automated trail cameras** can be used to provide data on breeding success and on the causes of failure (e.g., predation). This method is very effective in obtaining information, and multiple cameras can be deployed at several colonies. There are associated costs in the cameras and in the number of human hours required to analyse the images or videos. The use of **drones** allows for the estimation of the total area occupied by the breeding colony, as well as total number and several estimations of density. Some preparation is needed before the start of the breeding season. Surveys should be stopped at the first evidence of disturbance/stress.

15. **Comprehensive censuses** should cover all (most) breeding sites and should be carried out regularly, every 5 to 10 years. More intensive work can only be carried out at a few sites at a time: selected sites should be representative of the range of ecological conditions available in the country or region. Also, care is needed when extrapolating to the whole area of results from a few sites.

16. Survey effort should be timed to coincide with the **peak of detectability** of each species. The biggest effort must be directed at continuing the **time series** of previous monitoring activities. Most statistical analysis methods can cope with one gap in the series, but few can manage two consecutive gaps (seasons) without data.

17. Use of the monitoring **data** should be defined in the monitoring strategy. Data collection should be straightforward and clear, and it should remain constant for as long as possible, for consistency in the time series. The types of statistical analyses should be clear from the beginning, and they should be shared with the team doing the field work to increase the quality of the data.

18. **Reporting** must follow the UN Environment/MAP Barcelona Convention integrated data and information system and should be based on the structure of the Common Indicator Fact Sheets. For EU Member States, the specific reporting scheme of article 12 of the Birds Directive requires them to provide data on the actual state and trends of bird populations, with the next report due in 2019.

1. Introduction

19. UN Sustainable Development Goal 14 “Life below water” urges to conserve and sustainably use the oceans, seas and marine resources for sustainable development. To achieve this goal, it is necessary to manage human activities and to promote the conservation and wise use of marine ecosystems. Monitoring and assessment, based on scientific knowledge, become indispensable tools in order to assess the status of any marine system and to put in place adequate measures.

20. The Ecosystem Approach (CBD 2000) integrates the management of human activities and their institutions with the knowledge of the functioning of ecosystems. It requires to identify and take action on influences that are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity (Farmer et al. 2012). To inform management planning adequately, it is especially important that assessment methods and management tools can incorporate new knowledge, new monitoring methods (to tackle the problem of covering large areas) and indicators into assessments, but still maintain comparability with previous assessments so that any change in the status can be measured and quantified (Borja et al. 2016).

2. Policy framework

21. In the context of the Mediterranean, the United Nations Environment Programme / Mediterranean Action Plan adopted in 2017 its Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria, IMAP (Decision IG.22/7). IMAP describes the strategy, themes, and products that the Contracting Parties of the Barcelona Convention are aiming to deliver over the second cycle of the implementation of the Ecosystem Approach Process (EcAp process), between 2016 and 2021, in order to assess the status of the Mediterranean Sea and coast, as a basis for further and/or strengthened measures.

22. In relation to seabirds, IMAP proposes to monitor and assess the following common indicators:

    Common Indicator 3: Species distributional range (EO1);

    Common Indicator 4: Population abundance of selected species (EO1);

    Common indicator 5: Population demographic characteristics (EO1, e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates)

23. IMAP recommends monitoring and assessing those common indicators for a selection of representative sites and species, which can showcase the relationship between environmental pressures and their main impacts on the marine environment. For seabirds, these are summarised in Table 1 below:

FUNCTIONAL GROUP	SPECIES	
coastal top predators	*Falco eleonorae*	Eleonora’s Falcon
	Pandion haliaetus	Osprey
intertidal benthic-feeders	*n.a.*	
inshore benthic feeders	*Phalacrocorax aristotelis desmarestii*	(Mediterranean) Shag
offshore surface-feeders	*Larus audouinii*	
inshore surface feeders	*Larus genei* *Thalasseus (= Sterna) bengalensis*	Slender-billed Gull

	Thalasseus (= Sterna) sandvicensis	Lesser Crested Tern Sandwich Tern
offshore (surface or pelagic) feeders	*Hydrobates pelagicus* *Calonectris diomedea* *Puffinus yelkouan* *Puffinus mauretanicus*	European Storm-petrel Scopoli's Shearwater Yelkouan Shearwater Balearic Shearwater

24. It is also recommended that the Contracting Parties include at least the monitoring of those species with at least two monitoring areas, one in a low-pressure area (e.g. marine protected area/ Specially Protected Area of Mediterranean Importance (SPAMI)) and one in a high-pressure area from human activity.
25. In the context of the European Union, Commission Decision (EU) 2017/848 [1] sets the criteria, methodological standards, specifications and standardised methods for monitoring and assessment of biological diversity. It establishes the need to define the criteria, including the criteria elements and, where appropriate, the threshold values, to be used for each of the qualitative descriptors of Good Environmental Status (GES). Threshold values are intended to contribute to the determination of a set of characteristics for GES and inform their assessment of the extent to which it is being achieved. It further establishes that monitoring and assessment should be based on the best available science. However, additional scientific and technical progress may still be required to support their further development and should be used as the knowledge and understanding become available.

3. Species aggregation – functional groups

26. The use of functional groups for monitoring and assessment purposes results from the work of the Joint ICES/OSPAR Working Group on Seabirds (JWGBIRD) (ICES 2015). Functional groups aim to combine information on different species in order to illustrate the effect of common factors. The rationale for this classification is that it is expected that natural and anthropogenic factors are likely to act similarly on species that share the same food types and display similar feeding behaviours and are those, subject to the same constraints on food availability. Several regional conventions for the protection of the marine environment have adopted the use of functional groups of species (e.g., OSPAR, HELCOM), and they also feature in the revised Commission Decision on the Marine Strategy Framework Directive (2017/848/EU).
27. IMAP defines functional groups as ecologically relevant sets of species, in particular (highly) mobile species groups, such as birds, reptiles, marine mammals, fish and cephalopods. Each functional group represents a predominant ecological role (e.g. offshore surface-feeding birds, demersal fish) within the species group. For the Mediterranean region, and for seabirds in particular, the most relevant functional groups are:

coastal top predators – birds of prey and other large predators at the top of the food chain in the coastal environment, so not necessarily true seabirds *stricto senso*. In an unperturbed environment, a typical representative would be the White-tailed Eagle (*Haliaetus albicilla*), a predator of seabirds, as well as mammals and fish that historically suffered from prosecution and has now become rare in the region. Two other birds of prey, Osprey (*Pandion haliaetus*) and Eleonora's Falcon (*Falco eleonorae*) typically

[1] 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 standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU

nest on sea cliffs. Although ecologically their niche may be broader, they are considered to belong to this group for monitoring and assessment purposes.

intertidal benthic-feeders – typically shorebirds (including Spoonbill *Platalea leucorodia*), ducks, geese, swans and gulls that mostly walk or wade while feeding. In the Mediterranean region, such birds generally associate with wetlands or saltpans, rather than being characteristically coastal or marine. IMAP does not identify any particular species as belonging to this functional group, so none will not be considered for these Guidelines.

inshore benthic feeders – birds that dive to the seabed to feed, generally on demersal fish. In the Mediterranean region, this group is best represented by the Mediterranean Shag (*Gulosus (=Phalacrocorax) aristotelis desmarestii*), an endemic form estimated to number only 10,000 individuals and showing a comparatively local distribution. Mediterranean Shags have historically suffered a succession of declines and recoveries and may be heavily affected by human pressure, both as a result of habitat occupation and of bycatch in fisheries.

offshore surface-feeders – birds (e.g., gulls) that feed in the top layer of the water column on the outer part of the continental shelf or in the open sea. The Mediterranean endemic Audouin's Gull (*Larus audouinii*) is the most characteristic species of this functional group in this region. The species was once rare but has seen a substantial recovery (especially in the western Mediterranean), as a consequence of the increased availability of fishing discards and of the protection of its nesting habitat.

inshore surface feeders – restricted as feeders to the surface layer of the water column and occurring mostly near the shore. In the Mediterranean region, this niche is occupied by the Slender-billed Gull (*Larus genei*), Lesser Crested Tern (*Thalasseus (= Sterna) bengalensis*) and Sandwich Tern (*Thalasseus (= Sterna) sandvicensis*). The former two, whilst not being endemic as species, have geographically and numerically significant populations in the Mediterranean. Their specialised association to low-lying coasts and shallow waters has traditionally made them vulnerable to habitat transformation.

offshore (surface or pelagic) feeders – open seas are typically the realm of seabirds that feed across a broad depth range in the water column (albatrosses, petrels, penguins). In the Mediterranean, they form a small group of endemic species that are extremely important for conservation: the Balearic Shearwater (*Puffinus mauretanicus*) and the Yelkouan Shearwater (*Puffinus yelkouan*) are both globally threatened. Together with Scopoli's Shearwater (*Calonectris diomedea*), which is also endemic, they fall frequent victims to bycatch in longline fisheries and are also threatened on land by introduced predators in their breeding colonies. The European Storm-Petrel (*Hydrobates pelagicus*) is the sole representative in our region of the cosmopolitan group of storm-petrels; these are small but long-lived and truly oceanic seabirds that feed on plankton and act as effective indicators of the general state of the marine environment.

4. Monitoring strategy

28. For effective use of limited resources, it is crucial that competent authorities develop a monitoring strategy, which can provide detail on important aspects such as species, sites, methods and timing and regularity. It is also important to decide on the uses of the collected data. Ideally, the strategy will be implemented through successive multiannual work plans that will integrate pre- and post-field work, as well as the development of the monitoring activities that need to be undertaken.
29. Based on the species composition, area and available resources, a monitoring strategy should cover the following aspects:

a) **Species** – as a minimum, the representative species of each functional group (Table 1) should be monitored on a regular basis, if present in the country. It is possible to add more species to the mix, but such a decision must take into account that effective monitoring requires a long-term commitment, which may be difficult to meet for prolonged periods of time. Also, the decision to monitor additional species should not put at risk the monitoring of the standard species set, as these benefit from the fact that they are being monitored on a wider scale (e.g., whole Mediterranean region), which adds value to the data obtained at national or local scale.

b) **Data** – the nature of the data to be collected varies with the common indicator and is specified in the Common Indicator factsheets. A monitoring strategy should consider possible data in the form of numerical values of distribution (total area occupied, number of squares, maps), abundance (number of birds present, number of apparently occupied nests, etc.; relative density), breeding productivity (young fledged per egg laid, young fledged per breeding attempt) and general demography (annual survival rate, juvenile recruitment rate, age class ratio). Wherever possible, it is recommended to collect supplementary data on environmental pressures that may be biologically relevant, as already in practice in some countries. Such data may include colony surveys for evidence of predation or evidence of anthropogenic waste (e.g., plastics) in seabird nests, as well as blood and/or feather sampling for evidence of contaminants in adult birds or their young.

c) **Methodology** – an assessment of population size can be obtained either by counting the total number of individuals at a given time or by counting numbers at selected periods of sampling, and then calculating the total number through extrapolation. The latter method (i.e., sampling + calculating) is by far the commonest, but it requires an appropriate design of the sampling periods / sites, plus the use of robust statistical methods for the calculation. A monitoring strategy should be specific about the sampling methods, the monitoring techniques and the calculation procedures. It should also describe how different methods should interact, e.g. by calculating an annual population trend value (through stratified and representative sampling) and combining with a comprehensive, large-scale census every 5 or 10 years.

d) **Sites** – the monitoring strategy shall define the spatial dimension of its sampling effort. Whole-area censuses can only be carried every number of years (usually, between 5 and 10), whereas the annual effort of obtaining data on population trends or on breeding performance will have to be limited to a smaller sample of representative sites. Even within single (large) colonies, it is often necessary to obtain detailed data from a randomised selection of squares. The number and location of colonies monitored will influence the results [2], so it is important that the strategy considers the representativeness of each site in relation to the general context. It is generally recommended to treat the data with robust statistical methods that bear in mind the relative weight of each site in the wider context of the entire population.

e) **Timeframe** – the timing and repeatability of monitoring activities will vary according to species and area. In general, the monitoring strategy should aim at obtaining data *ad infinitum*, or at least for as long as

[2] Tobler's first law of Geography (spatial autocorrelation) applies: "Everything is related to everything else, but near things are more related than distant things" (Tobler 1970).

threatened species or sites remain in that status. For that reason, the strategy should aim at obtaining the most valuable data (e.g., overall productivity with preference over first egg laying date), and the multiannual work plan should guarantee that the necessary monitoring takes place at least once every year. For effective monitoring, the strategy should also take into account the issue of seasonality and propose the ideal timing for each sampling to take place. Ideally, the work plan should seek to optimise and combine samplings for different species, wherever possible, to maximise the outcome.

30. In general, it is advisable to keep things simple and aim for the long term; a few species monitored in a reasonable number of representative sites over 20+ years is likely to provide results that are far more informative than in the case of more ambitious approaches with a variable effort over shorter periods of time.

5. Monitoring methods

31. The choice of monitoring method will depend on the species and data being sought. For seabirds in the Mediterranean region, the following methods may be considered:

Colony census

- All seabirds invariably need to visit land in order to nest, and most breed colonially. Counting birds are colonies is the single most effective way of obtaining numerical information on their abundance (Common Indicator 4), and thus of their population trends over time. The number of colonies, and their spatial distribution also provides information on species distribution range (Common Indicator 3).

- In medium (250-1000 breeding pairs) to large colonies (> 1000 b.p.), it will be difficult to accurately assess the exact number of birds present. In these cases, it is recommended to record and plot the entire area of the colony (e.g., by using drones, see below), and to monitor the spatial evolution of the colony over time.

- For very large colonies (e.g., > 5000 b.p.), it is recommended to define smaller squares (e.g., 20 x 20 m, 50 x 50 m, 100 x 100 m or larger, depending on the species and the geography of the site) and to count every single nest inside the square, to obtain a measure of density. By repeating the same procedure on a number of squares, it is possible to obtain a measure of the average density, as well as its standard deviation. Such values can be used to calculate the total population of the colony, by multiplying the total number of squares by the average density ± standard deviation.

- For burrow-nesting species (storm-petrels, shearwaters), it is good practice to estimate the average number of nests per burrow, as a single burrow or cave may contain several breeding pairs or nests.

Land-based roost (aggregation) counts

- Several species, particularly of gulls, terns and cormorants (shags), aggregate at predictable sites after feeding or for roosting, bathing, etc. Assessing bird numbers at those sites can provide a good indication of their abundance (Common Indicator 4), especially if censuses are carried out simultaneously at all sites where birds aggregate in a particular area. This method is not without its drawbacks, as bird presence may be influenced by external factors such as weather, season, day of the week, etc., so good knowledge of local conditions and a large sample size can help improve accuracy of the estimates.

- Similarly, the well-known tendency of some seabirds, particularly shearwaters, to form rafts at sea near the breeding sites can be used as a proxy for breeding numbers at those sites. It is also known, however, that there is large variability in the size of those rafts, due to weather, time of year and local characteristics of each colony, so they do not necessarily represent differences in population size at the site. Given the number of potential biases (disturbance, time of day, weather conditions), this method should only be considered as supplementary to other monitoring methods, because it may not be indicative of abundance. The rafting behaviour at well-known breeding areas, though, may be useful to inform the management of marine extensions to breeding colonies, in terms of phenology, spatial extension, etc.

Migration point counts

- As birds travel between different areas (e.g., during migration), geography may force them to funnel through certain narrow points, where they become easier to detect and to count. One such place in the Mediterranean region is the Strait of Gibraltar, the only connection between the Mediterranean Sea and the Atlantic Ocean and a necessary gateway for all species whose populations move between the two. A small number of similar places exist in the region (e.g., Bosphorus, Dardanelles, northern Tunisia, strait of Otranto) but their accuracy in tracking bird numbers is probably less reliable. Bird abundance passing on migration near such places can be used as a proxy for their total abundance (Common Indicator 4). However, issues of detectability (only a proportion of all birds passing near the watchpoints can be seen from land) and representativeness (the breeding sites of passing birds cannot be known) make this method not entirely suitable for monitoring seabirds in the Mediterranean. Combined analyses of all watchpoints on a regular (annual) basis, and a long time series, may be able to reflect real population changes.

Ship-based surveys

- Systematic surveying of marine areas in search of seabirds has historically produced good results in the detection of hotspots of activity, generally associated to foraging behaviour. Observations of seabirds in set transects at constant speed are particularly useful if the probability of detection is estimated at the same time using the method of distance sampling (Buckland et al. 2001). This method allows for the estimation of the density of each species per transect (or per fraction of transect). Multiple estimations of density can be combined and averaged for each unit of space (e.g., 10 x 10 km or 1° x 1° cells), so they can be mapped and analysed spatially. This provides useful values of bird distribution (Common Indicator 3) and abundance (Common Indicator 4).

- This well-known method requires free use of a vessel that can offer good visibility, ideally with vantage points as used for cetacean surveys; line ferries are used in several places with positive results, but their inability to change course limits their effectiveness for seabird monitoring. Seabird distribution can be heavily altered by the appearance and activity of the survey vessel; fishing boats are the least suitable for this purpose, as they tend to attract a large number of species. When surveying, it is recommended to record the activity of the own as well as other vessels, especially if they are fishing.

- To make the data comparable inter-annually, it is important that surveys are carried out at the same time each year, and with efforts that are comparable. In addition, this monitoring must be coupled with measurements of environmental variables, particularly of the water mass (temperature, chlorophyll, etc.), to make it possible to link the inter-annual variability of observations to environmental conditions.

Aerial surveys

- Similar to ship-based surveys but on another scale, aerial surveys are used to collect distribution and abundance data on seabirds, particularly of species with high detectability (e.g., gannets Morus sp.) or low mobility (e.g., auks Alcidae). Using distance sampling methods, aerial surveys can provide abundance data over large sections of the ocean and are thus quite effective, albeit expensive. However, in the Mediterranean region and for our set of species, aerial surveying is arguably not the most suitable method. Detectability can be potentially quite low (e.g., of storm-petrels, shearwaters) and identification at species level may be very difficult, almost impossible in some cases (e.g. Balearic vs. Yelkouan Shearwater, or Sandwich vs. Lesser Crested Tern). For difficult species, the use of HD cameras for photo ID will undoubtedly improve identification (as successfully tested in e.g., France).

- As with other surveys, it is important during aerial transects to collect data on environmental variables to enable habitat modelling and testing of hypotheses.

Citizen science (bird portals, logbooks, opportunistic observations)

- Opportunistic observations of seabirds collected non-systematically by amateur ornithologists, seafarers or the general public can provide additional information on bird distribution (Common Indicator 3). Such data can rarely be used to estimate densities, and therefore abundance, because they generally lack essential information on the space covered (transect) or the observation effort (time). Their value lies in their ability to provide information on spatial distribution and is particularly useful in detecting change in the distribution of rapidly expanding species.

Questionnaires (fishermen, seafarers)

- Through the use of questionnaires, it is possible to obtain useful information from fishermen or professional seafarers. The value of this information is generally qualitative and not quantitative, so it is most useful when it involves data on seabird distribution (Common Indicator 3), particularly on the location of nesting sites / colonies. Occasionally, the collaboration of fishermen can provide additional info on breeding phenology or success, although the burden of the collection of demographic data must remain with objective methods such as colony counts by experienced staff possibly with the assistance of cameras near nests.

Capture – Mark – Recapture

- Capture – mark – recapture (CMR) methods provide robust estimates of demographic variables such as individual survival, recruitment and emigration (Amstrup, McDonald & Manly 2005). They require adequate planning and long-term commitment, because seabirds are generally long-lived. For this activity, highly specialised teams are required that can capture and ring a sufficiently large number of birds over a long sequence of years (at least 5 years, ideally 10 or more), and who can analyse the data using specific software (Program MARK: White & Burnham 1999). This restricts the use of CMR methods to a relatively small number of sites and species.

- In most cases, the same team of professional biologists collect data in situ on the breeding biology of the species under study (e.g., no. of eggs laid, hatching success, chick survival, breeding success) that add to the information on demography and are essential for the development of population models. Also, by taking additional data during the same fieldwork, e.g., samples of feathers/blood to monitor contamination by pollutants, it is possible to test hypotheses and develop population models that will contribute to our understanding of variations of the "Common Indicator 5 (demography)".

Use of tracking methods (VHF, GPS, PTT) to locate important sites

- With the development of tracking technologies, the movements and behaviour of many individuals of several seabird species have been unveiled. In the Mediterranean region, the most intensively studied species with this method are Scopoli's and Yelkouan Shearwaters, Audouin's Gull, Eleonora's Falcon and Osprey. Tracking only provides information about the unique movements of tagged individuals, so a large sample size may be needed to extrapolate those movements to the rest of the population. Despite the limitations, tracking data can be particularly useful in assessing the distribution of birds in a population or in finding their breeding sites (e.g., the discovery of new colonies) (Common Indicator 3). On the negative side, this method is expensive and can only provide presence-only data from a fraction of the population.

- Tracking data can be analysed against environmental variables, either collected in the field or from remote sensing, for functional habitat modelling or testing of hypotheses.

Trail cameras

- Automated trail cameras can be situated strategically at nesting sites to obtain timed data about breeding biology and behaviour with limited disturbance. Importantly, trail cameras can also provide data on breeding success and on the causes of failure (e.g., predation), so they can provide very useful additional data to inform and test data from Common Indicator 5 (demography), as described previously. This method is very effective in obtaining information, and multiple cameras can be deployed at several colonies. However, there are associated costs in the cameras themselves and in the number of human hours required to go through the recorded images or videos.

Drones

- The use of drones to assess breeding numbers at a given site is increasingly popular and constantly being developed. This method allows for the estimation of the total area occupied by the breeding colony (Common Indicator 4), as well as total number and several estimations of density if the necessary arrangements have been put in place before the birds settle to start breeding (see Sardà-Palomera et al. 2017). For asynchronous species (e.g., Eleonora's Falcon) it may useful to survey the colony several times in order to obtain data from all phases of the breeding cycle and count in all nesting attempts.

6. Territorial coverage

32. A monitoring strategy should recommend the spatial scale of the monitoring effort – should all areas be monitored all the time? Or, given limited resources, is it better to concentrate on a few sites and extrapolate to the whole? The answers to these questions depend on the geographical characteristics, and on the species being monitored. In general, it is advisable to carry out regular censuses that cover all (most) breeding sites and attempt to count all the birds; such censuses should be carried out regularly, every 5 to 10 years.
33. For more intensive work, such as a capture–mark–recapture scheme, or monitoring with trail cameras or drones, work can only be carried out at only a few sites at a time. In the selection of those sites, it is important to follow two criteria: (i) the sites should be representative of the range of ecological conditions available in the country or region, so that good sites as well as not-so-good sites are included; and (ii) extrapolation to the whole area of results from a few sites must be done with care because that the country is likely to be ecologically diverse.

7. Sampling design and representativeness

34. To obtain precise estimates, it is necessary to plan the sampling effort adequately. This is particularly important when the whole area cannot be surveyed and only a selection of squares (cells) can be visited to obtain data. Survey effort should cover a sufficient number of cells that (a) represents the entire spectrum of ecological conditions, and (b) is statistically robust to allow for analysis of the data. The same strategy applies to the local scale, in choosing the number of squares to count nests in a large breeding colony, or on a large scale, in surveying marine areas using transects.
35. Sampling should take place over enough cells, and preferably in the same cells or transects, every time. Through this spatial consistency, a data log of bird counts at each spatial unit will develop over time that will allow for further analysis in the future, if conditions change.

8. Timing and regularity – the importance of long-time series

36. Survey effort should be timed to coincide with the peak of detectability of each species, for optimal results. Peaks of breeding activity vary seasonally and often during the course of the day for all species, and a monitoring strategy should account for that variability whilst trying to integrate different monitoring activities into a single work plan. In any case, it is important to record all relevant details (day of week, time of day, activity of fishing vessels, disturbance events, etc.) when carrying out the surveys, so that they can be taken into account during the analysis of the data.

37. The value of monitoring becomes increasingly important as the time series becomes longer, because the ability to detect change also increases. Therefore, the biggest effort must be directed at continuing the time series of previous monitoring activities, which must remain unaltered with the same methods and in the same places unless there is good reason to change.

38. Most statistical analysis methods can cope with one gap in the series (generally equivalent to one season without monitoring), but few can manage two consecutive gaps (seasons) without data. Time series interrupted in this way are generally irreparable and end at that point.

9. Data management, analysis and control

39. Use of the monitoring data should be defined in the monitoring strategy. This aspect should be integrated in the design of all monitoring activities, and it should be taken into account when they are carried out. Data collection should be straightforward and clear, and it should remain constant for as long as possible, for consistency in the time series. Ideally, a data analyst should form an integral part of the monitoring team, and they should be able to inform survey design. This strategy will improve the overall efficiency of the team.
40. The types of statistical analyses should be clear from the beginning, and they should be shared with the team doing the field work. With an increased understanding of the whole process, individual observers will put more attention into collecting additional or supplementary data about the conditions at the time of conducting their activity; this will increase the quality of the data.

10. Reporting

41. As part of IMAP's integrated assessment, Contracting Parties to the Barcelona Convention are required to report on the quality and status of the marine environment under their jurisdiction. Reporting must follow the UN Environment/MAP Barcelona Convention integrated data and information system and should be based on the structure of the Common Indicator Fact Sheets. IMAP encourages Contracting Parties to use up-to-date tools for data exchange.
42. In the context of the European Union, article 12 of the Birds Directive 2009/147/EC (EU 2009) requires that EU Member States report on the implementation of the national provisions taken under this Directive. This includes providing data on the actual state and trends of bird populations, and must be done every six years, starting in 2013, so the next report is due in 2019. The Birds Directive applies to all species of naturally occurring birds in the wild state in the European territory of the Member States, and a detailed report has to be completed for all regularly occurring species in the relevant seasons, including breeding, wintering and passage.

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Annex I Comparative table.: Characteristics of monitoring techniques

Monitoring technique	Suitable species	Common Indicator(s)	Personnel requirements	Equipment	Recommendation
Colony census	all	4 – abundance (3 – distribution range)	trained staff/volunteers; at least one team (2-3 people) per colony; ideally several teams working simultaneously in several colonies; coordination	boat to access islands or difficult places; binoculars; camera / drone	▪ single most effective technique; ▪ should be carried out regularly every 5 – 10 yrs; ▪ must be done professionally to keep disturbance to minimum
Land-based roost (aggregation) counts	*Puffinus* (rafts) *Calonectris* (rafts) *Phalacrocorax* *Larus* *Sterna*	4 – abundance	single trained observer or, preferably one team (2-3 people) per site; ideally, several teams working simultaneously in several sites; coordination	binoculars / telescope; access to viewing points	▪ no substitute for colony census (especially true for shearwater rafts) ▪ suitable for non-breeding species ▪ weather, season and local conditions may affect numbers ▪ should be repeated regularly
Migration point counts	*Puffinus* *Calonectris* *Larus* *Sterna*	4 – abundance	trained observers; at least one team (2-3 people) per watchpoint; ideally several teams placed strategically to maximise cover	binoculars / telescope; access to viewing points	▪ reliable estimates only expected at few places like Strait of Gibraltar, Bosphorus, etc. ▪ no link to breeding (national) populations

					▪ partial detectability; could be improved by using distance sampling
Ship-based surveys	all	3 – distribution range 4 – abundance if additional data taken	1-3 trained observers to cover 180° view; binoculars	vessel with good visibility (e.g. for watching cetaceans); control over vessel course/speed of travel; binoculars	▪ very effective method to study distribution and non-breeding abundance ▪ vessel time very expensive, so less optimal solutions often used ▪ ability to fix course/speed of travel needed for density estimation ▪ fishing boats change bird distribution and behaviour and should be avoided ▪ important to record all events (e.g., presence of fishing boats) during survey ▪ important to collect data on environmental variables, especially of the water mass (temperature, salinity, chlorophyll, etc.).
Aerial surveys	most species	3 – distribution range 4 – abundance	1-2 trained observers to cover 180° view; binoculars	low-speed aeroplane with good visibility; control over plane course/speed of travel; binoculars	▪ effective method to study distribution and non-breeding abundance on large scale ▪ plane time very expensive

					▪ ability to fix course/speed of travel needed for density estimation ▪ distance/speed limits ability to identify difficult species ▪ important to record all events (e.g., presence of fishing boats) as well as environmental data during survey
Citizen science (bird portals, logbooks, opportunistic observations)	all	3 – distribution range	volunteers with varying degrees of training		▪ low effectiveness; only supplementary info expected ▪ most valuable data from boat-based observations ▪ important to record exact location (coordinates)
Questionnaires (fishermen, seafarers)	all	3 – distribution range (5 – demography)	volunteering professionals; interviewing staff		▪ limited effectiveness ▪ value increased when collaboration becomes well established over time
Capture – Mark – Recapture	all	5 – demography (4 – abundance)	professional team (2-3 people) with ringing licence; data analyst	ringing equipment; access to colonies	▪ very effective method to obtain demographic data ▪ monitoring must be maintained for >5 yrs ▪ work at breeding colonies should can be combined with collection of data on breeding biology for

					comprehensive demographic analyses ▪ during fieldwork, important to collect additional data (e.g., blood/feather samples) for analysis of environmental factors
Tracking methods (VHF, GPS, PTT) to locate important sites	all	3 – distribution	professional team (2-3 people) with ringing licence; data analyst	tagging devices; ringing equipment; access to colonies	▪ extremely useful method to unveil individual movements / behaviour ▪ not necessarily representative of whole population, so large sample size required ▪ presence-only data ▪ medium to very high cost
Trail cameras	all	5 – demography	small professional team (1-2 people); image/video analyst	trail cameras (several); access to site	▪ can be used to provide data on breeding success and causes of failure (e.g., predation) ▪ effective and relatively low cost, but require long man hours of lab work analysing images/footage ▪ useful as supplementary method ▪ low disturbance
Drones	all	3 – distribution 4 – abundance if additional data taken	small team (1-3 people) with licence to fly drone;	flying drone; HD camera	▪ very useful to assess total area of breeding colony (for estimation of density)

			image/video analyst		▪ some preparation before breeding season essential ▪ survey should be stopped at first evidence of disturbance/stress

D. Guidelines for monitoring marine turtles in the Mediterranean

Contents

ACRONYMS AND ABBREVIATIONS

ASM	Age at Sexual Maturity
CCL	Curved Carapace Length
CF	Clutch Frequency
CI	Confidence Intervals
CMR	Capture-Mark-Recapture
CS	Clutch Size
DE	Number of dead embryos
EES	Number of empty egg shells
ES	Emergence Success
GI tract	Gastro Intestinal Tract
GPS	Global Positioning System
IP	Incubation Period
IUCN	International Union of Conservation of Nature
PE	Number of predated eggs
PIT	Passive Integrated Transponders
RMI	Remigration intervals
RMU	Regional Management Units
RNI	Re-nesting (inter-nesting) intervals
SCL	Straight Carapace Length
SSF	Small-Scale Fleets
TED	Turtle Excluder Device
UAV	Unmanned Aerial Vehicle
UE	Number of unfertilized eggs

1. INTRODUCTION

1. Two species of sea turtle – the loggerhead turtle and the green turtle – regularly occur and breed in the Mediterranean Sea. The breeding activities of both species are regularly monitored in the main nesting areas of ten countries; namely, Cyprus, Egypt, Greece, Israel, Italy, Lebanon, the Libyan Arab Jamahiriya, the Syrian Arab Republic, Turkey and Tunisia. The species' distributional range, population abundance and demographic characteristics are generally estimated according to nest counts in those above countries. A recent approach has been to divide all species of sea turtle into Regional Management Units (RMU; Wallace et al. 2010), identifying Mediterranean RMUs for loggerhead turtles (RMU:11) and green turtles (RMU:17).

2. Sea turtles are a long-lived species; they can take more than two decades to reach maturity. They also use different habitats at different age classes. Post-hatchlings mainly use pelagic habitats as developmental areas and remain offshore until they reach large juvenile size (<40cm Curved Carapace Length (CCL). However, once their CCL exceeds 30 cm, they start to shift their developmental areas to neritic habitats. The monitoring of sea turtles must therefore be conducted not only on beaches but also in the water, as they migrate between feeding grounds and spend the winter months.

3. The monitoring of sea turtles is mostly performed using these techniques: **(i) counting the number of nests during nesting period, (ii) collecting stranded turtles, (iii) in-water capture-mark-recapture studies, and (iv) boat and aerial surveys.**

4. Nesting female sea turtles and their clutches in particular, have been used as indicators of population size and trends (Bjorndal et al., 1999; Broderick et al., 2002; Margaritoulis, 2005; Türkozan & Yilmaz, 2008). Nesting activity has the potential to address two indications that specifically relate to the Barcelona Convention Decision on Common Indicators (IG.22/3), namely:

- Common indicator 4 (CI4): Population abundance of selected species
- Common indicator 5 (CI5): Population demographic characteristics

5. Sea turtles inhabit the shallow waters along coasts and around islands, but most are highly migratory, particularly as juveniles, and are found in the open sea. After the nesting season, species in temperate areas migrate to warmer waters, to avoid cold temperatures. In addition, only female turtles are observed on the nesting beaches; males and juveniles never come ashore (Heppell et al., 2003). Consequently, determining empirical estimates for the number of juveniles is extremely challenging.

6. For instance, boat surveys and aerial surveys can be used to estimate the number of turtles on the surface as Visual Counting Surveys and then the total number can be extrapolated. These techniques give an indication in accordance with the Barcelona Convention Decision (IG.22/3), in particular:

- Common indicator 3 (CI3): Species distributional range

7. These monitoring activities can be classified as: 1- Monitoring carried out on beaches; 2- Monitoring carried out at sea and 3- Monitoring that takes place in rehabilitation centres and/or labs.

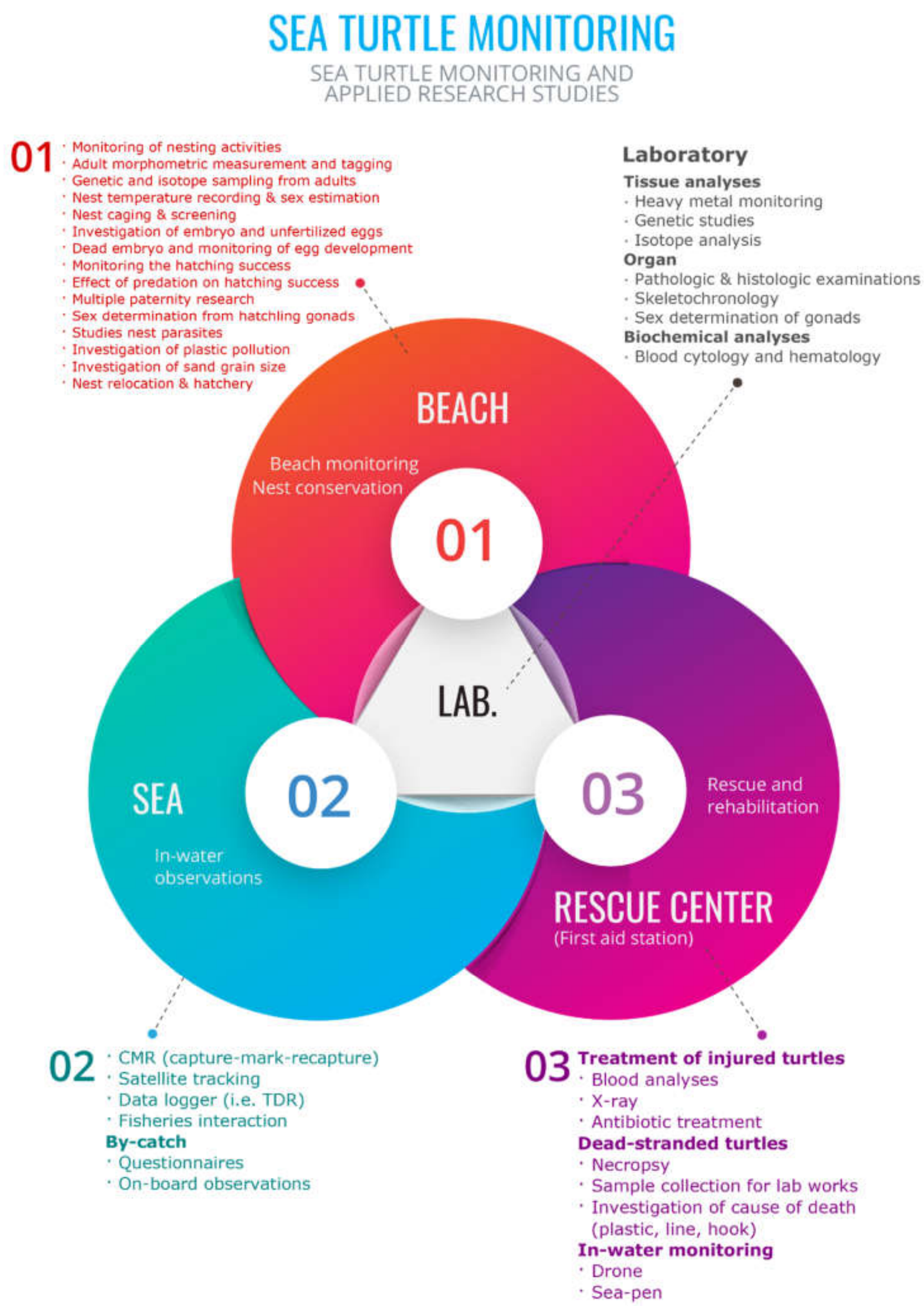

Figure 1. Spatial sea turtle monitoring and research activities

8. Sea turtles exhibit high nest-site fidelity. Research on migratory behaviour and the distribution of sea turtles shows that adult turtle fidelity to breeding sites is also a component of homing behaviour. It has also been directly observed, mainly in females, through flipper and satellite tagging (Margaritoulis, 1998; Broderick et al., 2003; Casale et al., 2013; Schofield et al., 2013). Site fidelity is even stronger in adults, as they appear to return to the same foraging ground after reproductive migration (Godley et al., 2003; Lazar et al., 2004; Broderick et al., 2007; Zbinden et al., 2008; Schofield et al., 2010a; Schofield et al., 2010b; Casale et al., 2013). Site fidelity can be monitored using standard flipper tagging and satellite tagging.

1.1. Distribution Ranges of Sea Turtles

1.1.1. Nesting Site Distribution of Loggerhead Turtles

9. Loggerhead turtle (*Caretta caretta*) nesting occurs over a wide area, with more than 96% of clutches laid in Cyprus, Greece, Libya and Turkey, which host the major nesting rookeries for this species in the Mediterranean. Lower levels of nesting take place on the Mediterranean shores of Egypt, Israel, Italy, Lebanon, Syria and Tunisia, with minor and infrequent nesting occurring along the western basin coastline of France, Italy, Spain and their offshore islands. Sporadic nesting is also recorded on the Aegean coast of Turkey and on the coast of Albania. If all the surveyed years are included, there is an average total of 6751 loggerhead turtle clutches per year, with 8179 in more recent times (Casale et al., 2018).

1.1.2. Nesting Site Distribution of Green Turtles

10. Green turtle (*Chelonia mydas*) nesting is restricted to the eastern Mediterranean and has only been recorded in Crete, Cyprus, Egypt, Israel, Lebanon, Syria and Turkey. There are 13 major nesting locations with an average of 1650 green turtle clutches per year, if all surveyed years are included and 2204 in more recent times (Casale et al., 2018). The principal green turtle rookeries are located in Cyprus, Syria and Turkey with minor nesting aggregations occurring in Egypt, Israel and Lebanon. The nesting sites in Turkey and Cyprus account for more than 90% of all green turtle nesting in the Mediterranean.

1.2. Population Abundance and Trends

11. The first parameter that needs to be analysed is population abundance and its trend in nesting populations. The nest counts and number of females nesting on the beaches, as mentioned above, need to be recorded using the same methodology. The population abundance in the sea has to be determined via in-water observations.

12. **Loggerhead turtle:** A more accurate comparison between past and current nest counts at 16 index nesting sites, which was included in a recent IUCN Red List assessment of the Mediterranean loggerhead turtle subpopulation as an RMU, reported a positive trend and was classified as of Least Concern (Casale, 2015). The abundance of adult females on the beach can be calculated from nest counts, clutch frequency (the number of clutches laid by a female in a nesting season), remigration intervals (the number of years between two consecutive nesting seasons) and adult sex ratio. The most recent available data provides an average of 8179 nests per year at the monitored nesting sites (Casale et al., 2018) and estimated 15843 adults (CI95%: 6915-31,958) (Casale and Heppell, 2016). Abundance estimates at sea, where juveniles represent the majority of the population, have been conducted through several spatially limited aerial surveys. Casale and Heppell (2016) attempted to provide at least the order of magnitude of a possible range of values for the total population abundance (including adults): from 1,197,087 (CI95%: 805,658-1,732,675) to 2,364,843 (CI95%: 1,611,085-3,376,104).

13. **Green Turtle:** For green turtles, a rough comparison of average nest counts at seven nesting sites between the same two arbitrary periods described above, indicates an overall positive trend. In Cyprus, an increasing proportion of neophytes (nesting females captured for the first time and assumed to be in their first year of breeding) was observed (Stokes et al., 2014), suggesting an increasing population. Monitoring programmes for green turtles at sea have yet to be established.

14. The most recent available data provides an average of 2204 nests per year at monitored nesting sites (Casale et al., 2018). Casale and Heppell (2016) estimated 3390 adults (CI95%: 1894-6552) with a population abundance from 261,727 (CI95%: 176,284-391,386) to 1,252,283 (CI95%: 679,433-2,209,833).

1.3. Population Demographics

15. Population demographic parameters need to be collected from nests and nest environments, as well as from in-water observations.

1.3.1. Monitoring of Development and Incubation Period

16. The monitoring of nests and embryos are also important and vary among the beaches. The incubation duration of clutches negatively correlates with nest temperature for both species of sea turtle (Godley et al., 2001a; Mrosovsky et al., 2002; Kaska et al., 2006) and is highly variable among the Mediterranean beaches. For example, viable hatchlings from loggerhead nest

temperatures as low as 26.5 ºC (with an incubation duration up to 79 days) have been recorded in Sicily, Italy (Casale et al., 2012a), whilst the longest incubation duration for loggerhead turtles in the Mediterranean (89 days) has been recorded twice on Marathonissi beach (Laganas Bay, Zakynthos) (Margaritoulis, 2005; Margaritoulis et al., 2011). At the opposite end of the temperature range, nest temperatures as high as 33.2ºC in Cyprus (Godley et al., 2001a) and with an incubation duration as short as 36 days in Calabria, Italy (Mingozzi et al., 2007) have been observed. Nest temperature measurements have also been carried out for green turtles and the nests were usually deeper than those of loggerhead turtles (i.e., Kaska et al., 1998; Candan & Kolankaya, 2016).

17. The parameters that need to be monitored here are as follows:

- Inter-nesting (or re-nesting) intervals (RNI) which is between 12.7-19.9 days,
- Remigration intervals (RMI),
- Clutch frequency (CF), the number of clutches deposited by a female in a single season,
- Incubation periods (IP),
- Hatchling sex ratios and,
- Hatching success and hatchling emergence success (ES%).

1.3.2. Recording the Clutch Size and Hatching Success

18. For loggerhead turtles in the Mediterranean, substantial differences exist in terms of clutch size, with the smallest females and clutch sizes observed in Cyprus and the largest females and clutch sizes observed in Greece. The number of clutches laid per season range between 1–5 clutches per season for loggerheads at Alagadi, Cyprus (Broderick et al., 2003) and this parameter could be associated with re-nesting interval. The mean clutch size for loggerhead turtles ranges from 64.3 to 126.8 eggs, among the different Mediterranean sites.

19. The mean clutch size among the different Mediterranean sites ranges from 108 to 120 eggs for green turtles (see references in Casale et al., 2018).

20. The monitoring and recording of nest depth, diameter, humidity, hatching success, clutch size, fertilization rates and mortality rates is essential.

1.3.3. Spatial and Temporal Monitoring of Sex Ratio

21. The sex ratio of hatchlings on the beaches and the sex ratios in adult and sub adult stages are important when monitoring the population of both sea turtle species. When estimating the sex ratio of the hatchlings, the most commonly used methods are nest temperature measurements and gonad histology. Laparoscopy can also be used for hatchlings and at later ages. The monitoring of the temporal and spatial changes of the sex ratio on the beaches is also very important when taking the possible effects of global warming into account.

1.3.3.1. Loggerhead turtle sex ratio estimations

22. The pivotal temperature (the egg incubation temperature at which both sexes are produced in equal numbers) for Mediterranean loggerheads assessed in laboratory and field conditions, is about 29-29.3°C and is similar to other populations elsewhere, with a pivotal incubation duration (at which both sexes are produced at equal numbers) of 53 days from laying to hatching (Kaska et al., 1998; Mrosovsky et al., 2002). Other studies carried out under natural conditions, (Fuller et al., 2013) found a slightly lower (28.9ºC) pivotal temperature and a longer incubation duration than expected (56.3 days), due to the effect of metabolic heating generated by the whole nest.

23. By applying different indirect sex determination methods, loggerhead hatchling production at most Mediterranean nesting sites are likely to be highly female-biased, with the major rookeries in Greece, Turkey, Libya and Cyprus producing 60-99% females (see references in Casale et al., 2018). Interestingly, gonadal histology as a direct sexing method, although possibly biased by the field sampling protocols and applied only in a limited number of cases, showed less skewed loggerhead hatchling sex ratios (55.6-79% females). Conversely, male-biased hatchling production occurs in some sites, such as Marathonissi beach in Zakynthos, Greece (Margaritoulis, 2005; Zbinden

et al., 2007; Margaritoulis et al., 2011) and Kuriat Island in Tunisia (Jribi & Bradai, 2014) and in some years may also be possible at other sites.

24. Spatio-temporal variations in sex ratios have also been reported (Kaska et al., 2006; Katselidis et al., 2012; Fuller et al., 2013), with more male hatchlings being produced from the nests laid at the beginning and the end of nesting season (May and August, respectively), than from those laid in the middle of nesting season (June-July). Eggs at the top of a nest are also likely to be exposed to more heat from the sun and produce relatively more females than those at the bottom of a nest (Kaska et al., 1998). Beach sand colour (albedo), sand grain size and shading by vegetation are all important factors when determining hatchling sex ratios (e.g. Kaska et al., 1998; Hays et al., 2001; Zbinden et al., 2007; Fuller et al., 2013).

1.3.3.2. Green Turtle sex ratio estimations

25. Clutch temperatures in green turtle nests range from 28.3 ºC with an incubation period of 59 days in Turkey (Candan & Kolankaya, 2016) and as high as 32.5 ºC and an incubation period of 43 days in Cyprus (Kaska et al., 1998; Broderick et al., 2000). Mean incubation durations range from 49 to 60 days (Casale et al., 2018). Primary sex ratios tend to be female-biased (70-96% females; (see references in Casale et al., 2018). An operational sex ratio of 1.4M:1F was estimated from a paternity study at Alagadi (Alagati) Beach, Cyprus (Wright et al., 2012).

1.3.3.3. In-Water Sex Ratio Estimations

26. Surprisingly, and contrary to predominant female-biased hatchling production, the sex ratios of juvenile loggerhead turtles in most Mediterranean marine habitats showed no significant deviation from a 1:1 ratio, with the proportion of females ranging between 52 and 56%. The explanation initially given for the discrepancy between strong-female biased hatchling production and almost even sex ratios in juvenile loggerheads was the strong male-biased immigration of Atlantic juveniles into the Mediterranean Sea (Casale et al., 2002; Casale et al., 2006). Overall, a female bias in the juvenile sex ratio (1.56:1) was recorded in the long-term study in the Tyrrhenian Sea, although in some years this ratio has shown no deviation from a 1:1 ratio (Maffucci et al., 2013).

1.3.3.4. Monitoring the Effects of Global Warming

27. Temperature profiles of monitored nesting beaches in the eastern Mediterranean strongly imply a female biased sex ratio for hatchlings (Casale et al., 2000; Godley et al., 2001a; Godley et al., 2001b; Kaska et al., 2006; Zbinden et al., 2007; Fuller et al., 2013). In the context of global warming, even more female-biased hatchling sex ratios may result. However, extremely skewed sex ratios resulting from a moderate increase of incubation temperature may not necessarily be negative for the population dynamics and a greater threat is represented by reduced hatching success at higher temperatures (Pike, 2014; Hays et al., 2017).

28. Measuring nest and sand temperature offers simple and reliable data for sex ratio estimation, a technique for which electronic data loggers are commonly used. Measuring the sand temperature provides information about the general profile of a beach but *metabolic heating* (the heat that embryos produce during incubation) should also be taken into account, as this usually means the nest temperature is higher than that of the surrounding sand.

29. In order not to interfere with the nest after nesting, the best time for placing data loggers is during egg laying. The data logger may be placed at the bottom or the top of the nest, but the most common practice is to place it in the middle of the nest.

30. If a nest is found after the eggs have been laid, the data logger can only be placed in the nest within the first 24 hours of egg laying. Follow the same procedure during nest relocation, when removing the eggs from the nest and returning them. Data loggers can be collected during the nest excavation. Data loggers, their launching, placement into the nest, information retrieval and the downloading of temperature data can be found in the references (Kaska et al., 1998, 2006).

1.3.3.4.1. Monitoring of Beach erosion and Coastal development

31. Coastal development is largely the result of recreational/tourist activity. It is associated with the presence of hotel resorts and other tourism related constructions such as restaurants, bars,

houses and related businesses, typically built along the beach, impacting an originally flexible and adjustable coastal system. There are many examples of these developments on the nesting beaches of sea turtles in the Mediterranean and all such activities and changes in the nesting habitat should be monitored.

32. Beach erosion and beach armouring may also be recorded, as this very much relates to changes in the ecological conditions of the nests and the development of embryos and hatchlings.

33. Coastal development is also associated with the activities that have an impact on sea turtle nesting activity. Driving on the beach and the use of heavy machinery for beach cleaning purposes are common practices and are responsible for alterations in sand characteristics and the destruction of turtle egg clutches.

34. Water sports, a leisure activity closely linked with high tourist activity, can lead to collisions between turtles and speed boats, especially close to nesting areas where turtle density is high. Such recreational activities and their potential impact on sea turtles should be recorded and necessary precautions and mitigation measures need to be taken into account.

35. Coastal development can be easily monitored during beach monitoring studies. The nesting beach can be photographed at the beginning, middle and end of the nesting season and GPS coordinates recorded. This procedure can be repeated each year. Optionally, satellite images from previous years can be used for comparison. Free images are available from different sources (e.g. https://earthengine.google.com/timelapse/).

1.3.4. Growth, Age at Sexual Maturity and Survival

36. Different aging methods result in the similar estimation of Age at Sexual Maturity (ASM), ranging between 14.9-18.6 years for small nesters of 66 cm CCL and 26.3-34.9 years for larger reproductive females of 84.7 cm CCL (see references in Casale et al., 2018). The mean size of female loggerhead turtles nesting in the Mediterranean is 79.1 cm CCL and males appear to reach maturity at a similar size (Casale et al., 2005; Casale et al., 2014). The average ASM for the Mediterranean loggerhead population was estimated at 25 years (range: 21-34 yrs) from the mean values of the eight age-at-length relationships obtained by the above studies, applied to a size at maturity of 80 cm CCL (Casale & Heppell, 2016).

37. Mediterranean loggerheads appear to reach 28 cm CCL at about 3.5 years old, with the growth rates ranging from 11.8 cm $year^{-1}$ in the first months of life to 3.6 cm $year^{-1}$ at the age of 2.5-3.5 years, similar to that of Atlantic loggerhead turtles (Casale et al., 2009). Broderick et al. (2003) reported growth rates of 0.36 cm $year^{-1}$ for loggerhead females nesting in Cyprus.

38. Based on capture-mark-recapture data, the annual survival probability of loggerheads of 25-88 cm CCL was estimated at 0.73 and this was considered to be underestimated by at least 0.1 because of tag loss (Casale et al., 2007b). The annual survival probabilities of large juveniles at four different foraging areas were estimated through a catch curve analysis, resulting in values ranging 0.71-0.86 depending on the area (Casale et al., 2015). These values were considered to be lower than expected from a healthy population and are possibly due to anthropogenic mortality such as bycatch, especially in some areas like the south Adriatic (Casale et al., 2015).

39. For green turtles, the current information on growth rates is limited to adult females showing a slow growth of 0.11 cm yr^{-1} CCL (Broderick et al., 2003).

40. Oceanic nursery areas for post-hatchling and small juvenile turtles (< 40 cm CCL) are largely unknown in the Mediterranean. Loggerhead turtles, especially juveniles, can be found in virtually all oceanic areas within the Mediterranean. Their distribution is fundamentally driven by the circulation system of the Mediterranean as indicated by genetics (Carreras et al., 2006), telemetry (Revelles et al., 2007) and flipper tagging (Casale et al., 2007a; Revelles et al., 2008). Identifying the most frequented areas is not a simple task and at present the best insights are provided by interaction with fisheries. Turtles in the oceanic zones belong to at least three different Regional Management Units (RMUs) (Wallace et al., 2010): the Mediterranean, the Northwest Atlantic and, to a lesser extent, the Northeast Atlantic (Clusa et al., 2014). Juveniles from Atlantic RMUs enter the Mediterranean through the Straits of Gibraltar and mainly distribute across the south of the western basin following the less saline waters from the Atlantic (Millot, 2005). They can also be found in other regions of the Mediterranean, but at much lower proportions (Clusa et al., 2014). Juveniles from the Mediterranean RMU can be found throughout the basin, although their relative proportion is greater in the eastern, central and north-western Mediterranean (Clusa et al., 2014).

41. Adult sea turtles in the Mediterranean are primarily found in neritic areas, and also on the nesting beaches. Loggerhead turtles can be encountered at pelagic areas, but priority should be given to the aggregation areas in neritic habitats, taking time, budget, and human resources into account. Population demographic parameters need to be collected by conducting in-water studies for both species, especially for juveniles and sub-adults.

1.3.5. Data can be collected from Fishermen-Fisheries Interaction

42. There is a large body of data on turtle bycatch in the Mediterranean, which has recently been reviewed, showing that the level of information available is not equal across countries or sub-regions (Casale, 2011). This review estimated more than 132,000 captures and 44,000 deaths in the Mediterranean annually, from all gear combined. The resulting ranking order of different fishing gears for the number of captures per year was: pelagic longline, bottom trawl, set net and demersal longline. For fatalities, the ranked order was: pelagic longline, set net, bottom trawl and demersal longline.

43. Small-scale fleets (SSF), polyvalent vessels of up to 12 m in length, are the dominant fishery segment and account for 80 percent of the total vessels in the Mediterranean and Black Sea (FAO 2016). Sea turtles are at high risk from SSF, possibly due to the long soak durations of gear (Carreras et al., 2004; Echwikhi et al., 2010, 2012; Coelho et al., 2013) and this fishery may be responsible for most of the fishing-induced mortality in the Mediterranean (Casale, 2011).

44. Bottom trawlers cause death by drowning and mitigation measures are represented, among others, by the modification of the gear (turtle excluder device or TED) to enable any captured turtle to exit the net (FAO, 2009; Lucchetti et al., 2016) and by keeping comatose (i.e. semi-drowned) turtles on-board until they recover (Gerosa & Aureggi, 2001; FAO, 2009). However, decompression sickness may represent an additional and overlooked problem (García-Párraga et al., 2014). Pelagic longlines generally cause death after release, as result of internal damage caused by the line and secondarily by the hook (Casale et al., 2008; Parga, 2012; Alvarez de Quevedo et al., 2013). Mitigation measures are represented, among others, by using larger hooks (e.g., circle hooks) (Piovano et al., 2012; Gilman & Huang, 2017), which decrease the catch rate and by removing the gear (especially the line) from the turtle before releasing it (Gerosa & Aureggi, 2001; FAO, 2009). Set nets cause death by drowning, with very high mortality rates due to the long time the net is left

in the water (Echwikhi et al., 2012) and the only mitigation measure available at present it the illumination of the net, so that turtles can see and avoid it (Ortiz et al., 2016).

45. The highest catch rates in the Mediterranean have been observed off the coast of Tunisia, in the Adriatic Sea and in the easternmost part of the Levantine basin, off Turkey, Syria and Egypt (Casale, 2011; Casale et al., 2012b). A regional bycatch project (supported by the MAVA foundation) should be established to update bycatch figures.

2. MONITORING METHODS

46. The monitoring of sea turtles can be performed by:

a) counting the number of nests during the nesting period and monitoring nest parameters
b) collecting stranded turtles and obtaining information from collected tissues
c) in-water capture-mark-recapture studies for population distribution
d) boat and aerial surveys can also be used for the beach monitoring and in-water monitoring of sea turtles

47. To monitor the distributional range, the population abundance and the demographic characteristics of sea turtles, two monitoring methods can be applied:

- beach monitoring: ground based or aerial monitoring
- in-water monitoring: boat based or aerial monitoring

48. Before starting a sea turtle monitoring study, it should be noted that the necessary permits from the National authorizations should be taken from the relevant authorities.

Table 1. Data to be collected, data collection tools, and relevant common indicator.

Common Indicator	**Nesting Beach Monitoring**		**Marine Habitat Monitoring**	
CI3 Distribution range	*Implementation/ Tools*	*Data collected*	*Implementation/ Tools*	*Data collected*
	Beach foot patrol	Yearly number of nests and tracks; nesting success; spatial and temporal distribution of nests	Boat surveys	Number of individuals; size classes; species distribution; habitat use
	UAV or plane surveys	Number of tracks, and identify nests if possible	UAV or plane surveys	Number of individuals; size classes; species distribution
	Satellite-GPS tracking turtles	Migratory corridors, cutch frequency, inter-nesting habitats, feeding grounds	Satellite-GPS tracking turtles	Migratory corridors; wintering areas; nesting grounds; habitat use
	Sand, nest, and sea water temperature monitoring	Sex ratio trends; suitable nesting beaches; nesting periodicity	Fisheries bycatch data	Sex ratio, maturity, distribution of species, size classes;

				number of individuals
	Stranded turtle network	Spatial and temporal distribution and age classes of turtles	Stranded turtle network	Spatial and temporal distribution and age classes of turtles
	Stable Isotope Analysis	Habitat use; estimating origin of feeding ground;	Stable Isotope Analysis	Habitat use
	Monitoring potential nesting grounds	Yearly number of sporadic nest counts		
	Photo ID, flipper tag, PIT tag, genetic tag	Number of individuals; multiple paternity; haplotype diversity		
CI4 Population Abundance	Beach foot patrol	Yearly number of nests counts and the number of nesting females	Boat surveys	Number of individuals; size classes; species distribution
	Photo ID, flipper tag, PIT tag, genetic tag	Number of individuals; multiple paternity; haplotype diversity	Genetic sampling	Mix stock analyses; genetic diversity (mitochondrial and nuclear DNA)
	Monitoring potential nesting grounds	Yearly number of sporadic nest counts	Fisheries bycatch data	Sex ratio, maturity, distribution of species, size classes; number of individuals
			UAV or plane surveys	Number of individuals; size classes; species distribution; habitat use
			Stranded turtle network	Spatial and temporal distribution and age classes of turtles
CI5 Population Demographics	Beach patrol	Hatching and emergence success; predation rate; hatchling sex ratio	Boat surveys	Number of individuals; size classes; species distribution; habitat use
	Photo ID, flipper tag, PIT tag, genetic tag	Number of individuals; multiple paternity; haplotype diversity	CMR studies	Age and size classes, sexing, maturity, health status
	Stranded turtle network	Aging dead turtles through skeletochronology	Genetic sampling	Mix stock analyses; genetic diversity (mitochondrial and nuclear DNA)

			Stranded turtle network	Spatial and temporal distribution and age classes of turtles
			Fisheries bycatch data	Sex ratio, maturity, distribution of species, size classes

49. Both methodologies can be applied for the Loggerhead turtle as well as the Green turtle. Selecting the most appropriate monitoring method depends on the budget, equipment and personnel available. Beach monitoring should be established on all known nesting beaches, on daily basis, during the nesting period. Potential nesting sites may also be monitored once or twice a week. The monitoring of beaches allows for counting the emergence of adult female turtles, their clutches, and the number of hatchlings. Therefore, estimates for breeding populations can be calculated. For ground-based monitoring, the number of people working in the field depends on the size of the beach, while the equipment can easily be acquired on a low budget. For instance, for daily foot patrols, at least three (2-8) people should be considered for a five km nesting beach.

50. The monitoring of in-water populations requires more expensive equipment, such as boat, entanglement net, or Unmanned Aerial Vehicles (UAVs).

2.1. Time and Area

51. Sea turtles are a highly migratory species. They can be found in different habitats at different times of the year. Therefore, the demography and sex ratio of the population changes temporally throughout the year. Breeding, foraging and overwintering areas are the main ones to be monitored.

2.1.1. Breeding Area

2.1.1.1. Nesting Female Population

52. Nest counts, the direct observation of nesting females, and reproductive outputs are observed during the nesting season. The monitoring of nesting beaches starts at the beginning of May and continues until the end of September, every year.

2.1.1.2. Operational Sex Ratio

53. Operational sex ratio is the proportion of ready to mate individuals from both sexes. This requires the direct sampling of individuals from the sea. In the Mediterranean, mating mainly occurs during April and May. Therefore, monitoring activity should start in April and continue until the end of May and it should be conducted every year.

54. The monitoring of the operational sex ratio before April and after May should be avoided, as individuals captured during these periods may represent different populations and the results can be misleading.

2.1.2. Foraging and Overwintering Areas

55. Monitoring sea turtles at foraging and overwintering sites can be conducted annually and throughout the year. Loggerhead turtles can be found throughout the Mediterranean, especially in bays and estuaries. Green turtles can be found in the eastern Mediterranean and are rare in western locations. The best period for monitoring foraging and overwintering areas is during the months of September and October, as the turtles will have completed their post-nesting migration.

2.2. Samples and Data to be Collected from Sea Turtles

Implementation and/or sampling	Data to be collected	Monitoring methodology		
		Beach Monitoring	In-water Surveys	Rescue/ Stranding
Morphometric measurements	• Size class • Age at Sexual Maturity	X	X	X
Tagging *Metal tags* *Plastic tags* *PIT tags* *Photo ID*	• Population size estimates • Inter-nesting period • Migration route	X	X	
Sampling skin	• Genetic analysis • Stable isotope analysis • Trace element analysis • Heavy metal analysis	X	X	X
Sampling scute	• Stable isotope analysis • Trace element analysis • Heavy metal analysis	X	X	X
Sampling blood	• Genetic analysis • Blood biochemistry and health parameters • Sexing juveniles • Blood cell physiology • Stable isotope Analysis • Trace element analysis • Heavy metal analysis	X	X	
Tissue sampling from internal organs and muscles	• Histologic investigation • Genetic analysis • Heavy metal analysis • Marine litter ingestion			X
Parasite – Epibiont	• Health status • Stable isotope	X	X	X

2.2.1. Size measurement of individuals and Tagging

56. Regardless of monitoring methodology, measuring carapace length is an essential tool for identifying the age class of sea turtles.

57. Adult body size varies greatly among different nesting sites for both species. One of the most distinctive characteristics of Mediterranean loggerhead turtles is a smaller adult female size in comparison with other populations worldwide (Tiwari & Bjorndal, 2000; Kamezaki, 2003). Some loggerhead males start to develop an elongated tail at size >60 cm CCL (Bolten, 1999) and a clear dichotomy in this trait is evident in the population in the >75 cm size class CCL (Casale et al., 2005; Casale et al., 2014). For Straight-line Carapace Length (SCL), 70 cm is usually accepted as a mature female. This type of information can only be obtained by the measurement of individuals.

58. Sea turtle measurement techniques, as explained by Bolten (1999), are frequently used. The measurement of carapace length is an important parameter for identifying size classes. The most common measurements are given below:

- Straight carapace length (SCL): A calliper is used to measure straight length. Three types of measurements are available for SCL:

(i) SCL_{min}: measured from the anterior point at midline (nuchal scute) to the posterior notch at midline between the supracaudals

(ii) SCL_{n-t}: measured from the anterior point at midline (nuchal scute) to the posterior tip of the supracaudals.

(iii) SCL_{max}: measured from the anterior edge of the carapace to the posterior tip of the supracaudals.

- Curved carapace length: A tape measure is used to measure straight length. Three type of measurements are available for CCL:

(i) CCL_{min}: measured from the anterior point at midline (nuchal scute) to the posterior notch at midline between the supracaudals

(ii) CCL_{n-t}: measured from the anterior point at midline (nuchal scute) to the posterior tip of the supracaudals.

(iii) CCL_{max}: measured from the anterior edge of the carapace to the posterior tip of the supracaudals.

- Straight carapace width (SCW): A calliper is used to measure the straight width of the carapace. SCW is measured at the widest point and there is no anatomical reference point for the measurement.
- Curved carapace with (CCW): A tape measure is used to measure straight width of the carapace. As in SCW, CCW is measured at the widest point and there is no anatomical reference point for the measurement.

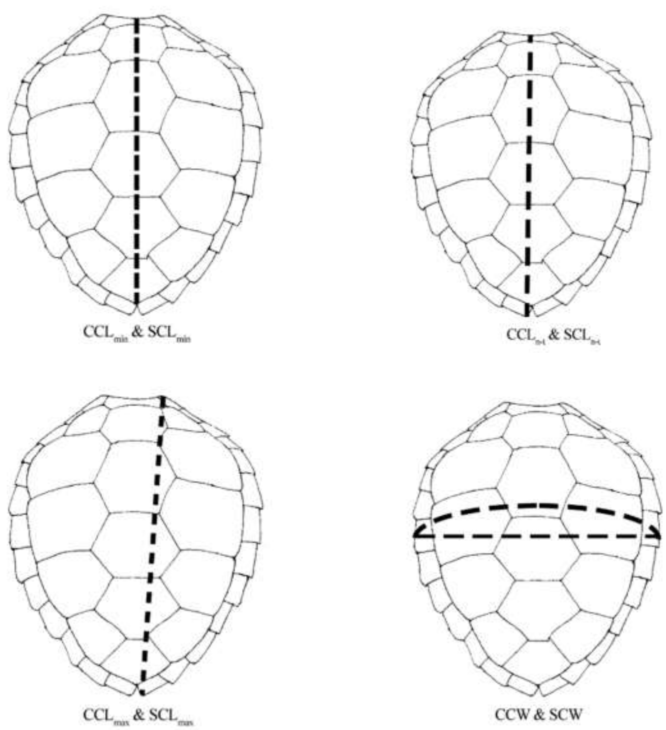

Figure 2. Morphometric measurements of carapace. (For abbreviations see the above text)

59. Tagging is an important tool for monitoring sea turtle populations, as it allows the identification of each turtle as an individual. Each size class of sea turtle, apart from hatchlings, can be tagged. Different types of external tags are available; the most common are Monel, Inconel and Plastic flipper tags. These tags can be found in various sizes and should be selected accordingly to the size of the turtle. A range of tag models can be found at https://nationalband.com/.

60. The advantages of these tags are:

- Visual identification is possible without additional equipment or device by different researchers, fishermen or any person who encounters the turtle. Tag returns are important for monitoring projects
- Cheaper in comparison with other methods.

61. The disadvantages of these tags are:

- High loss rates, especially when the turtle is not properly tagged
- External tags may cause entanglement in fishing nets or marine garbage

62. Passive Integrated Transponders (PIT tag) are also used in monitoring projects. This is an invasive technique that can be applied with a gun or a needle applicator. Sea turtles are tagged with a very small microprocessor. Although the PIT tag remains in the turtle's tissue and may have a low tag loss rate, these tags are not visually identifiable, and an electronic reader is required. Furthermore, PIT tags are more expensive than flipper tags.

63. Photo-identification: Photo identification is an alternative tagging method that is becoming increasingly popular. The methodology is minimally invasive, as it is a technique that basically depends on photographing an individual's scales, creating photo database, and evaluating database photos. Computer programmes for photo-identification are available. This method is currently well developed for green turtles and hawksbill turtles (*Eretmochelys imbricate*) (Carpentier et al., 2016; Calmanovici et al., 2018), and can be used as a viable tool for loggerhead turtles (Schofield et al., 2008). The lateral scale patterns of turtles are commonly used. To obtain the best results, photographs should be taken from the same distance and angle for each individual.

Required Equipment

Measuring the Size

- Notebook
- Pencil
- 150 cm long calliper
- 150 cm long tape measure

Tagging

- Monel, Inconel, or plastic flipper tags
- Tagging Pliers (different pliers for each type of the tags)
- PIT tags
- PIT tag needle applicator or applicator gun
- Electronic PIT tag reader
- Camera

2.2.2. Skin and Scute Sampling

64. Carefully clean the sampling area prior to the procedure. First, gently clean the sampling area to remove all possible epibionts and algae and rinse the area with water. Next, clean with ethanol or another disinfection agent. Using a 6 mm biopsy punch is an easy way to take skin samples. If a scalpel is being used, the turtle should first be restrained and immobilized. After stabilizing, use forceps to facilitate sampling. The biopsy should be no deeper than 0.5 mm. This will prevent bleeding. After sampling, clean the area with betadine to prevent any bacterial infection. Tissue samples should be placed in ethanol (70% or 96%). Use disposable single-use sampling materials and gloves. Using the same sampling materials – such as a biopsy punch or scalpel for different turtles – may transfer DNA from one sample to another. Place the samples in cryovials or Teflon bags and store, frozen to at least -20°C, until analysis.

65. There are two preferred methods for collecting scute samples. The first is by cutting a small piece of keratin with a biopsy punch or scalpel, and second is by shaving. If the turtle is large, use a biopsy punch or scalpel to sample the scute, as this enables different layers of keratin tissue to be collected.

66. After cleaning the area of algae, sand and any other materials, the top layer can be gently shaved then rinsed with distilled water, if possible. A 1X1 cm scute sample is usually sufficient for analysis. Place the samples in cryovials or Teflon bags and store, frozen to at least -20°C, until analysis.

67. If sampling is taken from a juvenile turtle, it can be collected via shaving the scute. The keratin layer is very thin, especially with green turtles. Clean and rinse the sampling area, then start shaving an entire scute by using a knife (5th ventral scute is suitable for this procedure). Approximately 2.00 mm of the keratin should be shaved. Using a wind shield (e.g. umbrella) whilst shaving is beneficial.

2.2.3. Blood Sampling

68. Blood is widely used for scientific purposes, such as:

- Diagnosing a turtle’s health status
- Physiologic studies (blood cells, hormones, antibodies, etc.)
- Blood biochemistry studies (electrolytes, blood enzymes, proteins)
- Sex identification (hormones and enzymes)
- Stable isotope analyses
- Genetic analyses
- Toxicological analyses

69. Whole blood tissue comprises two main parts: blood cells and plasma. A study can therefore be made using whole blood, blood cells (haematocrit), or plasma. In each case, a sufficient amount of blood should be collected and stored. If the blood sample is not properly collected and/or is incorrectly stored, the results will not be reliable.

70. Blood sampling should be completed as soon as possible after the capture of the animals; ideally, within 5 minutes of capture and a maximum of 15 minutes. A sea turtle’s dorsal cervical sinus is an easily accessible location for taking blood samples. The turtle should be restrained in stable position. The best position is to lift the turtle’s back, as this will help to fill the cervical sinus with blood. Gently pull the head forward and downward to stretch the neck.

71. Once the neck is stretched, locate its midpoint. Move 1 cm. towards the nuchal scute, a suitable area for blood collection. Do not insert the needle into the median line of the neck, as this

could strike the vertebral column. When the neck is stretched, two tendons become visible. The needle can be inserted by these tendons, at the lateral sides. Insert the needle vertically. Suction should start after passing the integument. Carefully continue to insert the needle downward, using a small amount of suction until the blood starts to flow. On seeing the blood, maintain the needle in a stable position until sufficient blood is collected.

Required equipment

- 21g Needle and Syringe/Vacutainer
- Heparinized blood tubes
- Centrifuge (for separating blood cells from the plasma)
- Vials and cryo tubes
- Ice box (for transportation)
- Gloves
- An antiseptic (e.g. ethanol)

2.3. Beach Monitoring

72. Beach monitoring should be conducted at night or during morning patrols. Night patrols permit encounters with nesting females, while finding nests at night helps them to be protected from predation, inundation risk, or poaching. Night patrols begin after sunset and may continue until morning. Morning beach surveys start at dawn.

Required Equipment

- Notebook
- Pencil
- Measure tape (30 m or longer)
- GPS
- Headlamp with red-light
- Camera (optional)

73. To determine turtle activities, potential nesting sites should be monitored every two weeks during the summer period. Beaches identified as nesting areas should be monitored every 1-3 days for nest/track counts. During these visits stranded turtles can also be recorded and the necessary samplings conducted.

2.3.1. Beach Monitoring during nesting season

74. Existing and potential nesting beaches should be monitored during the nesting season. Ground-based surveys with a hand-held GPS should be used to map the sea turtle nesting beaches.

- All equipment must be ready prior to beach monitoring.
- At night, only red-lights should be used on beaches; ideally, patrol teams should be silent, and any sounds should be minimal.
- On patrols, avoid large numbers of people.
- To avoid covering sea turtle tracks, patrol teams should walk on wet sand in the ebb tide. Once a track is found, only one person should follow the track, notifying the rest of the team if a female sea turtle is found.
- If a turtle is found, the group should sit quietly, waiting until it finishes laying its eggs and starts to cover the nest.
- It will save time if the location can be marked at this stage.

- The sea turtle should be tagged and measured as soon as it finishes laying. Once the turtle is tagged, it should also be recorded.
- Tissue samples should be collected after tagging. If sensitive samples are to be taken, such as blood, these should be collected first.
- Minimal light should be used to record data, to avoid distracting the female and affecting the nesting activity.
- The location of the nest should be recorded using physical measurements. To obtain three-point positioning, measure the distance from the shore line and also from at least 2 permanent points at the back of the beach. Record the GPS coordinates.
- The nest should be covered with a grid to protect it from predation (eggs dug up by animals searching the beach for food).
- All turtle tracks should be erased, so subsequent teams can clearly see new tracks and are not distracted by tracks and nests that have already been logged.
- The presence of predators (dogs, cats, ferrets, seabirds, foxes etc.) on the beach can be recorded by direct observation and the documentation of tracks. If a predation occurs, it should be recorded immediately. In such cases the actions to be taken are given below:
- The predator should be identified. Egg shells scattered around the nest should be collected and counted to establish how many eggs have been damaged as a result of the predation.
- In cases of infestation in the scattered eggs, specimens (adults, pupae, larvae) should be collected for further examination in the laboratory
- The damaged eggs should be removed from the beach.
- The centre of the predated and distorted nest should be located and opened
- Carefully search for intact (undamaged) eggs.
- In cases of completely ruined nests where intact eggs are observed, excavate a new nest close to the existing one and carefully relocate the undamaged eggs.
- The eggs should be kept in the same position (for transporting over long distances, mark the top of the eggs with marker pen) to avoid them being affected by vibration, rotation or temperature changes. The number of the intact eggs and the GPS coordinates of the new nest should also be logged.
- For every measurement location or sampling collection point, the GPS position should be recorded, and all information should be added to the GIS database

75. Aerial surveys are also an effective way of monitoring of nesting beaches; when the nesting beach is in a remote area, the beach is long, or human resources and equipment are insufficient. Ariel surveys by UAV or plane may be used for counting sea turtle tracks and nests. Surveys can be conducted daily, on alternate days, or on a weekly basis.

2.3.2. Beach Monitoring during the hatching season

76. Data collected during the nesting season is used to estimate the hatching period. This will be confirmed by physical evidence and the observation of tiny tracks leaving the nest towards the sea. The hatching period usually occurs between 45 and 70 days after the first nesting date. Nests that have reached the 40 days incubation period should be monitored.Nest excavations should be conducted 4 days after spotting the first tracks and the following data should be recorded:

a) Live hatchlings
b) Dead hatchlings
c) Yolk sacks still attached
d) Half developed eggs
e) Unfertilized eggs

f) Empty shells

2.3.3. Hatched Nest Excavation

77. Nest excavations are essential for saving hatchlings that are unable to exit the nest because they are not strong enough or due to the nest being closed by an external factor. During a nest excavation, information is recorded about healthy hatchlings, unfertilized eggs, dead embryos, empty shells and live hatchlings that could not exit the nest. Egg shells found in the nest are recorded as empty shells, and eggs with dead embryos inside are recorded as dead embryos. However, the detection of dead embryos early in life can be difficult.

78. Data collected during the nest excavation are given below:

- Early Stage Embryo: An embryo that is smaller than 1 cm. The embryo may have died a few days after egg laying. For this reason, it is difficult to distinguish an early stage embryo from an unfertilized egg.
- When the egg is opened in such cases, a blood clot should be observed, and the egg yolk should be still be attached to the shell. Also, the part of the outer shell should be examined for the clarification of the whitening calcium layer, due to the breathing of the embryo. Furthermore, all or part of the egg colour will be white. If the egg has these characteristics, it is called early stage embryo.

i. Middle Stage Embryo: These are embryos of between 1 and 2 cm.
ii. Late Stage Embryo: These are embryos larger than 2 cm.
iii. Dead Hatchling in the Nest: These hatchings are found in the nest during the excavation process.
iv. Live Hatchling Outside the Nest: These hatchlings are found during field work, or their presence is determined by the tracks they leave.
v. Dead Hatchling Outside the Nest: These hatchlings are detected during field work on the beach, by their traces, which do not reach the sea.
vi. Unfertilized Eggs: Eggs in which the embryo failed to develop. These eggs are yellowish-brown or greyish in colour and show none of the above characteristics.
vii. Empty Shells: Eggs shells left behind by the hatchling after emerging.
viii. Alive Hatchlings in the Nest: Living hatchlings found in the nest during the excavation process.

79. The timing of nest excavations for control is variable. The first nests of the season (April, May and early June) usually have a longer incubation period and it takes longer for hatching to commence in these nests with incubation lasting up to 70 days. The hatchlings that belong to these earliest nests may take 8-10 days to hatch.

80. Nests from the middle of the season have shorter incubation period, when 45 days is sufficient for the incubation process. The complete hatching process may take only a few days, although in some cases it can last as long as 6-7 days. Excavation for these nests should be made 5-6 days after the first hatching. During excavation, live hatchlings that have reached the sea; unfertilized eggs; dead embryos; dead hatchlings; empty shells and living hatchlings still in the nest, should be recorded.

2.3.3.1. Calculation of Hatching and Incubation Period

81. Usually, the surface of the nest collapses 2-3 days before the hatching begins and the egg crumples as the hatchlings begin to emerge, allowing sand to enter. This movement opens a route through which the hatchling can emerge from the nest. At night, the temperature of the sand decreases and the hatchlings start scrambling to the surface. Most of the hatchlings exit the nest on the first night and the rest during the next few days. The hatching process is usually completed within a week.

The incubation period is from the nesting date to the date of the first emergence of hatchlings and is measured on a day-by-day basis.

2.3.3.2. Calculation of Hatching Success

82. The calculation of hatching success:

- Hatching Success = (Empty Egg Shells) / (Total Number Eggs) X 100
- Total Number of Eggs = EES + UE + DE + PE
- EES: Number of empty egg shells; UE: Number of unfertilized eggs; DE: Number of dead embryos; PE: Number of predated eggs

2.3.3.3. Sand, Nest, Sea Surface Temperature

83. It is recommended that sand, nest and sea surface temperatures are monitored to track the effect of climate change. The temperature of these environments is a useful gauge for assessing different parameters.

Sand Temperature	Sea Surface Temperature	Nest Temperature
Affects nest temperatures	Affects nest temperatures (see Girondot and Kaska, 2015)	Sex ratio estimates
Temporal and spatial temperature changes in different beach sections	Breeding periodicity of adults	Assessing hatching success

84. The use of data loggers that record temperature is a common and simple way for monitoring sand and nest temperatures. Sea surface temperature may be recorded, or the data can be requested from national meteorological organisations.

Monitoring sand temperature

85. Data loggers are placed at specific intervals on the nesting beach. For most sea turtle nesting sites, 1 km intervals between each data logger is preferred, buried at a depth of 50 cm, although this depends on the condition of the beach. When placing/planning devices, attention should also be paid to the following:

- Devices should not be placed in the inundation zone.
- If possible, devices should be placed in different zones within the location (e.g. nesting zone, vegetation zone).
- Devices should be placed by the second week of April and collected at the end of September.
- The beach structure is likely to be affected by natural phenomenon; for instance, winds, waves, and inundation. It is therefore advisable to take precautions, such as fixing the devices or covering them with grids.
- Take GPS coordinates of the device locations.

Required equipment

- Data loggers
- GPS
- An interface programme (to programme devices and download data)

2.4. Monitoring of Abundance of In-Water Population

2.4.1. Boat Survey

86. In-water population monitoring is used to estimate the population size, abundance, and sex ratio of a population in a particular area. It is also very useful for collecting biological samples. A research area can be a breeding, feeding, overwintering ground or a mixture of these three areas. This means that different populations can be found in an area. Sea turtles are a migratory species, so the timing of the study is important and should be selected carefully and a standardized methodology should be followed.

Boat based survey: capture-mark-recapture (CMR) method

87. Two common methods are used for in-water surveys. First, a capture net is set in the sampling area. Second, the turtles are captured using the rodeo technique.

(i) In the case of a large study area with low visibility and deeper water, a capture net is preferable.
(ii) The mesh size of the net should be large to avoid the by-catch of other marine animals but small enough to capture turtles.
(iii) The mesh size of the net can be from 10 to 15 cm. Once the net is set, it should be monitored regularly from a boat.
(iv) If the team is sufficiently large and the visibility is high, it is best to swim to the net for this study.
(v) When a turtle becomes entangled in the net, it should be removed and transferred to the boat for measurements and sample collection.
(vi) The turtle should remain on the boat until the net is collected and then released into the sea.
(vii) This study can be used to estimate the size and sex ratio of the population.
(viii) The rodeo technique requires smaller team and can be used in small areas and in shallow waters with high visibility.
(ix) When a sea turtle is spotted from the boat, a swimmer dives and captures the turtle.
(x) The sea turtle is then measured, and biological samples are collected.

Required Equipment

- A Boat
- Entanglement net
- Measurement equipment
- Tagging equipment
- Balance
- Snorkel
- Mask
- Fins
- Ultrasonic-type depth meter
- GPS
- A minimum of five crew members, which can be increased according to type of study, area, and budget

2.4.2. Satellite Tracking

88. A satellite telemetry of adult sea turtles is required for identifying the foraging grounds used by the adults of each population. This technique can also be used to assess the surface time of

turtles at foraging grounds. A parameter is necessary to derive absolute population estimates for aerial surveys.

2.4.2.1. Application of satellite tags and data loggers

89. Satellite tracking is one of the most commonly used techniques for tracking sea turtles, as it can determine migratory corridors, feeding and overwintering areas. It also gives precise information on the localisation of the animal. However, as the cost of the tracking devices is high, this may limit the number of turtles that can be tracked.

90. The Argos tracking system is the most commonly used, but the Iridium satellite device has become a new option in recent years. The systems work in similar way, and a common methodology is used for attaching transmitters to turtles.

91. Before attaching the transmitter to the sea turtle, it should be checked using a small receiver device. If the transmitter is emitting signals, turn the receiver device off and prepare the turtle for the attachment.

92. The turtle can be stabilised in a large tank (1m X 1.5 m). The transmitter is normally attached on the second vertebral scutes. The attachment area on the carapace should be cleaned of epibionts, then rubbed with sandpaper until smooth. Carefully remove any dust and swab the area with acetone, before leaving it to dry for a few minutes.

93. Use a strong glue, such as marine epoxy, to attach the device. Depending on the type of glue being used, it can be mixed prior to application, or on the carapace itself. The glue is also applied to the device but avoid getting it on important parts, such as the magnet connection point or sea water switches. After completing the attachment, leave the sea turtle in the open air until the glue is completely dry. Then it can be released into the sea.

Double check! Make sure the device is switched on before releasing the turtle. Forgetting to check that the transmitter is operational before the release is a common mistake.

Required Equipment

- Satellite transmitter tags (order at least two months before they are needed)
- Container for handling turtle (100 X 150 cm)
- Sandpaper
- Acetone
- Glue (marine epoxy resin)
- Magnets (to switch on and off the tags)

2.4.3. Aerial Surveys and use of UAV

94. Aerial surveys are the best method for determining the abundance of turtles at sea and detecting changes in population, before they translate into changes in nest counts.

95. Aerial surveys necessitate information about time spent on the surface, in order to produce absolute estimates of turtle abundance. Drones, for monitoring nesting activities and making individual counts of sea turtles swimming on the surface, are becoming popular in recent years.

96. Aerial surveys should be conducted every five years at each major foraging ground (Alboran Sea, Balearic Sea, Algerian Basin, Tyrrhenian Sea, Libyan Sea, Adriatic Sea, Aegean Sea, the southern coast of Turkey and the Levantine Sea).

97. Unmanned aerial vehicles (UAVs) or drones are increasingly being adapted for gathering data, at previously unprecedented spatial and temporal resolutions, in diverse geographic locations. This easily available, low-cost tool is improving existing research methods and enabling novel approaches in sea turtle ecology and conservation. For studies on turtle nesting, sea distribution

and behaviour surveys, UAVs can reduce costs and field time, while improving safety, as well as data quality and quantity, over existing methods. They are also expanding into new avenues, such as the surveillance of illegal take (See Rees et al., 2018 for further information).

98. However, there are some limitations on the use of UAVs:

(i) They require a trained pilot
(ii) The battery life of most UAV's is less than 30 min. Therefore, flight time and the monitoring area should be carefully determined before starting the study.
(iii) Meteorological conditions (strong winds, light, etc.)
(iv) Legal limitations (no-flight zones, necessary licences and permissions)
(v) Ethical implications (privacy, effects on animals etc.)

99. Plane surveys are also a useful methodology for estimating sea turtle abundance. However, considering the flight altitude especially in the areas with deeper water and low visibility, plane surveys have challenges identifying species, sex and size classes for sea turtles (Jean et al., 2010; Herren et al., 2018), and other marine animals (Laran et al., 2017).

Required Equipment

- UAV (DJI drones are the most common for sea turtle research)
- Trained UAV pilot
- Tablet, computer
- Remote control device
- Replacement batteries

2.4.3.1. Monitoring Remote Nesting Beaches

100. A UAV can be used for the regular monitoring of remote beaches with low nesting density, especially when the beach is inaccessible. This saves time and gives precise information about sea turtle nesting activities.

2.4.3.2. In-Water Observations

101. UAVs are very useful tools for monitoring in-water populations. They can be used to determine the density and distribution of sea turtles in foraging areas, as well as investigating their behaviour, monitoring and mapping habitats.

2.5. Genetic Structuring

102. Molecular genetic techniques are widely used and there are several non-invasive sampling methods. Although these look simple enough, they require close attention during sampling, due to the possible contamination of DNA from different individuals. Genetic samples can be collected from adult females, hatchlings and dead embryos.

103. Blood and skin are the two most common tissues used for collecting genetic samples. Blood collection is described above. A tissue biopsy from skin is straightforward: tissues are collected from the front or (preferably) the rear flipper using a biopsy punch. If no biopsy punch is available, use a scalpel. A skin sample of 1.5 to 2.0 cm is adequate for genetic analyses. To prevent bleeding the biopsy should be no deeper than 0.5 mm.

104. After sampling, clean the area with betadine to prevent any bacterial infection. Place the tissue sample in 70% ethanol. Always use single-use disposable sampling materials and gloves.

If the same sampling materials are used, such as biopsy punch or scalpel, for different turtles, DNA may be transferred from one sample to another.

105. For genetic analyses, take a small amount of muscle from a dead turtle during necropsy. It is best to collect the same tissue for each research study, if possible.

106. Cheek swabs and carapace scrubbing are other sampling methods. A cheek swab is not ideal, as the mouth of the turtle must be kept open during sampling.

107. When collecting samples for a stable isotope from the carapace, carapace scrubbing can be used. When scrapping a carapace, the white epidermal tissue can be seen on the inner part of the carapace sample. Rinse the carapace sample and let it air-dry for a short period. It is easy to remove the epidermal tissue and store the sample in ethanol.

108. Available information is based on the use of mitochondrial haplotypes and nuclear microsatellites. This allows the individual assignment of loggerhead and green turtles to major nesting areas in the Atlantic (Carreras et al., 2011, 2014).

109. Genetic structuring on nesting beaches and in foraging grounds is better determined by using genetic analyses together with other nesting information, such as remigration interval and clutch frequency through female fingerprinting. This helps to understand the genetic contribution made by nesting beaches to foraging grounds.

2.6. Monitoring Stranding

110. Most research on sea turtles has traditionally been conducted on nesting beaches, even though they spend most of the time in the ocean. The available information suggests that turtles do not distribute homogenously within the sub-basins (Clusa et al., 2014) and that some key parameters, such adult body size and fecundity, vary between females foraging in different sub-basins, although they nest on the same beach (Zbdinen et al., 2011; Cardona et al., 2014). Therefore, detailed information about adult habitat use is critical, albeit some for major nesting beaches is still missing.

111. Stranded turtles are a good data source for collecting various data about sea turtle biology and possible threats. The following information can be collected from stranded turtles:

- The spatio-temporal distribution of turtles
- Tissue sampling for genetic and stable isotope analyses
- Bone sampling for skeletochronology
- Size classes
- Sex
- Threats (cause of deaths)
- Marine pollution (marine litter ingestion; monitoring organic and chemical pollutants in the marine environment).

112. Common protocols are available for data collection from stranded turtles. For example, a detailed protocol for collecting data from stranded turtles, in order to monitor marine litter ingestion, was prepared by the INDICIT consortium. This can be found at their project website https://indicit-europa.eu/indicit-documents/ .

2.7. The Monitoring of Pollution and Pollutants

113. Sea turtles can ingest or become entangled by anthropogenic debris. In contrast to ingestion, entanglement has been reported as an important cause of stranding in the Mediterranean (Tomás et al., 2008; Casale et al., 2010). Studies on marine debris ingestion by sea turtles in the Mediterranean have been reviewed by Casale et al. (2016). It shows that the

occurrence of marine debris varies among studies, with the highest occurrence (80%) reported from turtles caught by pelagic longlines in the central Mediterranean (Casale et al., 2016). Investigations into plastic ingestion can be made using the necropsies of dead turtles but contamination from the environment during the necropsy should be avoided.

114. Before removing the GI tract, tie the anterior part of the oesophagus. Then, tie it above cardiac sphincter and at the beginning of intestine (after the pyloric sphincter). Finally, tie the end of the intestine. In this way the contents of the different GI tract sections will not become mixed.

115. The working space should be cleared before an investigation of the GI tract for possible contamination. Cut each section apart, then measure the weight (and the volume, if required) of the sections (oesophagus, stomach, intestine).

116. Start by cutting each section separately and placing them in a sieve with a mesh size of 1 mm under running water. Collect each foreign object from the contents of each section and place in a container with 50% ethanol. Collect organic materials for diet studies and keep the organic materials in 70% ethanol.

117. Follow the same procedure for each section. Always clean the sieve before starting on another section of GI tract. Measure the empty weight and volume of each section.

118. Clean and dry the collected foreign materials, then measure the weight and volume (if possible). Plastic sheets are needed, and a four-digit precision scale is necessary for measuring micro plastics (from 1 mm to 5 mm in diameter). After measuring, label and keep all samples in a plastic bag.

Chemical Pollutants

119. Chemical pollutants represent a potential threat for sea turtles too. This is especially significant when the several large rivers that flow into different parts of the Mediterranean and its semi enclosed nature are taken into consideration. The presence of heavy metals in sea turtles has been studied in different parts of the Mediterranean Sea. Most of the concentration values were below toxicity levels, apart from the north Adriatic (Franzellitti et al., 2004) and the sea off southern Turkey (Kaska et al., 2004).

120. Recently, Cortes-Gomez et al. (2017) reviewed the metal concentrations revealed in 58 studies among sea turtle species. They summarised the results and reported that the accumulation of pollutants varies between species, the geographic locations and their life-stages. Ross et al. (2017) also reviewed the toxic metal contamination in sea turtle tissues from 95 studies and remarked on the implications for human health. A recent study reported ecotoxicological assessment of stranded loggerhead turtles from blood, skin and scute tissues (Casini et al., 2018). They tested biomarker responses of the selected tissues and contaminant levels in these tissues. Their results also suggest that older animals showed highest levels of erythrocyte nuclear abnormalities, which may indicate a long term ecotoxicological stress in marine environment.

121. Stranded sea turtles are extremely useful for molecular studies, stable isotope analysis and skeletochronology and should be monitored regularly. Carapace length is a parameter commonly recorded from most stranded and rehabilitated turtles. Although stranded individuals are certainly a biased sample, they offer the most cost-effective method for collecting information about size distribution in foraging grounds.

Required Equipment:

- Please see section 2.2. for sampling methodology of blood, skin and scute tissues and required equipment

- For sampling from internal organs, necropsy should be performed. Please see standard protocols of INDICIT Consortium, and Protocols for monitoring interactions between marine litter and marine turtles (UNEP/MAP/SPA/RAC, in press) for sea turtle necropsy. These protocols are planned to be harmonized in 2019. Video tutorials are also accessible at INDICIT Consortium webpage.

2.8. Habitat Use: Stable Isotope Analysis

122. Stable isotope analysis (Carbon (^{13}C), Nitrogen (^{15}N) and Sulphur (^{34}S)) offers an inexpensive method for mass monitoring. The Mediterranean Sea is subdivided into a number of isotopically distinct sub-basins (Cardona et al., 2014), which offers a good opportunity to use stable isotopes as habitat markers both for loggerhead and green turtles (Zbinden et al., 2011; Cardona et al., 2014). Regular collections of tissue samples from nesting females will enable the identification of the foraging grounds used by the females nesting at each major site.

123. The first approach is the collection of tissue samples from adult satellite tagged turtles, tagged at their nesting beaches, and the use of the stable isotope ratios in these samples to characterize the foraging grounds of the turtles (Zbinden et al., 2011).

124. The second approach is the collection of tissue samples of adults and juveniles captured at their foraging grounds and use the stable isotope ratios to characterize them. This approach assures a large sample size from most areas, but there is no way to discriminate between transient and resident individuals, which will reduce the spatial accuracy of the data. The stable isotope ratios of satellite tracked turtles are also useful for identifying potentially transient individuals.

125. The third approach is the use of stable isotope ratios in potential prey from different foraging grounds to characterize them. This is necessary in order to understand the sources of variability among foraging grounds and to make sure that differences in the stable isotope ratios of turtles are because of differences in the isotopic baseline and not because of variances in diet. However, to derive stable isotope ratios in turtle tissues from those of their potential prey is not straightforward, even if prey-to-predator discrimination factors are known.

126. Tissue selection is critical for stable isotope analysis, as diet-to-predator discrimination factors are tissue dependent (Seminoff et al., 2006; Reich et al., 2008; Vander Zanden et al., 2012). Skin is probably the best option, as can be sampled easily from both dead and alive individuals and integrates diet over several months. However, collecting skin samples from most females is unlikely at most nesting beaches due to logistical constraints.

127. Sampling dead hatchlings is easier and less intrusive, but the probability of finding a dead hatchling increases with clutch size and hence this approach may bias the sample in favour of the females using the most productive foraging grounds, as they lay more eggs (Cardona et al., 2014). Egg sampling offers an alternative to avoid such a bias, but this means that each nest has to be excavated once discovered. Furthermore, the methods need to be improved to infer stable isotope ratios in female skin from those in an egg.

Sample Collection for Stable Isotope Analyses

128. The most common stable isotope sampling tissues are blood, carapace and skin from live turtles. Bone samples from dead turtles also contains important information. Each tissue may contain different information about their life cycle.

129. The volume of a sample needed for stable isotope analyses is minimal. Samples of 0.5g to 2.0g samples are sufficient.

130. To collect blood, follow the same procedure as given previously. If samples are to be collected from other tissues, bear in mind that all samples must be collected from the same part of each animal. Tissues collected from different parts of the animals (e.g. a skin sample from the proximal part of the front flipper from one turtle and a skin sample from another's rear flipper) may provide different information and as a result the study samples will not be homogenous.

131. Sampling from the skin: Begin by cleaning the sampling area. Gently remove any epibionts and algae and rinse with water. Using a 6 mm biopsy punch is an easy way to obtain a skin sample. If using a scalpel, restrain and immobilize the turtle and use forceps to facilitate sampling. Place the samples in cryovials or Teflon bags and store, frozen to at least -20℃, until analysis.

132. Sampling from the carapace: There are two methods for collecting scute samples: cutting a small keratein with biopsy punch or a scalpel, and shaving. If the turtle is large, use a biopsy punch or scalpel to sample the scute. In this way, it is possible to collect different layers of keratin tissue. Be careful when using a scalpel, as the blade can break during sampling.

133. Start by cleaning the sampling area of algae, sand any other materials. Gently shave the top layer then rinse with distilled water, if possible. An 1X1 cm scute sample is usually enough for analysis. Try to reach the white epidermal tissue under the keratin layer. After sampling, remove the white epidermal tissue from the scute. Rinse the sample with ethanol and air dry it to facilitate removing the tissue. Place the samples in cryovials or Teflon bags and store, frozen to at least -20℃, until analysis.

134. If the samples are from a juvenile turtle, collect samples with shaving the scute, as the keratin layer is very thin, especially in green turtles. Clean and rinse the sampling area, then start shaving an entire scute using a knife (the 5th ventral scute is suitable for this procedure). Approximately 2.00 mm of the keratin can be shaved. Use a wind shield (e.g. umbrella) while shaving. Place the samples in cryovials or Teflon bags and store, frozen to at least -20℃, until analysis.

Required Equipment

- Biopsy punch
- Scalpel
- Blade (for scratching)
- Vials (for sample storage)
- Teflon bags (for sample storage)
- Ethanol 70%
- 21g needle and syringe/vacutainer (for sampling blood)
- Heparinized blood tubes
- Centrifuge (for separating blood cells from the plasma)
- Vials and cryo tubes

2.9. Contributions from Fisheries

135. Fishing activities are one of the main threats to sea turtles, as they can be caught as bycatch in the various fishing gears. Then again, collaborating with fishermen can be an important monitoring tool. Such partnerships allow researchers to collect data from inaccessible areas, especially from pelagic areas. When limitations such as time, human resources, and budget and so on are taken into account, collecting data from oceanic areas is invariably difficult but the following information can be gathered from fishing operations:

- Distribution ranges in marine habitats
- Demography
- Sex ratio in marine habitats
- Tag return
- Seasonality of marine habitats
- Sampling tissues (e.g. blood, skin, scute)
- Health assessment

136. Researchers are able to collect data on-board during fishing operations. In addition, fishermen may provide important information by self-sampling without the assistance of a researcher. There are also technologies available for *citizen scientists*, such as smart phone applications for collecting data on an entangled or a stranded animal. Smart phones can also be provided to the fishermen to encourage their involvement in monitoring projects. Nevertheless, with or without new technologies, fishermen can collect the following data:

- Entangled sea turtle species
- GPS location
- CCL measurement
- Tag return information
- Tagging
- Photograph of entangled/stranded turtles

137. In addition, collaboration with fisheries researchers and use of their database would be useful for monitoring sea turtles in marine habitats. It should be noted that specific codes (e.g. TURAA00 for turtles) designed by FAO for each species or groups are used in these databases (Sparre 2000).

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E. Guidelines for monitoring non-indigenous species (NIS) in the Mediterranean

Table of Contents

1. Background

1. The Ecosystem Approach (EcAp) process was elucidated in 2008 at the 15th Meeting of the Contracting Parties to the Barcelona Convention, in Decision IG. 17/6, with the vision of "A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations", along with an Ecosystem Approach Roadmap, aiming to achieve this vision. Subsequently, the Parties agreed on strategic goals to achieve the Ecosystem Approach vision, on 11 Ecological Objectives (EOs), and on matching Good Environmental Status (GES) descriptions, targets and indicators, including EO 2 (Non-indigenous species).

2. At their 19th Ordinary Meeting (COP 19, Athens, Greece, 9-12 February 2016), the Contracting Parties (CPs) to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) adopted the Integrated Monitoring and Assessment Programme and related Assessment Criteria (IMAP) which describes the strategy, themes, and products that the Contracting Parties are aiming to deliver, through collaborative efforts in the framework of the Mediterranean Action Plan(MAP) , during the second cycle of the implementation of the Ecosystem Approach Process in 2016-2021.

3. The overarching principles guiding the development of the IMAP include (i) adequacy; (ii) coordination and coherence; (iii) data architecture and interoperability based on common parameters; (iv) concept of adaptive monitoring; (v) risk-based approach to monitoring and assessment, and (v) the precautionary principle, in addition to the overall aim of integration.

4. Data and information are gathered through integrated monitoring activities on the national level and shared in a manner that creates a compatible, shared regional pool of data, usable by each Contracting Party. The IMAP information system will ensure the establishment of the regional pool of data and will allow the production of common indicator assessment reports in an integrated manner, following the monitoring specifics and data provided, which ensures comparability across the Mediterranean region. Integration is achieved through IMAP both at monitoring level, through an integrated monitoring system, following common principles and undertaken in a coordinated manner, and at assessment level, with the overall aim to assess the overall status of the marine and coastal environment.

5. The common indicators are the backbone of IMAP which covers 11 ecological objectives including the non-indigenous species (EO2), Citing UNEP/MAP (2017):

'In the context of the IMAP, a common indicator is an indicator that summarizes data into a simple, standardized, and communicable figure and is ideally applicable in the whole Mediterranean basin, or at least on the level of sub-regions, and is monitored by all Contracting Parties. A common indicator is able to give an indication of the degree of threat or change in the marine ecosystem and can deliver valuable information to decision makers.'

1.1 Definitions

6. The following definitions have been extracted from the Decision IG.22/7 (Barcelona Convention, COP19, 2016) entitled ''Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria'' and from the Joint Research Centre (JRC) guidance document on the MSFD Descriptor 2 (Non-indigenous species), citable as Olenin et al. (2010).

7. **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.

8. **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 adverse effect on biological diversity, ecosystem functioning, socio-economic 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.

9. The key term "…levels that do not adversely alter the ecosystems" is described as the absence or minimal level of "biological pollution". The latter is defined as the impact of IAS at a level that disturbs environmental quality by effects on: an individual (internal biological pollution by parasites or pathogens), a population (by genetic change, i.e. hybridization), a community (by structural shift), a habitat (by modification of physical-chemical conditions) or an ecosystem (by alteration of energy flow and organic material cycling). The biological and ecological effects of bio-pollution may also cause adverse economic consequences.

1.2 Legislative framework outside EcAp

10. The CBD's (Convention on Biological Diversity) Strategic Plan for Biodiversity 2011-2020 includes twenty measurable Aichi Biodiversity Targets, which need to be met by 2020, including Target 9 which refers to NIS: '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.'

11. COP Decision VI/23 includes guiding principles for the prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species9. Guiding principle 5 on Research and monitoring recognizes that these are required not only to develop an adequate knowledge base to address the problem but are also key to early detection of new invasive alien species.

12. Monitoring should include both targeted and general surveys, and benefit from the involvement of other sectors, including local communities. Research on an invasive alien species should include a thorough identification of the invasive species and should document: (a) the history and ecology of invasion (origin, pathways and time-period); (b) the biological characteristics of the invasive alien species; and (c) the associated impacts at the ecosystem, species and genetic level and also social and economic impacts, and how they change over time.

13. The European Union's Marine Strategy Framework Directive (MSFD) is a wide-ranging framework directive (2008/56/EC) with the overall objective of achieving or maintaining Good Environmental Status (GES) in Europe's seas by 2020 (MSFD, 2008). Eleven high level qualitative Descriptors of GES have been defined in Annex I of the MSFD, including Descriptor 2, for which GES has been defined as 'Non-Indigenous Species introduced by human activities are at levels that do not adversely alter the ecosystem.' Currently, the first six-year cycle of the MSFD is nearing completion, with EU Member States having submitted to the EU Commission their respective Programme of Measures (PoM) prior to their eventual implementation, following the collection of monitoring data for different Descriptors.

14. EU Regulation 1143/2014 lists the Invasive Alien Species (IAS) of Union Concern which should be the target or management measures and in which no commercial trade is allowed. Currently, this Regulation lists only terrestrial and freshwater species, and not marine ones.

15. Parties to the Bern Convention are required to Parties "to strictly control the introduction of non-native species" (Article 11.2.b). The European Strategy on Invasive Alien Species adopted under the framework of the Convention similarly addresses research and monitoring10. Monitoring that is systematic helps build an understanding of the ecological, distribution, patterns of spread and responses of IAS to management.

1.3 Scope and introduction to EcAp Common Indicator 6

16. The scope of this document is to elucidate the monitoring guidelines to address the EcAp Common Indicator 6: "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".

17. This Common Indicator was selected by the February 2014 Integrated Correspondence Group on GES and Targets (Integrated CorGest) of the EcAp process of the Barcelona Convention from the integrated list of indicators adopted in the 18^{th} Conference of the Parties (COP18), as a basis of a common monitoring programme for the Mediterranean in relation to non-indigenous species, being preferred over other Common Indicators for Ecological Objective (EO) 2 (Non-indigenous species), such as the 'Ratio between non-indigenous invasive species and native species in some well-studied taxonomic groups.'

18. Common Indicator 6 is a trend indicator, whose main objective is to establish reliable, long-term datasets as a first step of monitoring. In order for this trend indicator to become operational, at least two years of relevant data are necessary, in order to allow a minimal comparison of two annual datasets. In the absence of relevant pre-application (of the trend indicator) data, it is advised to deploy a two-year dataset collected after the optimisation of the indicator.

19. Although the GES for EO2 has not yet been fully elucidated by Contracting Parties, with respect to Non-Indigenous species, UNEP/MAP (2014) establishes the following aspirations:

(i) that no new non-indigenous species are introduced, and
(ii) that the number and composition of non-indigenous species have decreased to such a level where only non-indigenous species which had previously settled at a location are present, i.e. a reference level indicating that the number of non-indigenous species has remained the same in the period of three successive years, assuming that the eradication of established marine NIS is virtually impossible.

1.4. Aims and objectives

20. The main aim of this document is to provide guidance to environmental management practitioners (e.g. environmental authority representatives, researchers, students, Marine Protected Area [MPA] representatives) on field methodologies for monitoring Non-Indigenous Species (NIS) in MPAs and in identified hotspots. This provision of guidance is pursuant to enabling the same practitioners to achieve the goals of EcAp Common Indicator 6, by reviewing recognised good practices in the field of NIS monitoring protocols.

2. Monitoring protocol

2.1 Rationale and strategy

21. Two potential metrics/attributes of the Common Indicator 6 identified within UNEP/MAP (2014) are the following:
(i) Abundance of non-indigenous species
(ii) Temporal occurrence and spatial distribution of non-indigenous species

(i) It is widely recognised that the collection of abundance monitoring data is an expensive process. It is thus recommended to focus monitoring efforts on the recording of all NIS in a particular area – i.e. on the compilation of site-specific NIS inventories. The collection of abundance monitoring data might only be justified in cases of a species exhibiting abrupt spreading beyond a pre-defined threshold. Given the broad geographical range of monitored areas within different Contracting Parties, it is recommended that these thresholds are calculated as a fraction or percentage of the total monitored coastline, rather than as an absolute length of coastline. A relevant threshold example could be the spread of a NIS within a coastal stretch exceeding 5% of the total national coastal extent, or the doubling of the number of coastal monitoring stations at which a NIS has been reported.

(ii) To monitor the trend indicator of non-indigenous species two parameters [A] and [B] should be calculated on a 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, computed as follows:

[A]: The number of non-indigenous species at T_n (year of reporting) that was not present at T_{n-1} (previous year). To calculate this parameter, the non-indigenous species lists of both years are compared to check which species were recorded in T_n but were not recorded in T_{n-1} regardless of whether or not this species was present in years antecedent to T_{n-1}. To calculate this parameter, the total number of non-indigenous species is used in the comparison (although species names should also be listed).

[B]: The number of non-indigenous species at T_n minus the number of non-indigenous species at T_{n-1}.

22. Trends in both [A] and [B] should be monitored to develop the best management plan for non-indigenous species in an area.

2.2 Spatial and temporal considerations (the 'Where' and the 'When')

23. It is recommended that NIS surveys are conducted within both 'hotspots' areas (e.g. ports and their surrounding areas, docks, marinas, aquaculture installations, heated power plant effluents sites, offshore structures) and within marine areas subject to some form of environmental management, most notably Marine Protected Areas (MPAs).

'Hotspots' 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 considerable number of vessels) or
(ii) an elevated number of NIS already established within the confines of the same hotspot.

24. Typically, hotspots 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' hotspots could also be considered within this same category, including locations subject to intense anchoring pressure during the tourist season.

25. In terms of NIS 'hotspots', UNEP/MAP (2014) recommends that NIS monitoring is conducted for at least two hotspot 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 locations do not directly influence each other;
- Vulnerable areas with prospects for 'inoculation' or 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 representativity. 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.

26. The exact geographical location of each selected sampling station in both hotspots and MPAs should be recorded through GPS coordinates, so as to enable consistent sampling on successive occasions.

27. In terms of sampling frequency, it is recommended that hotspots are monitored on a bi-annual/six-monthly frequency, so as to cover both spring and autumn seasons, with the same monitoring survey being conducted after three years.

28. MPAs should be monitored on an annual basis (preferably in spring), given that the rate of introduction of new NIS within MPAs is expected to be lower than that observed within hotspots, such that the latter sites should be sampled with a higher intensity. The rationale behind the preference for the spring season for monitoring purposes is that recruitment in most marine species takes places during this season, and thus conducting monitoring surveys in spring allows for the collection of different NIS life stages which only occur during this time of the year.

29. The following table summarises the recommended spatial and temporal recommended dimensions of the NIS monitoring:

Sampling location typology	**Recommended number of sampling stations**	**Recommended sampling frequency**
‘Hotspots’	Two per NIS introduction pathway	Bi-annual/six-monthly
Marine Protected Areas (MPAs)	At least two per MPA	Annual

2.3 Procedures (the ‘Which’ and ‘How’)

30. Which NIS to focus upon within the trend analyses is one of the most important considerations to make. The trend indicator (2.1ii), in fact, hinges on the compilation of a preliminary inventory of NIS present within a monitored marine area, which will then also feed into attribute/metric 2.1i. The compilation of this baseline NIS list will also, in turn, allow the identification of reference conditions and thus facilitate a better definition of GES for EO2. This first NIS inventory can be compiled through the exclusive or mixed deployment of any of the following tools:

(a) **Rapid Assessment Survey**. According to Lehtiniemi et al. (2015), rapid assessment is ‘a synoptic assessment, which is often undertaken as a matter of urgency, in the shortest time frame possible to produce reliable and applicable results for its defined purpose. Protocols for rapid assessment of marine and coastal biological diversity are available (e.g. UNEP/CBD/SBSTTA/8/INF/13 – Pedersen et al., 2005). Rapid assessment monitoring for targeted species enables direct reporting to management when a notable species is encountered, and the ‘field’ work can be undertaken by a small group of experts. The method is cost-effective and relevant when prompt management response is sought, but unsuitable for detection of newly arrived introductions;

(b) **Literature review**, specifically of recently published (preferably not earlier than 2010) national censuses or inventories of recorded NIS. For EU Member States, the MSFD IA (Initial Assessment) reports for Descriptor 2 could hold useful relevant information, as well as a number of international and regional (European or Mediterranean basin-scale) databases and lists. These include the European Alien Species Information Network (EASIN) developed by the Joint Research Centre of the European Commission, which facilitates the exploration of non-indigenous species information in Europe (and the entire Mediterranean), from distributed resources through a network of interoperable web services, following internationally recognized standards and protocols. Additional global relevant databases include the CABI Invasive

Species Compendium, the GISD (IUCN Invasive Species Specialist Group and IUCN Global Invasive Species Database) and FISHBASE, whilst additional databases of regional interest include DAISIE (Delivering Alien Invasive Species Inventories for Europe), the CIESM Exotic Species Atlas linked with NIS base, the MAMIAS Database from the Specially Protected Areas Regional Activity Centre (SPA/RAC) of the UNEP/MAP Barcelona Convention and the ESENIAS East and South European Network for Invasive Alien Species. Regional data portal on invasive alien species (IAS) in East and South Europe.

(c) **Citizen science**. 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' events organised 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. An example of a national citizen science campaign is Spot the Alien Fish (www.aliensmalta.eu) one, targeting fish NIS in the Maltese Islands, whilst a number of additional citizen science campaigns operate on.

Within hotspots, a two-pronged monitoring approach is recommended, namely:

(i) Rapid Assessment Survey, as optimised for NIS monitoring within hotspots in Minchin (2007) and in UNEP/MAP (2014). These surveys are conducted by a team of marine species experts spending a specified time period (ideally, this is standardised to ensure uniformity, with a duration of 30 minutes considered to be a feasible one for each individual survey) at the survey site (preferably through SCUBA diving, but possibly even through snorkelling in very shallow areas) and identifying species by observation of artificial substrates such as jetties and wharves, pontoons, long-standing buoys and other artificial structures such as fish-farm cages. A site master records the scientists, findings and abundance of species at each site. Samples of specimens may also be taken back to the lab, where species identification is confirmed, through ex situ analyses involving dissection, microscopic examination and liaison with reputable taxonomists of a pan-Mediterranean profile. This is especially feasible for taxonomically challenging groups such as sponges, hydroids, serpulids, bryozoans and ascidians. In order to further assist in taxonomic identification efforts within the targeted taxa, samples of recorded species should be preserved in absolute, non-denatured ethanol for subsequent molecular analyses. The basic equipment necessary to conduct this monitoring survey includes underwater photographic and/or video cameras, preferably supplemented by the provisions of high levels of artificial light (e.g. through the provision of strobes or basic flash) and underwater data recording facilities, which might include an underwater slate and pencil, or a laminated notebook, per SCUBA diver.

(ii) Scraping technique. This is to be deployed along vertical transects running from the surface of the monitored artificial structure hosting the fouling assemblage down to the foot of the same structure, with sampling stations being placed at a minimum of three different depths along the same transect. The scraping protocol was developed within CIESM's PORTAL programme (Galil, 2008), which in turn was based on the CRIMP methods first described by Hewitt & Martin (1996) and later by Hewitt & Martin (2001). It involves the collection of the fouling community enclosed within a quadrat of standard dimensions (commonly, 50cm x 50cm) through scraping by means of appropriate utensils (e.g. hammer and chisel), within a fine-mesh bag, followed by ex situ, laboratory analyses and identification. Once on land, the collected samples should be preserved by placing the fine-mesh bag directly in a five-litre bucket where its contents are left to soak in non-denatured ethanol (at least 70%) prior to laboratory examination. Different preservatives other than ethanol might need to be deployed for taxa such as ascidians, for which a formaldehyde: seawater mixture is preferred. Caution should be applied when handling formaldehyde given its highly corrosive and carcinogenic nature.

Figure 1 illustrates the standard 50cmx50cm quadrat normally deployed during scraping exercises within fouling communities.

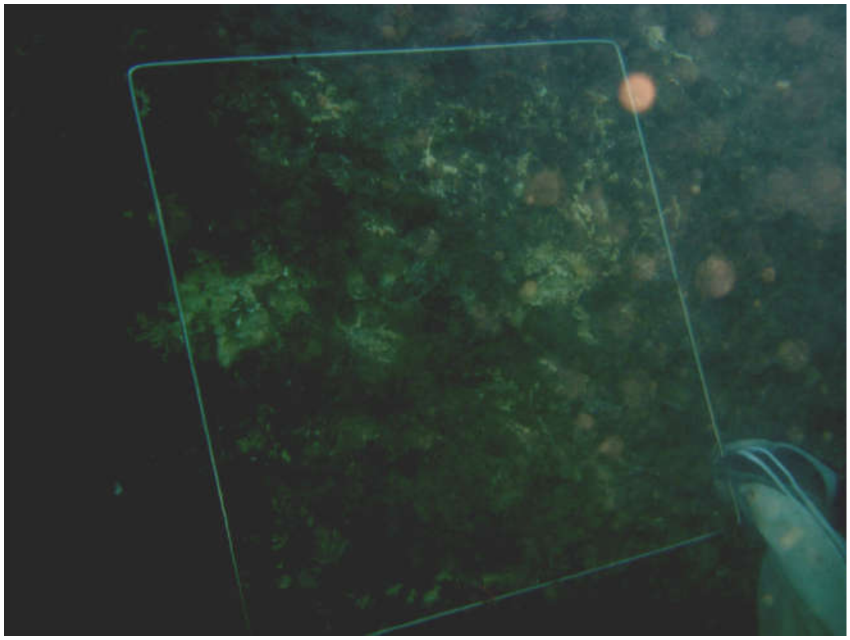

Figure 1 – 50cmx50cm quadrat deployed during scraping exercises within fouling communities (credits for photo: A. Deidun).

Within MPAs, the monitoring protocol for NIS have been developed by the IUCN and is elucidated in Otero (2013). Linear transects having an individual length of 100m, perpendicular to the shoreline and representative of the habitats, depth ranges and substrates within the MPAs are identified. Three replicate and comparable transects at each MPA sampling station are deployed, with a minimum distance of 10m between each transect. Ideally, the linear transect is laid out in the field through the use of a measuring tape of adequate length, which is secured on the seabed at both ends through the use of extra weights.

31. The location of each transect is identified by GPS coordinates for latitude and longitude to ensure faithful reproduceability in future occasions of the conducted monitoring. Non-indigenous species encountered up to five meters on either side of transect are recorded, counted and geo-referenced. Figure 2 illustrates the field conduction of the prescribed monitoring protocol within MPAs.

Figure 2 – Field conduction of the proposed monitoring protocol within MPAs (credits for photos: http://blog.owuscholarship.org/).

32. The water depth at which different NIS species are recorded during RAS or at which scraping samples are collected should be recorded. SCUBA divers must thus be equipped with water depth gauges to be able to achieve this requisite. Voucher specimens of first records should be retained within catalogued collections for reference purposes.

33. Additional, complementary data which should be collected for **both hotspots and MPA**s on a non-mandatory basis include:

(a) Semi-quantitative estimates of abundance of both (i.e. native and non-native) community components, through the deployment of different techniques for different taxonomic groups. For instance,

(i) for fish, direct counting for a fixed (e.g. 10-15 minutes at each site) span of time within a visual census could be deployed;

(ii) for benthic macroalgae, direct counting of clusters of the same species, followed by an estimation of the Braun-Blanquet cover index for a standard number of clusters (e.g. 3) of the same macroalgal species could be performed. A similar approach would be useful for quantifying sessile, encrusting invertebrates present in the area. Alternatively, the CARLIT index, adopted within the Water Framework Directive (WFD) and the MSFD, could be quantified;

(iii) individuals sessile and slow-moving non-encrusting invertebrates (e.g. gastropods) can be counted directly over a pre-determined time span (e.g. 10-15 minutes) or within a pre-determined spatial area (e.g. 5mx5m benthic area).

(b) Values for salient water biogeochemical parameters, including water column temperature, salinity and dissolved oxygen content, should be recorded, where possible.

Collection of ancillary socio-economic metrics, through:

(c) Preliminary observations of tangible impacts of the recorded NIS on native species, also through semi-quantitative (and probably arbitrary) indices of impact intensity on native species, potentially including broad impact categories ranging from ‘High’ to ‘Low’;

(d) Assessment and identification of potential introduction pathways for each recorded NIS.

Assessment of potential introduction pathways should take into consideration ongoing developments from the pathway assessment exercise by the IUCN-Species Survival Commission-Invasive Species Specialist Group on pathway terminology, classification and analysis of pathway data (http://www.cbd.int/doc/meetings/cop/cop-12/information/cop-12-inf-10-en.pdf).

34. The salient features of every proposed NIS monitoring protocol for both invasion hotspots and MPAs are summarised in Table 1.

Table 1 - Summary table of salient features of the proposed NIS monitoring protocols for invasions hotspots and MPAs.

Monitored marine area typology	Monitoring parameter	Recommended monitoring methodology	Recommended equipment to be deployed during monitoring	Advantages of monitoring protocol	Limitations of monitoring protocol
NIS hotspots	Number/diversity of broader NIS community	Rapid Assessment Survey (RAS)	• Underwater photographic and/or video camera • Underwater slates or notebooks	Rapid and easy to apply	Requires taxonomic experts in the field; might overlook some cryptic NIS through non-observation; provides only semi-quantitative

					measures of abundance
	Number, abundance and density of native and non-native fouling community	Scraping technique	• Quadrat (e.g. 50cmx50cm) • Chisel and hammer • Fine-mesh bag • Five-litre buckets • Preservative (e.g. non-denatured ethanol)	Exhaustively records all species (both NIS and non-NIS) occurring in an area; provides abundance and density (quantitative data)	Destructive technique
MPAs	Number and abundance of NIS	Linear transect and visual census technique	• Underwater photographic and/or video camera • Measuring tape • Extra weight for securing both ends of measuring tape Underwater slates or notebooks	Rapid and easy to apply; allows analyses of trends in NIS abundance if conducted regularly in the same area	Requires taxonomic experts in the field; might overlook some cryptic NIS through non-observation; provides only semi-quantitative measures of abundance

2.4 Data analyses and interpretation

35. A positive or negative trend in [B] illustrates respectively an increase and a decrease in the total number of non-indigenous species in an area, which is a good trend indicator of non-indigenous species. One also needs to calculate [A] however as it is possible to have both a negative trend in [B], indicating a decrease in the total number of non-indigenous species, and a positive trend in [A] at the same time, indicating that management in the area is not sufficient yet. A positive trend in [A] ([A]>0) indicates that ―new species are introduced into the area and one should therefore investigate how and with which pathway they are introduced. If this concerns a pathway introduced by anthropogenic activities, one may focus management on that pathway. If the new non-indigenous species arrive by their natural distribution capacities, one may focus on back tracking the location of origin and focus management on that location.

36. Consequently, for all monitored stations, [A] at T_n = [A] at T_{n-1} = [A] at T_{n-2} = 0 and [B] at T_n = [B] at T_{n-1} = [B] at T_{n-2}, should indicate that no new non-indigenous species were introduced in the last three years, and that the number of non-indigenous species is decreased to a level where only settled (for at least three years) non-indigenous species are present.

3. Data handling policies

37. NIS and ancillary data collected on a national basis should be validated by an expert panel prior to it being submitted to a pan-Mediterranean, geo-referenced repository which can referenced by different user typologies (e.g. MPA managers, government environmental agencies, NGOs, research institutes). The MAMIAS database is a good candidate for such a repository, given its pan-Mediterranean nature, but unless this database is re-activated and its public access reinstated, alternative, relevant repositories should be availed of, including the EASIN, CIESM and GBIF ones. Protocols detailing how the NIS databases held within the selected final repository can be

supplemented by citizen science reports being submitted by the public should be elucidated at a subsequent stage.

38. Field workers engaged in the deployment of the monitoring protocols must be confident they are recording most of the NIS species occurring in a particular area, in order to ensure a good quality of the data being recorded. UNEP/MAP (2014) states that the minimum threshold of the total NIS in an area which need to be recorded is that of 90% and that different statistical techniques exist for assessing progress towards achieving this. Further guidance to NIS monitoring practitioners should be provided in future on how to quantify statistically the fraction of total NIS occurring in an area which have been sampled.

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F. Guidelines for monitoring marine benthic habitats in the Mediterranean Sea

Table of contents

General premise

1. The Contracting Parties to the Barcelona Convention have adopted the Ecosystem Approach (EcAp) in 2008 with the Decision IG. 17/6, aimed at reaching “A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations” (UNEP/MAP, 2008). This process (EcAp) aims to achieve the Good Environmental Status (GES) through informed management decisions, based on integrated quantitative assessment and monitoring of the marine and coastal environment of the Mediterranean, in order to manage human activities sustainably.
2. In 2016, during the 19th Meeting of the Contracting Parties to the Barcelona Convention (COP 19, Athens, Greece, 9-12 February 2016), an Integrated Monitoring and Assessment Programme and related Assessment Criteria (IMAP) has also been adopted by the Mediterranean region. The resulting document describes the strategy, objectives and products that the Contracting Parties have to deliver over the second period of the implementation of the EcAp (2016-2021) in the framework of the Mediterranean Action Plan (UNEP/MAP, 2008). The main goal of IMAP is to build and implement a regional integrated monitoring system gathering reliable quantitative and updated data on the status of marine and coastal Mediterranean environment. A list of agreed 27 Common Indicators (CIs), articulated on 11 Ecological Objectives (EO) in synergy with the European Union’s Marine Strategy Framework Directive (2008/56/EC), and GES targets of the IMAP have been set in the Decision IG.22/7. In the context of the IMAP, a Common Indicator is defined as “an indicator that summarizes data into a simple, standardized, and communicable figure and is ideally applicable in the whole Mediterranean basin, or at least on the level of sub-regions, and is monitored by all Contracting Parties. A common indicator is able to give an indication of the degree of threat or change in the marine ecosystem and can deliver valuable information to decision makers”.
3. During the initial phase of the IMAP implementation (2016-2019), the Contracting Parties to the Barcelona Convention were asked to develop or update their national monitoring programmes in order to provide all the data needed to assess whether the GES defined through the EcAp process has been achieved or maintained. Monitoring programmes at the national level are shared to create a compatible, shared Mediterranean pool of data, usable by each Contracting Party to product common indicator assessment reports in an integrated manner, which ensures comparability across the Mediterranean region.

4. Among the five EcAp Common Indicators related to “biodiversity” (EO1) fixed by IMAP, two are related to habitats in the Barcelona Convention Decision IG.22/7 (UNEP/MAP, 2008), namely:

- Common Indicator 1: Habitat distributional range, to also consider habitat extent as a relevant attribute
- Common Indicator 2: Condition of the habitat’s typical species and communities.

5. Regarding the assessment of the EO1 “biodiversity”, a quantitative definition of GES is difficult, considering the variety of conceptual facets existing around the term “biodiversity” (e.g., genetic diversity, species diversity, and habitat diversity). Thus, the GES boundaries are here defined as “the acceptable deviation from a reference state, which reflects conditions largely free from anthropogenic pressures”.

Purpose and aims

6. The purpose of this document is to elucidate the guidelines for monitoring marine benthic habitats in Mediterranean following common and standardized monitoring programmes, to address the two CIs that specifically related to habitats, and specifically to those habitatsselected by the Parties, i.e. marine vegetation, coralligenous and other calcareous bioconstructions, and dark habitats.

Common Indicator 1: Habitat distributional range, to also consider habitat extent as a relevant attribute.

7. This indicator is aimed at providing information about the geographical area in which the benthic habitat occurs. It reflects the distributional range of benthic habitats that are present on Mediterranean bottoms. The main outputs of the monitoring for this indicator will be maps with the habitat presence and distributional range. Availability of updated and complete maps will allow detecting any important change in the habitat distributional patterns to understand their evolution over time, and measuring their distance from the original, reference status (i.e., the baseline).

Common Indicator 2: Condition of the habitat's typical species and communities.

8. This indicator is aimed at providing information about the ecological status of the benthic habitat. Assessments should be focused in collecting data on the status of habitats using typical/target species as indicators and/or considering the community composition. Thanks to this indicator any important change in the status of the habitat can be detected, and again availability of long-term data series will allow understanding the trajectories of change experienced by those habitats through time.

9. The main aim of these guidelines is to provide guidance to managers and decision makers (e.g., environmental authority representatives, researchers, Marine Protected Area - MPA representatives) on field methodologies for long-term monitoring of marine benthic habitatsin 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 from human activity.,. These indications should help environmental practitioners in deciding what kind of method to choose at regional and national level to answer the Common Indicators 1 and 2.

10. In particular, the document is organized along 3 monitoring guidelines for the main benthic habitats:

(1) Guidelines for monitoring marine vegetation

(2) Guidelines for monitoring coralligenous and other calcareous bioconstructions

(3) Guidelines for monitoring dark habitats.

11. All the three guidelines provide information on the monitoring protocols of the agreed EcAp Common Indicators 1 and 2 towards the GES objective, and address the same common purposes to all monitoring guidelines developed to date:

(i) Harmonization and standardization of monitoring and assessment methods

(ii) Assuring the quality of long time series of data to monitor the trends in the status of the marine environment

(iii) Improvement of availability of synchronised datasets for marine environmental state assessment, including data stored in other databases where some of the Mediterranean countries regularly contribute

(iv) Improvement of data accessibility and their continuous upgrading, with the view to improving knowledge on the Mediterranean marine environment, to accommodate data submissions for all the IMAP Common Indicators.

12. For all the three benthic habitats addressed in these guidelines (i.e., marine vegetation, coralligenous and other calcareous bioconstructions, and dark habitats), available information and existing monitoring protocols have been taken into account, as the base for the updating and harmonization process. In particular, the following documents represented the starting point of the monitoring guidelines here proposed:

1. Guidelines for standardisation of mapping and monitoring methods of marine Magnoliophyta in the Mediterranean (UNEP/MAP-RAC/SPA, 2015a)[3]
2. Methods for inventorying and monitoring coralligenous and rhodoliths assemblages (UNEP/MAP-RAC/SPA, 2015b)[4]
3. Draft guidelines for inventorying and monitoring of dark habitats (UNEP/MAP-SPA/RAC, 2017)[5].

13. Also, a lot of scientific papers exist for each of the three benthic habitats. Many of them explain in detail the steps of implementation, the scientific background, and tools requested for their application. Various methods have already been recognised as standard.

14. In each monitoring guideline here proposed, a global overview of available methods is presented, with the main advantages and disadvantages, the human resources and material requested in order to better estimate the investment needed, and any other practical information. The scale of monitoring is of primary importance for biodiversity assessment, due to the nature of the biodiversity related common indicators, especially the Common Indicator 1 (distributional range, and habitat extent). The assessment scale is expressed as the relevant spatial and temporal resolution of required data. Resolution includes number and location of sampling stations, accuracy of remote indirect surveys, sampling frequencies, and sampling surface, which has to be clearly defined in each monitoring guideline. A balance between accuracy and costs is always required, to ensure a cost-efficiency resolution that will be the correct compromise between very accurate and complete assessment, but more expensive, and partial assessments in accordance with available resources.

15. All the three documents focus more on the surveying technique for data collection rather than on the following associated analyses. However, a reference to the available recent ecological indices purposely developed for environmental quality assessment is also reported for each habitat. Implementation of rigorous methods to ensure reliability of the data collected in a standardized manner is the fundamental first step to ensure comparability among different regions of the Contracting Parties. Further details on each specific method described and on the most used analyses can be found in the bibliographic references provided.

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[3] UNEP/MAP-RAC/SPA. 2015a. Guidelines for standardization of mapping and monitoring methods of Marine Magnoliophyta in the Mediterranean. Pergent-Martini C. (Ed.), RAC/SPA publ., Tunis, 48 p. + Annexes.

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

[5] UNEP/MAP-SPA/RAC. 2017. Draft guidelines for inventorying and monitoring of dark habitats. Aguilar R., Marín P. (Eds), SPA/RAC publ., Tunis, 58 p.

1. Guidelines for monitoring marine vegetation in Mediterranean

Table of contents

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 (Waycott et al., 2009 and references therein). A major economic value of over 17000 $ per ha and per annum has been quantified for seagrass meadows worldwide (Costanza et al., 1997).

2. Seagrass, like all Magnoliophyta, are marine flowering plants of terrestrial origin which 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 of coastline between the surfaces to about 50 m depth in very clear marine waters 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 import 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 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). An alarming and accelerating decline of seagrass meadows has been reported in the Mediterranean Sea and mainly in the north-western side of the basin, where many meadows have already been lost during last decades (Boudouresque et al., 2009; Waycott et al., 2009; Pergent et al., 2012; Marbà et al., 2014; Burgos et al., 2017).

4. Concerns about these declines have prompted efforts to protect legally these habitats 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, identified as Sites of Community Interest (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 sustainable use of marine coastal areas. First 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) and a few extent of the coastline has 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 following explicit request by managers on the need of 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 scientific round tables 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 standardization 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 (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 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 ease the task of the MPA managers when implementing their monitoring programs. A reviewing process on the scientific literature, taking into account the latest techniques and the recent works carried out 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 MESH (Mapping European Seabed Habitats) 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

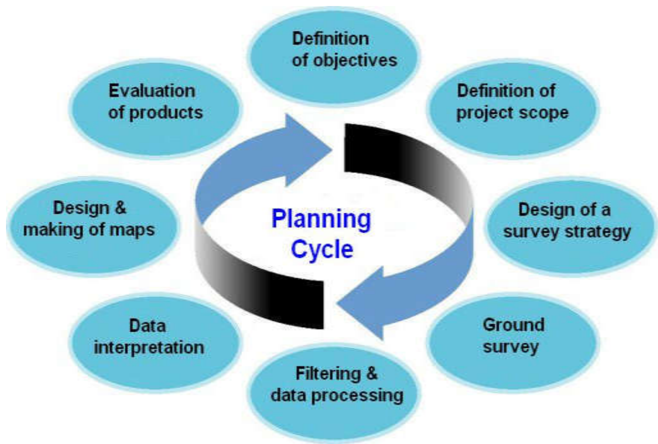

Figure 1: Planning cycle for a habitats' mapping programme (according to the MESH project, 2008).

11. Initial planning includes the definition of the objectives in order 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 used and the surface area to be mapped (Mc Kenzie et al., 2001; Fig. 2).

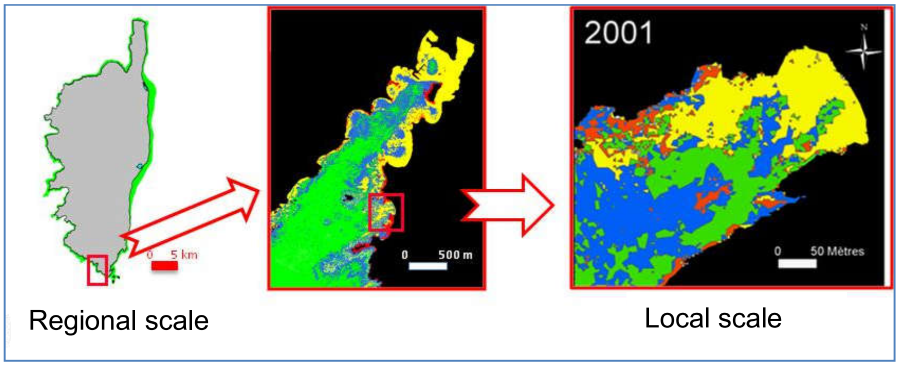

Figure 2: Resolution of a map from regional study to local study (from UNEP/MAP-RAC/SPA, 2015).

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 the 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 period of time. These high-resolution scales are also used to select remarkable sites where monitoring actions must be concentrated. As highlighted by the MESH project (2008), most of the environment management and marine spatial planning activities require a range of habitat maps between these two extremes.

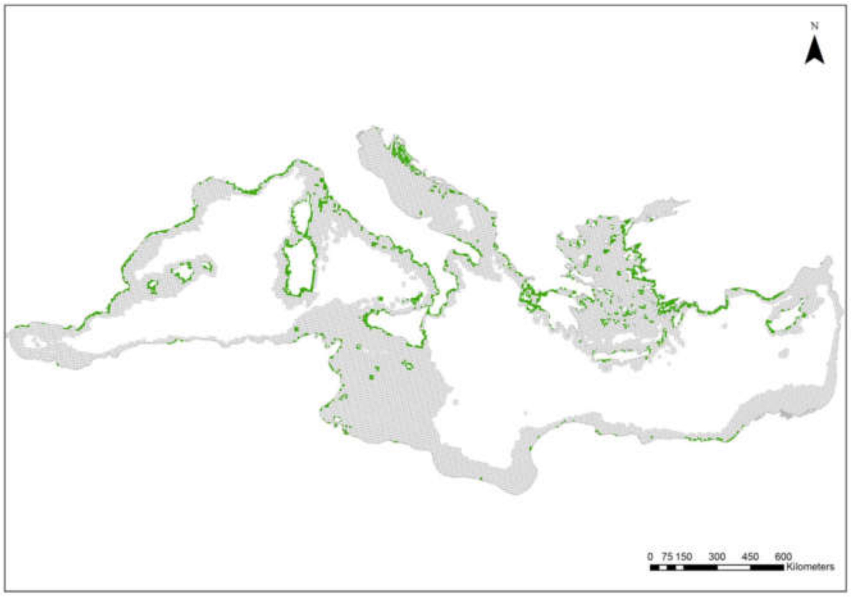

Figure 3: Distribution of *Posidonia oceanica* meadows in the Mediterranean Sea (green areas) (from Giakoumi et al., 2013).

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). 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). 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 the spatial patterns of seagrass meadows, 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 vessel acoustic systems. The power of remote sensing techniques has been highlighted by Mumby et al. (2004), who highlighted that 20 s of airborne acquisition time would equal 6 days of field surveys. However, all indirect mapping techniques are intrinsically affected by uncertainties due to manual 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 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 to rapidly automate the interpretation of sonograms and make this interpretation more reliable (Montefalcone et al., 2013 and references therein). 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. Human eye, however, always remains the final judge.

19. Satellite telemetry is a valuable tool providing a cost-effective way to easily acquiring large-scale and high-resolution seagrass distribution information in shallow waters. Landsat images have been used successfully for regional mapping of seagrass distribution in many Mediterranean countries. The wide 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. 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).

20. Despite the increasing number of studies on seagrass mapping with remote sensing instruments, datasets are not often available in the geographic information systems (GIS) platform. As a final remark, only recently some modelling approaches have been developed to obtain estimation of the potential distribution of seagrass meadows in the Mediterranean. The probability of presence of the 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. 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), 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
Satellite images	From 0 to 10-15 m	From few km^2 to large areas (over 100 km^2)	From 0.5 m	Over 100 km^2/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	Kenny et al. (2003)
Multispectral and/or hyperspectral images	From 0 to 25 m, with an optimum up to 15 m	From 50 km^2 to 5000 km^2	From 1 m		High resolution allowing to distinguish 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	• 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	Frederiksen et al. (2004); Kenny et al. (2003); Diaz et al. (2004)
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 • Quick execution	• 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)
Single-beam acoustic sonar	Below 10 m		From 0.5 m	1.5 km²/hour	• Good geo-referencing • Quick execution	• Low discrimination between habitats • Lower reliability compared to satellite techniques	Kenny et al. (2003); Riegl and Purkis (2005)

Survey tool	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Multi-beam acoustic sonar	Below 2-8 m	From large (50-100 km^2) to small areas (a few hundred square meters)	From 50 cm	0.2 km^2/hour	• Possibility to obtain 3 D image of meadows • 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 m^2 for permanent square	From 0.1 m	0.01 km^2/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 • Possibility to do simultaneous monitoring	• Many working hours • Small areas mapped • Necessity of numerous observers to cover larger areas	Pergent et al. (1995a); Montefalcone et al. (2006)
Video camera (ROV or towed camera)	Whole bathymetric range of seagrass distribution	Small areas, usually under 1 km^2	From 0.1 m	0.2 km^2/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 relationship to the base, and thus no possibility to work over large areas • Necessity for markers on seafloor for positioning of 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			• Same characteristics as for laser-telemetry, but with a greater range (1.5 km)	• Quite difficult technique • Need of many related equipments, and of team of divers	Descamp et al. (2005)

21. Once the surveying is completed, data collected needs to be organised so that it can be used in the future by everyone and can be appropriately archived and easily consulted. Resulting dataset can be integrated with similar data from other sources, providing a clear definition of all metadata (MESH project, 2008).

1) Optical data

22. Satellite images are gained from satellites in orbit around the earth. Data is obtained continuously and today it is possible to buy 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 requirements), but this will require much higher costs.

23. 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 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 image classifiers, for example the OBIA systems (Object-Based Image Analysis).

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)
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. In view of the changes of 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. 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, resolution of the LandSat 8 satellite is not adequate to have high resolution mappings of seagrass meadows. However, the image LandSat 8 OLI represents a valid 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. 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. 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, so that measured values can be compared to distinct component species and appraise the vegetation cover (Ciraoloet al., 2006; Dekker et al., 2006).

27. 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 of the progress made in the last few decades in terms of shooting (e.g., the quality of the film, filters, lens) and in following processing (e.g., digitalization, geo-referencing), aerial photographs represents today one of the most preferred surveying methods for mapping 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).

2) Acoustic data

28. Sonar provides images of the seafloor through the emission and reception of ultrasounds. Among the main acoustic mapping techniques, Kenny et al. (2003) distinguish: (1) wide acoustic beam systems like the side scan sonar (SSS), (2) single beam sounders (3), multiple narrow beam bathymetric systems, and (4) multi-beam sounders.

29. Side scan sonar 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 (Clabautet 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 (Clabautet al., 2006) could be helpful in interpreting the data. 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).

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

31. Multi-beam sounder 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 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. 3D structure of the seafloor is also obtained, where meadows can be visualized and the biomass can be evaluated (Komatsu et al., 2003).

3) Samplings and visual surveys

32. Field samples and direct 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 (complete coverage of surface

[1]CASI: Compact Airborne Spectrographic Imager

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 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 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.

33. Observations from the surface can also be made by observers on a vessel using, for instance, a *bathyscope*, or by using imagery techniques such as photography and video. Photographic equipment and cameras can be mounted on a vertical structure (sleigh) or within remotely operated vehicle (ROV). 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), whilst the ROVs have their own propulsion system and are remotely controlled from the surface.

34. 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 this preliminary video survey may be also 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, images of the seafloor and geographical positioning have been developed (UNEP/MAP-RAC/SPA, 2015).

35. 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. 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).

36. Marking the limits of a meadow also allows obtaining a distribution map. Laser-telemetry is a useful 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 DGPS 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 records their times of arrival. 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 fixed on a submarine scooter driven by a diver. The maximum distance of the pinger in relationship to the centre of the polygon formed by the 4 buoys can be approx. 1500 m (UNEP/MAP-RAC/SPA, 2015).

37. Free diving monitoring with a differential GPS can also be envisaged to locate the upper limits of the meadows. The diver follows precisely the contours of the limits and the DGPS continuously records the diver's geographical data. 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 transect perpendicular on the coastline.

Data interpretation

38. The MESH project (2008) identified four important stages for the production of a habitat map:

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

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

39. During the processing analysis and classification stage, 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., seagrass species). As seagrass assemblages are often small in size, they can only be identified with high (metric) precision mapping. The updated list identifies 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 description of these habitats and the criteria for their identification are available in Bellan-Santini et al. (2002). Habitats that must be represented on maps are the following (UNEP/MAP-SPA/RAC, 2019):

LITTORAL

MA3.5 Littoral coarse sediment

MA3.52 Mediolittoral coarse sediment

MA3.521 Association with indigenous marine angiosperms

MA3.522 Association with *Halophila stipulacea*

MA4.5 Littoral mixed sediment

MA4.52 Mediolittoral mixed sediment

MA4.521 Association with indigenous marine angiosperms

MA4.522 Association with *Halophila stipulacea*

MA5.5 Littoral sand

MA5.52 Mediolittoral sands

MA5.521 Association with indigenous marine angiosperms

MA5.522 Association with *Halophila stipulacea*

MA6.5 Littoral mud

MA6.52 Mediolittoral 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)

[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.

MB1.541 Association with marine angiosperms or other halophyta

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, atolls)

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 halophyta

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

40. 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).

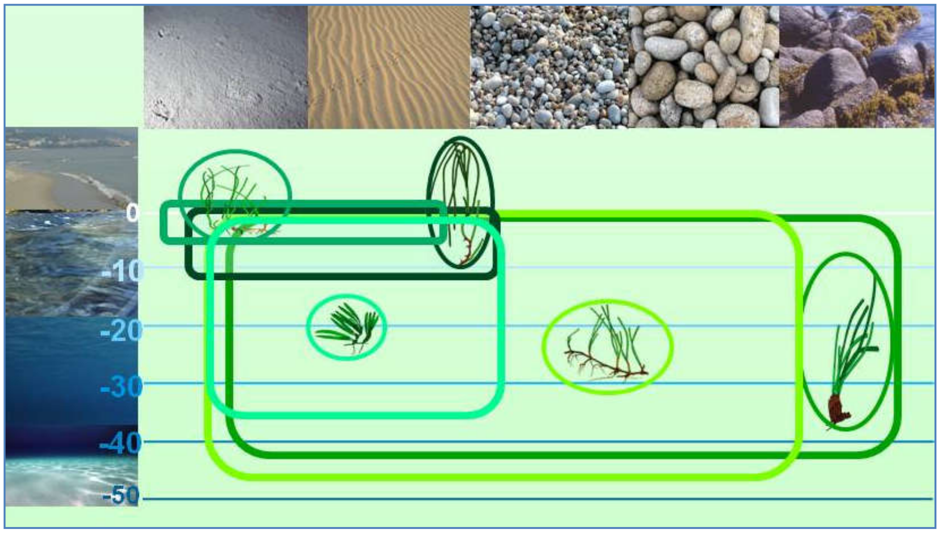

Figure 5: Distribution of seagrass species depending on the nature of the substrate and the depth in the Mediterranean (from UNEP/MAP-RAC/SPA, 2015).

41. The data integration and modelling stage will differ depending on the survey tools and acquisition strategy used. Due to its acquisition rapidity, aerial techniques usually allow to cover completely littoral and shallow infralittoral zones and this greatly reduces interpolation of data. On the contrary, surveys from vessels are often limited because of time and costs involved, and only rarely allow to obtain a complete coverage of the area. Coverage under 100% automatically means that it is impossible to obtain high resolution maps and therefore interpolation procedures have to be used, so that from partial surveys a lower resolution map can be obtained (MESH project, 2008; Fig. 6). Spatial interpolation is a statistical 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 (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 field and the percentage of interpolations run.

42. 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 limits (upper and lower) of the meadow, and the presence between these two limits could be reduced to occasional field investigations leaving the interpolation to play its part (Pasqualini et al., 1998).

43. The processing and digital analysis of data (optical or acoustic) on GIS allows to creating charts where each tonality of grey is associated to a specific texture representing a type of population/habitat, also on the basis of in situ observations 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) make additional information accessible, such as the seagrass cover or the presence of anthropogenic signs (Pasqualini et al., 1999).

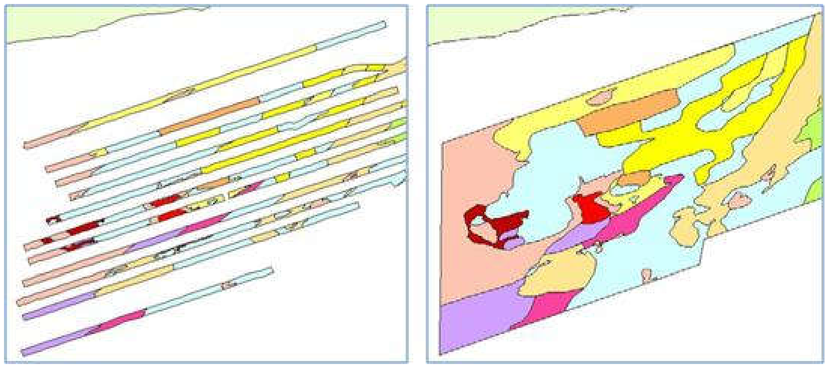

Figure 6: Example of partial coverage survey (left) and the output of the final map produced through interpolation (right). The area surveyed is about 20 km wide (from UNEP/MAP-RAC/SPA, 2015).

44. 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). When the cartographical detail is good enough, it is possible to indicate also 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 map.

45. 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 compared with previous historical available data from literature to evaluate any changes experienced by meadow over 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 term of percentage gain or loss of the meadow extension, through the creation of concordance and discordance maps (Barsanti et al., 2007).

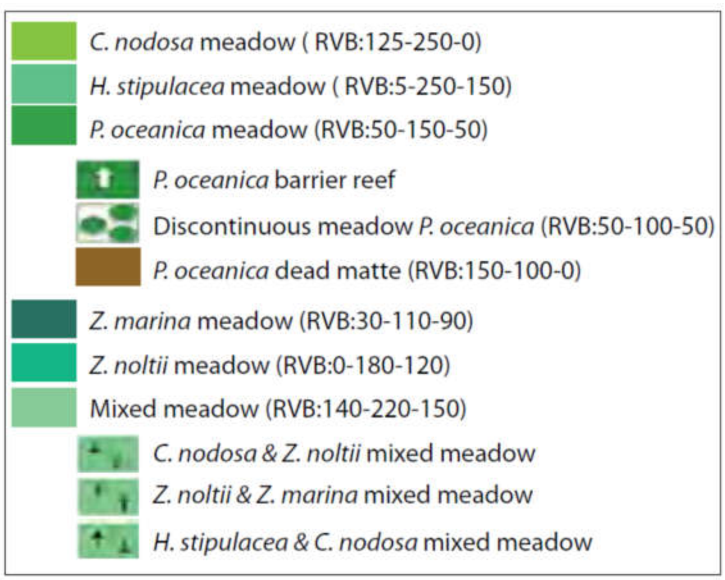

Figure 7: symbols and colours used for the graphic representation of the main seagrass assemblages. RVB: values in red, green and blue for each type of meadow (from UNEP/MAP-RAC/SPA, 2015).

46. The reliability of the map produced should also be evaluated. Several evaluation scales of reliability have already been proposed and may be useful for seagrass meadows. Pasqualini (1997) proposes a reliability scale in relation to 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, 2015). 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 scale needs to be adapted.

47. Denis et al. (2003) propose a reliability index of 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, 2015). The reliability index ranges from 0 to 20 and can vary from one point to another of the map, depending on the bathymetry or the technique used.

48. 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

49. 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 MSFD (2008/56/EC) and the EcAp CI2 fixed by IMAP and related to "biodiversity" (EO1). The CI2 is aimed at providing information about the condition (i.e., ecological status) of seagrass meadows.

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

- Four out of the five species present in the Mediterranean (*C. nodosa*, *P. oceanica*, *Z. marina*, and *Z. noltei*) are listed in the Annex 2 (list of endangered or threatened species) of the Protocol concerning Specially Protected Areas and Biological Diversity (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 1 (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).

51. 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 seagrasses 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).

52. A defined and standardized procedure for monitoring the status of seagrass meadows, comparable to that 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.

53. 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.

54. 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 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 be planned during a favourable season, also because some of the parameters chosen for monitoring purposes must be collected during the same period. This phase might be quite long especially if numerous sites have to be monitored.

55. Monitoring over time and data analysis phase seem to be easy being the data acquisition a routine 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 be useful, must be 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.

56. The objectives of the monitoring can cover the conservation of seagrass meadows and also their use as an ecological indicator of the quality of the marine environment. The main aims of seagrass monitoring are generally:

- Preserve and conserve the heritage of the priority habitats, with the aim of ensuring that the meadows are in a satisfactory ecological status (GES) and also identify as early as possible any degradation of these priority habitats or any changes in their distributional range and extent. Assessment of the ecological status of meadows allows to measure 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. The main goal of IMAP is to gather reliable quantitative and updated data on the status of marine and coastal Mediterranean environment
- Evaluate effects of any coastal activity likely to impact seagrass meadows during environmental impact assessment procedures. 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 meadows during the development works phase or at the end of the phase, to check for any impacts.

57. The objective(s) chosen 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.

58. 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 depths of their 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 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 impacted site, all representative of the coastal area	• Descriptors of the quality of the environment (e.g., turbidity, depth of lower limit, enhancement in nutrients, nitrogen content of leaves, chemical contamination, trace metals in plant)	• Medium term (5 to 8 years) • Data acquisition is variable depending on the species concerned (1-3 years)
Environmental impact assessment	The site subject to coastal development or interventions. The selection of 2 reference/control sites might be also useful	• Specific descriptors to be defined depending on the possible consequences of human activities	• 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

59. 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 detailed descriptions of sampling tools and methodologies can be found.

60. The available descriptors work at each of the different ecological complexity levels of seagrass (Montefalcone, 2009): the population (i.e., the meadow), the individual (i.e., the plant), the physiological or cellular, and the associated community (especially leaf epiphytes). Some ecological indices (see next section) have been developed to work at the highest ecological levels, i.e. the seascape level (CI, Moreno et al., 2001; SI and PSI, Montefalcone et al., 2007; PI, Montefalcone et al., 2007) or the ecosystem level (EBQI; Personnic et al., 2014). Some recent ecological indices integrate different ecological levels (e.g., PREI, Gobert et al., 2009; POMI, Romero et al., 2007).

61. 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 depths of the limits); ii) in situ observation by scuba diving (e.g., lower limit type, cover, and rhizome baring); 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 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 MPAs. An effective monitoring should be done at intervals over a period of time, even if it could mean a reduced number of sites and a reduced number of descriptors being monitored. Number of adopted descriptors should be adequate enough 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). The nature of the descriptors is less important than reproducibility, reliability and the precision of the method used for its acquisition.

62. In situ observation 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 (the plant), physiological or cellular, and most of the analyses associated at the community level (the associate organisms of leaves and rhizomes) require collection of shoots. For *P. oceanica*, the mean number of sampled and measured shoots ranges between a minimum of 10 to a maximum of 20 shoots collected at each sampling station (Pergent-Martini et al., 2005). For measuring *P. oceanica* shoot density, a standardized surface area is settled at 40 cm × 40 cm with a minimum of 5 replicated counts per station. An adequate number of stations must be localised randomly within the meadow, and usually in correspondence of the meadow upper limit, the meadow lower limit and at intermediate depths, in a number of 2 to 3 sampling stations per depth. To assess the overall ecological condition of the meadow, samples of shoots can be performed only at the intermediate meadow depth, which is usually at about 15 m depth, where the meadow is expected to find the optimal conditions for its development (Buia et al., 2004) and during late spring or early summer season (Gobert et al., 2009).

63. 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 in the European countries, the existing scales for its classification have been adapted with the creation of five classes (bad, poor, moderate, good, and high; Annex 1). 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 classification scale of the lower limit depth (Annex 1) is another valid tool, although this scale could require some adaptations according to the specific geographical area and the morphodynamics setting of the site. For instance, in many *P. oceanica* meadows in the Ligurian Sea (NW Mediterranean) the lower limit rarely reaches depths greater than 20-25 m, due to natural constrains (e.g., substrate typology, seafloor topography). In all these cases, meadows would be classified from moderate to bad ecological status using the lower limit depth, even without or with very few human pressures.

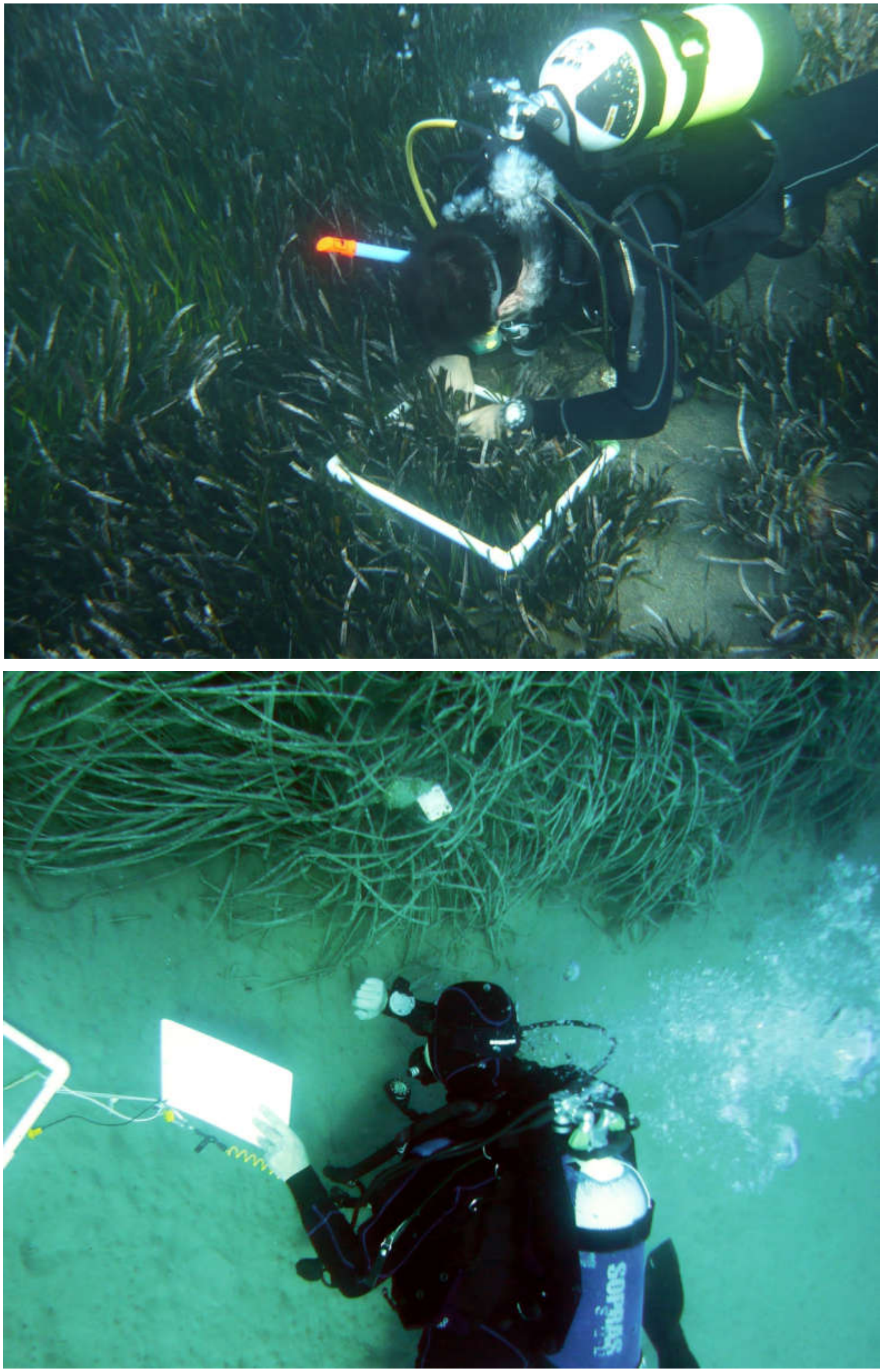

Figure 8: In situ measurement of *Posidonia oceanica* shoot density using the standard square frame of 40 cm × 40 cm (upper image) and monitoring over time of the meadow lower limit position with permanent marks (lower image).

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 descriptor, the destructive nature of the method (Destr.), the target species, the advantages and limits, and some bibliographical 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., population, individual, physiological, community).

Descriptor	Method	Expected response/factors	Destr.	Target species	Advantages	Limits	References
Population (meadow)							
Meadow extent (i.e. surface area)	Mapping (Cf. Part "a" of this document) and/or identification of the 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)
Bathymetric position of meadow upper limit (in m) and its morphology	A detailed mapping of seagrass extension 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	No	All	Easily measured (also by scuba diving) Morphology of this limit may reflect environmental conditions	For Cn, Hs and Zn, strong seasonal variability necessitating periodical monitoring or observations at the same season for all sites Fixed markers might disappear if site is strongly frequented	Pergent et al. (1995); Montefalcone (2009)

Descriptor	Method	Expected response/factors	Destr.	Target species	Advantages	Limits	References
Bathymetric position of meadow lower limit (in m)	A detailed mapping of seagrass extension 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 Turbidity	No	All	Easily measured (also by scuba diving) Classification scale available for Po	For Cn, Hs and Zn, strong seasonal variability necessitating periodical monitoring or observations at the same season for all sites Beyond 30 m depth, acquisition is 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	In situ observations	Change in morphology Turbidity, mechanical impacts (e.g., trawling)	No	Po	Well known descriptor Several types described Classification scale for Po	Good knowledge of Po meadows necessary to identify some of the types Difficult and costly the assessment at great depths (>30 m)	Boudouresque and Meinesz (1982); Pergent et al. (1995); Montefalcone (2009); Annex 1
Presence of inter-matte channels and dead matte areas	Highly 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 (e.g., anchoring, fishing gear)	No	Po	Easy to measure Surface areas can be measured on maps	Dead matte areas are natural components intrinsic to some types of meadows (e.g., striped meadows) and do not reflect systematically human influence	Boudouresque et al. (2006)

Descriptor	Method	Expected response/factors	Destr.	Target species	Advantages	Limits	References
Density (shoots · m^{-2})	No. of shoots counted within a square frame (fixed dimension and depth) by divers. The square size depends on the species meadow density. For *P. oceanica* is 40 cm × 40 cm	Reduction Turbidity, mechanical impacts (e.g., anchoring)	No	All	Easy to measure Low-cost Can be measured at all depths Classification scale available for Po	Strong variability with depth Long acquisition time for densities over 800 shoots Many replicates necessary to evaluate meadow heterogeneity Considerable risk of error if: a) 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 lab. (destructive technique)	Duarte and Kirkman (2001); Pergent-Martini et al. (2005); Pergent et al. (2008); Annex 1
Cover (in %)	Average percentage of the surface area occupied (in vertical projection) by meadow in relation to the surface area observed. Various methods to measure the cover in situ by divers or in lab. (photos or video, visual estimation). Variable observation surface area (0.16 to 625 m²), visualised by quadrate or transparent plate	Reduction Turbidity	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 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)

Descriptor	Method	Expected response/factors	Destr.	Target species	Advantages	Limits	References
Percentage of plagiotropic rhizomes	Counting of plagiotropic rhizomes in a given surface area (e.g., 40 cm × 40 cm, which can be visualised by a quadrate)	Increase Mechanical impacts (e.g., anchoring, fishing gear)	No	Cn, Po	Easy, rapid and low-cost Classification scale available for Po	Mainly used at shallow depths (0-20 m)	Boudouresque et al. (2006); Annex 1
Individual (plant)							
Leaves surface area (cm² · shoot), and other phenological measures	Counting and measuring the length and width of different types of leaves in each shoot (10 to 20 shoots)	Reduction of leaves surface area (Po) for overgrazing and human impacts Increase in the length of leaves (Po, Cn) for nutriments enhancement	Yes	All	Easy, rapid and low-cost Possibility to measure the length of adult leaves (most external leaves) in situ to avoid sampling 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
Necrosis on leaves (in %)	Percentage of leaves with necrosis, through observation in lab.	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 the bit of some animals are easily recognizable	Not informative of the grazing pressure in the case of strong hydrodynamism and on old leaves	Boudoresque and Meinesz (1982)

Descriptor	Method	Expected response/factors	Destr.	Target species	Advantages	Limits	References
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 markings or by using the relationship bases length/leaves growth (Zm)	Reduction Nutrients deficit, increase in interspecific competition	Yes/ No (Zm)	All	For Po lepidochronolo-gy allows assessments at all depths Classification scale available For Zm the relationship bases length/leaves growth allows in situ non destructive measuring	Long time to acquire Monthly monitoring, or at least for 4 seasons 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 scale available for Po	Interpretation sometimes difficult as rhizome production increase can be also observed in reference sites in the absence of human impacts Destructive sampling	Pergent et al. (2008); Annex 1
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	Easy to measure in situ Not destructive and low-cost Independent from season		Boudoresque et al. (2006)

Descriptor	Method	Expected response/factors	Destr.	Target species	Advantages	Limits	References
Physiological (cell)							
Nitrogen and phosphorus content in plant (in % dry weight)	Dosage through mass spectrometry and plasma torch in different plant tissues after acid mineralisation (e.g., rhizomes for Po)	Increase Nutriments enhancement	Yes	All	Short response time to environmental changes Classification scale for Po	Very expensive Analytical equipment and specific competence necessary Destructive sampling	Romero et al. (2007); Annex 1
Carbohydrate content (in % dry weight) in plant and sediments	Dosage through spectrophotometry after alcohol extraction in different plant tissues (e.g., rhizomes for Po)	Reduction Human impacts	Yes	All	Short response time to environmental changes 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
Trace metal content (in $\mu g \cdot g^{-1}$)	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
Nitrogen isotopic relationship ($d^{15}N$ in ‰)	Dosage through mass spectrometer in different plant tissues after acid mineralisation (e.g., rhizomes for Po)	Increase for nutriments enhancement from farms and urban effluents Reduction for nutriments enhancement from fertilizers	Yes	Po	Short response time to environmental changes	Very expensive Analytical equipment and specific competence necessary Destructive sampling	Romero et al. (2007)

Sulphur isotopic relationship (d^{34}S in ‰)	Dosage through mass spectrometer in different plant tissues (e.g., rhizomes of Po)	Reduction Human impacts	Yes	Po	Short response time to environmental changes	Very expensive Analytical equipment and specific competence necessary	Romero et al. (2007)
Descriptor	**Method**	**Expected response/factors**	**Destr.**	**Target species**	**Advantages**	**Limits**	**References**
Community							
Epiphytes biomass (in mg dry weight · shoots^{-1} or % dry weight · shoots^{-1}) and epiphytes cover (in %) of leaves	Measure of biomass (µg · shoots-1) after scraping, drying and weighing Measure of nitrogen content (in % dry weight) Measure using simple CHN analyser Estimate the epiphytes cover on leaves under a binocular Indirect estimation of biomass from epiphytes cover	Increase Nutriments enhancement from rivers, high touristic frequentation	Yes	All	Easy to 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); Giovannetti et al. (2008, 2015)

64. 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 also constitute an output of a monitoring system (Kenny et al., 2003), and cartography could also represent a monitoring tool (Tab. 4; Boudouresque et al., 2006).

65. At the regional spatial scale, two main monitoring systems have been developed: 1) the seagrass monitoring system (SeagrassNet), which was established at the 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 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.

66. SeagrassNet allows to comparing the data obtained in the Mediterranean with the data obtained in other regions of the world, having world coverage of over 80 sites distributed in 26 countries (www.seagrassnet.org). However, this monitoring system is not suitable for large-size species (such as *Posidonia* genus) and for meadows where 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 to compare different meadows in the Mediterranean and also to evaluating the plant's vitality and the quality of the environment in which it grows. Other monitoring systems, such as permanent transects with seasonal monitoring, or acoustic surveys, can be used in particular situations like the monitoring of lagoons environments (Pasqualini et al., 2006) or for the study of relict meadows (Descamp et al., 2009).

67. The sampling technique and the chosen descriptors define the nature of the monitoring (e.g., monitoring of chemical contamination of 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.

68. As a final remark, the IMAP should also consider the long-term organic carbon stored in seagrass sediment from both in situ production and sedimentation of particulate carbon from the

water column, known as "Blue Carbon" (Nellemann et al., 2009). 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.

69. 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.

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	x		
Temperature	x		x
Salinity	x		
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

70. Measurements made in situ must be analyzed 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 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.

71. The huge increase of studies on *Posidonia oceanica* (over 2400 publications indexed in the Web of Science) 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).

72. 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), 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

73. Ecological synthetic indices are today widespread for measuring the ecological status of ecosystems in view 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 programmes in the past, e.g. the Leaf Area Index (Buia et al., 2004), the Epiphytic Index (Morri, 1991). Following the requirements of the WFD in the European countries, many synthetic indices have been set up to provide, on the basis of 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 (Table 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)

74. Most of the ecological indices integrate different ecological levels (Table 6). The POSWARE index is based on 6 descriptors working at the population and individual 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 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), thus showing little usage in the *P. oceanica* monitoring programs (Pergent-Martini et al., 2005). The Valencian CS index integrates 9 descriptors from individual to community level. The PREI index is based on 5 descriptors working at the population, individual and community levels. The BiPo index is based only on 4 non-destructive descriptors at the population and individual levels and is particularly well suited for the monitoring of protected species or within MPAs.

75. Some not-destructive ecological indices have been developed to work at the seascape ecological level, such as the CI (Moreno et al., 2001), the SI and PSI (Montefalcone et al., 2007), and the 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). 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. 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 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, not only for assessing the quality of the water bodies.

76. One of the most recently proposed indexes works at the ecosystem level (EBQI; Personnic et al., 2014). This index has been developed on the basis of 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 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 complex formulation makes this index more time-consuming when compared to other indices.

77. 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 Mediterranean sites yields an identical classification of the Catalonia sites as the classification obtained with the POMI index (Lopez y Royo et al., 2010c). Finally, using both the POSID and the BiPo indices within the framework of the "MedPosidonia" programme, a similar classification of the meadows studied was found (Pergent et al., 2008). A recent exercise to compare a number of descriptors and ecological indices at different ecological levels (individual, 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 descriptors (Karayali, 2017). In view of this result, the combined use of more descriptors and indices, covering different levels of ecological complexity, should be preferred in any monitoring program.

78. 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 on a single site. 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).

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

Index	Physiological	Individual	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	Leaves 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	Leaves surface ; Coefficient A; rhizomes elongation	Shoot density; meadow cover; percentage of plagiotropic rhizomes; depth of the lower limit	Epiphytes biomass		
Valencian CS		Leaves surface; percentage of foliar necrosis	Shoot density; meadow and dead matte cover; percentage of plagiotropic rhizomes; rhizome baring/burial	Herbivore pressure; leaf epiphytes biomass		
PREI		Leaves surface; leaves biomass	Shoot density; lower limit depth and type	Leaf epiphytes biomass		
BiPo		Leaves 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

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 – Classification 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 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 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%

<u>Cell (physiological level): environment contamination</u>

Argent Concentration (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 Concentration (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 Concentration (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 Concentration (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 Mediterranean

Table of contents

Introduction

1. The calcareous formations of biogenic origin in the Mediterranean Sea are represented by coralligenous reefs, vermetid reefs, cold water corals reefs, *Lithophyllum byssoides* concrations/trottoirs, banks formed by the corals *Cladocora caespitose*, *Astroides calycularis*, *Phyllangia americana mouchezii*, *Polycyathus muellerae*, reefs formed by the stylasteridae *Errina aspera*, 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 circalittoral 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 (pictures by Simone Musumeci, Monica Montefalcone).

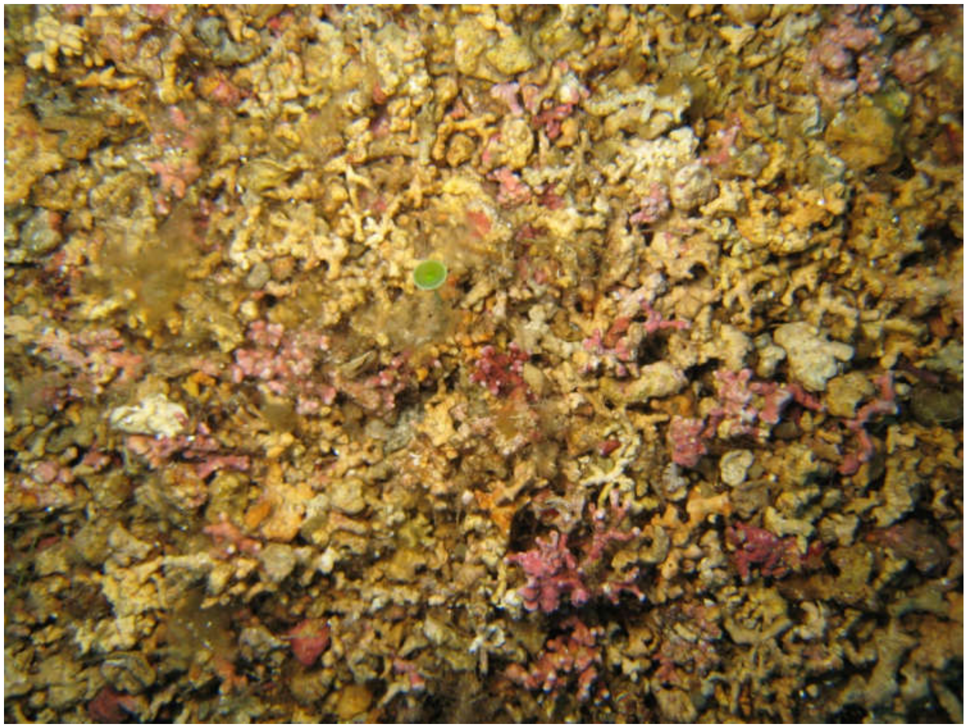

Figure 2: Rhodoliths habitat (picture from UNEP/MAP-RAC/SPA, 2015).

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 biocenosis of the 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 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 develops on rocky and biodetritic bottoms in relatively constant conditions of temperature, currents and salinity.

3. Two main coralligenous typologies can be defined, coralligenous growing on the circalittoral rocks (cliffs or outcrops), and coralligenous developing over circalittoral soft/detritic bottoms creating biogenic platforms (Piazzi et al., 2019b). Coralligenous structure results from the dynamic equilibrium between bioconstruction, mainly made by encrusting calcified Rhodophyta belonging to Corallinales and Peyssonneliales (such as 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 to 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, creating a biogenic, unstable, three-dimensional habitat typically exposed to bottom currents, which harbours greater biodiversity in comparison to surrounding habitats, and thus viewed as an indicator of biodiversity hotspot. They mostly occur on coastal detritic bottoms in the upper mesophotic 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 bed 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), but are vulnerable to either global or local impacts. 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 (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 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 the Directive, and appear also in the Bern Convention. This implies that the most important Mediterranean bioconstruction still remains without formal protection as it is not included within the list of Sites of Community Interest (SCIs). Few years after the adoption of the Habitat Directive, coralligenous reefs were listed among the "special habitats types" needing rigorous protection by the Protocol concerning the special protected areas and biological diversity (SPA/BD) 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 emphasized. Coralligenous has also been included in the European Red List of marine habitats, where 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 State of the marine environment. Biogenic structures, such as coralligenous reefs, have thus been recognized as important biological indicators of environmental quality.

7. Similarly, rhodoliths seabeds are expected to be damaged by dredging, heavy anchors and mooring chains and adversely affected by rising temperatures and ocean acidification. 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 habitats of the Directive and therefore is given protection through the designation of Special Areas of Conservation. Moreover, a special plan for the legal protection of Mediterranean rhodoliths 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). Rhodoliths seabeds have also been included in the Natura 2000 sites and in the Red List of Mediterranean threatened habitats.

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 the composition (list of species) of these habitats

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

9. Detailed information on habitat geographical distribution and bathymetrical ranges is a prerequisite knowledge for a sustainable use of marine coastal areas. Coralligenous and rhodoliths distribution maps are thus a fundamental prerequisite to any conservation action on these habitats. The scientific knowledge concerning several aspects of biogenic concretions (e.g., taxonomy, processes, functioning, biotic relationships, and dynamics) has been currently increasing, but it is still far away from the knowledge we have from 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-temporal studies on their geographical and depth distribution 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 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 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 coralligenous 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 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 scuba diving is often used for mapping small areas, it becomes unsuitable when the study area and/or the depth increase (usually at depths >40 m)
- The use of acoustic survey methods (side scan sonar or multibeam) 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.

12. For monitoring the condition of coralligenous and other bioconstructed habitats, the previous Guidelines (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 mainly on scuba diving but given the above listed constraints, using other tools of investigation (e.g., ROV, towed camera) should be also considered because it allows monitoring with less precision but on larger areas
- Although the use of underwater photograph or video may be relevant, the use of specialists in taxonomy with a good experience in scuba diving is often essential given the complexity of these habitats. If it is possible to estimate the abundance or coverage by 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 necrosis are other factors to be considered

- Monitoring of coralligenous habitat starts with the realisation of micro-mapping and then the application of descriptors and/or ecological indices. However, these descriptors vary widely from one team to another, as well as their measurement protocol
- Monitoring of rhodoliths habitats can be done by scuba diving, but the observation using ROVs or towed cameras and the collection of samples using dredges, grabs or box corers are privileged because of the greater homogeneity of these populations. However, there is not yet any standardized method widely accepted to date for monitoring rhodoliths, also because the action of hydrodynamics may cause a shift of these habitats on the seabed making their inventory rather difficult.

13. In the framework of the Barcelona Convention Ecosystem Approach implementation and based on the recommendations of the Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON), Biodiversity and Fisheries (Madrid, Spain, 28 February – 1 March 2017) , the CPs requested SPA/RAC to develop standirdized monitoring protocols by considering the previous work elaborated of the Guidelines for monitoring coralligenous and other bioconstructed habitats in Mediterranean (UNEP/MAP-RAC/SPA, 2015), 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 scientific literature, taking into account the latest techniques and the recent works carried out by the scientific community at the international level, has also been carried out. If standardized protocols for seagrass mapping and monitoring exist and are well-implemented, and a number of 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 "minimal" 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 of use, are presented. Some of the existing monitoring methods for coralligenous have already been compared or cross-calibrated and are here briefly introduced and, finally, a standardized method recently proposed for coralligenous monitoring is described.

Monitoring methods

a) COMMON INDICATOR 1: Habitat distributional range and extent

Approach

14. The CI1 is aimed at providing 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 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 equipments
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 require knowledge and experience to ensure that data collected are usable and reliable.

Resolution

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 are often only indicative. 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 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 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 sites where monitoring actions must be concentrated.

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).

17. Although we have an overall knowledge about the composition and distribution of coralligenous and rhodoliths habitats in the Mediterranean (Ballesteros, 2006; UNEP-MAP-RAC/SPA, 2009; Relini, 2009; Relini and Giaccone, 2009), the scarceness of fine-scale cartographic data on the overall 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 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 years in some countries thanks to the new monitoring activities afferent to the MSFD, and this information will become available in the coming years.

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 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 the presence of coralligenous formations in the southern and eastern coasts of the Levantine Sea. 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 south and 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.

19. Knowledge on maërl seabeds was somewhat limited compared to what is available for coralligenous. 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 Seas and the Tyrrhenian Sea. Datasets are available for Greece, France (Corsica), Cyprus, Turkey, Spain and Italy. Malta and Corsica, in particular, have significant datasets for this habitat as highlighted by fine-scale surveys in targeted areas (Martin et al., 2014).

20. These low-resolution global maps 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, they 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.

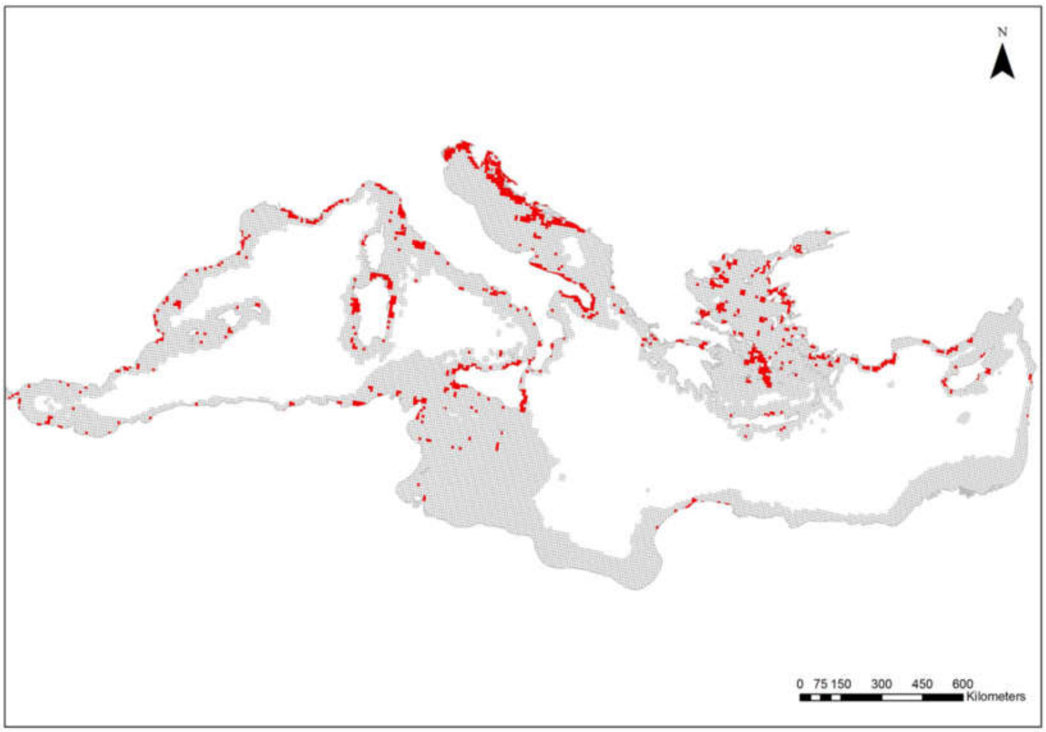

Figure 3: Distribution of coralligenous habitats in the Mediterranean Sea (red areas) (from Giakoumi et al., 2013).

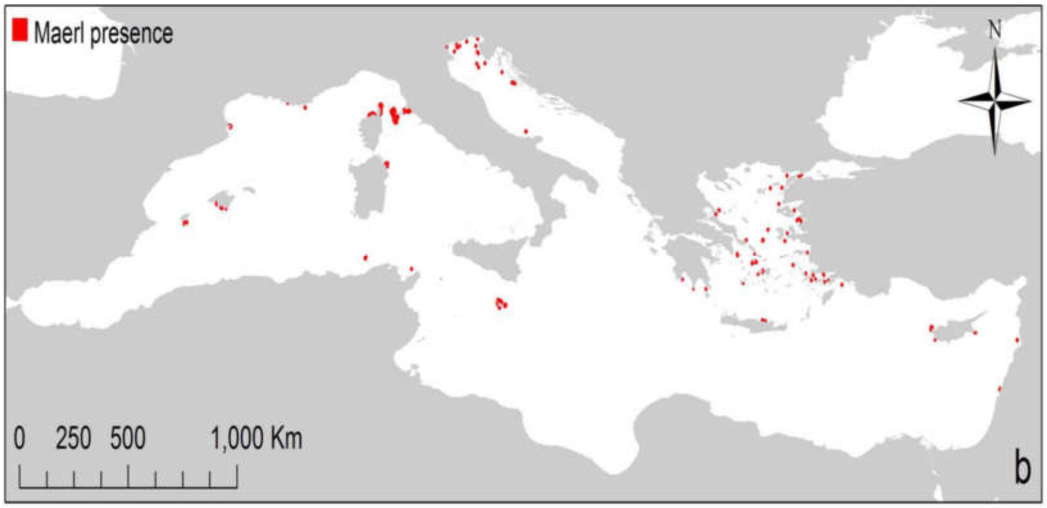

Figure 4: Distribution of maërl habitats in the Mediterranean Sea (red areas) (from Martin et al., 2014).

Methods

21. Definition of distributional range and extent of coralligenous and rhodoliths habitats requires "traditional" habitat mapping techniques, similar to those used for seagrass meadows in deep waters (Tab. 1). Indirect instrumental mapping techniques and/or direct field visual surveys can be used and are often integrated. The simultaneous use of two or more 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 and the area concerned, means and time available.

<u>Underwater observations and sampling methods</u>

22. Although underwater direct observation by scuba diving (e.g., using transects, permanent square frames) is often used for mapping small areas, this method of investigation quickly shows its limits when the area of study and the depth increase significantly, even if the technique can be optimised for a general description of the site through a towed diver or video transects (Cinelli, 2009). Direct observations provide discrete punctual data that are vital for ground-truthing the instrumental surveys, and for the validation of modelled continuous information (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 habitat.

23. In situ underwater observations represent the most reliable, although time-consuming, mapping technique of coralligenous habitat. Surveys can be done along lines (transects), or over small surface areas (permanent square frames) positioned on the seafloor and located to follow the limits of the habitat. 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., 2004a). 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. The information registered allows precise and detailed mapping of the sector studied (Tab. 1).

24. Scuba diving is also suggested as a safe and cost-effective tool to obtain a visual description and sampling of shallow rhodoliths beds (Tab. 1). Underwater observations are effective for a first characterisation of the aboveground facies of this habitat, whilst to describe the belowground community samples on the bottom become necessary. The surface of a living rhodoliths bed is naturally composed of a variable amount of live thalli and their fragments, lying on a variable thickness of dead material and finer sediment. There are 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 substratum 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 range, areal extent, occurrence of sedimentary structures of 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.

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 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 landscape for complementary information on demersal fish and extent of assemblages.

26. Sampling methods from vessels 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 (ground-truth of acoustic data) and for a complete 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 $\geq 0.16\ m^2$ is recommended because it has the advantage of preserving the original substratum stratification. The use of dredges for sampling rhodoliths should be discouraged, in order to minimize the impact of the investigation.

Remote sensing surveys

27. Being the bioconstructed habitats distributed in deep waters (down to 20 m depth), the acoustic techniques (e.g., side scan sonar, multi-beam echosounder) or underwater video recordings (ROVs, towed cameras) are usually recommended (Georgiadis et al., 2009). The use of remote sensing allows characterising extensive coastal areas for assessment of the overall spatial patterns of coralligenous and rhodoliths habitats. From maps obtained through remote sensing surveys, the presence/absence of the habitat, its distributional range 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 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 allow monitoring change in the extent of rhodoliths habitat over time (Bonacorsi et al., 2010).

28. Observations from the surface can be made by using imagery techniques such as photography and video. Photographic equipment and cameras can be mounted on a vertical structure (sleigh) 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), whilst the ROVs have their own propulsion system and are remotely controlled from the surface. 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 this preliminary video survey may be also useful to locate monitoring 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, images of the seafloor and geographical positioning have been developed (UNEP/MAP-RAC/SPA, 2015).

29. 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 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 substrate types on sonograms. Errors in sonograms 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 processing techniques were proposed in order to rapidly automate the interpretation of sonograms and make this interpretation more reliable (Montefalcone et al., 2013 and references therein), also considering that current technology provides systems of neural networks and artificial intelligence to support these operations. These methods allow a good discrimination between soft sediments and rocky reefs. Human eye, however, always remains the final judge.

Modelling

30. 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, nutrient concentrations, seabed types), which are typically easier to record and map at the regional and global scales, in contrast to species and habitat data. 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 in the North African coast, for which there are no available 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 of occurrence data for this habitat across the Mediterranean, and especially in the North African coast, the model output is relatively informative in highlighting several suitable areas where no data are available to date.

31. A recent application of predictive spatial modelling was done starting from a complete acoustic coverage of the seafloor together with a comparatively low number of sea-truths 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 coralligenous habitats within the MPA and showed that the distribution of habitats was mainly driven by distance from coast, depth, and lithotypes. Another example of habitat prediction can be found in Zapata-Ramírez et al. (2016).

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	0 m up to 40 m, according to local rules on scientific diving	Small areas, less than 250 m^2	From 0.1 m	0.0001 to 0.001 km^2/hour	Very great precision for the identification (taxonomy) and distribution of species (micro-mapping) Non-destructive Low cost, easy to implement	Small area inventoried Very time-consuming Limited operational depth Highly qualified 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 km^2/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 habitat)	Intermediate areas (a few km^2)	From 1 to 10 m	0.025 to 0.01 km^2/hour	Very great precision for the identification (taxonomy) and distribution of species (micro-mapping) All species taken into account Possibility of *a posteriori* identification Low cost, easy to implement	Destructive method Small area inventoried Sampling material needed Work takes a lot of time Limited operational depth	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)	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	Cánovas Molina et al. (2016b)
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 centimeters	0.5 to 6 km²/hour	Possibility of obtaining 3-D picture 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 (nature of bed) than side scan sonar Acquisition of field data necessary to validate sonograms 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 pictures Good identification of habitat and 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 areas (a few km^2)	From 1 m to 10 m	0.025 to 1 km^2/hour	Easy to implement and possibility of taking pictures Good identification of habitat and species Non-destructive Large area covered	Limited to homogeneous and horizontal bottom Slow recording and processing of information Variable positioning (geo-referencing) Water transparency Hard to handle in heavy surface traffic	UNEP/MAP-RAC/SPA (2015)

Data interpretation

32. Once the surveying is completed, data collected need to be organized so 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 to ensure future integration with similar data from other sources. Four important steps for the production of a habitat map must be followed:

a. Processing, analysis and classification of the biological data, 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 information
d. The map produced must then be evaluated for its accuracy, i.e. its capacity to represent reality, and therefore its reliability.

33. During the processing analysis and classification step, 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

MC1.51 Coralligenous

MC1.51a Algal-dominated coralligenous

MC1.511a Association with encrusting Corallinales

MC1.512a Association with Fucales or Laminariales

MC1.513a Association with algae, except Fucales, Laminariales, Corallinales and Caulerpales

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

MC1.51b Invertebrate-dominated coralligenous

MC1.511b 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

[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.

MC1.514b 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*)

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*, *Sarcotragus foetidus*, *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. *Parazoanthus axinellae*, *Savalia savaglia*)

MC2.519 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madracis pharensis*, *Phyllangia mouchezii*)

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

MC3.52 Coastal detritic bottoms with rhodoliths

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

MC3.522 Association with *Peyssonnelia* spp.

MC3.523 Association with Laminariales

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

MC3.525 Facies with Hydrozoa

MC3.526 Facies with Alcyonacea (e.g. *Alcyonium* spp., *Paralcyonium spinulosum*)

MC3.527 Facies with Pennatulacea (e.g. *Veretillum cynomorium*)

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

MC3.529 Facies with Ascidiacea

34. 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 rhodoliths habitats, 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, geostrophic velocity of sea surface current, silicate concentration, and bathymetry for rhodoliths (Martin et al., 2014).

35. The data integration and modelling is often a necessary step because indirect visual or remote sensing surveys from vessels are often 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 high resolution maps and therefore interpolation procedures have to 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 actual data collection 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.

36. The processing and digital analysis of acoustic data on GIS allows creating charts where each tonality of grey is associated to 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.

37. To facilitate the comparison among maps, the standardized red colour is generally used for the graphic representation of coralligenous and rhodoliths habitats. On the resulting maps the habitat distributional range and its total extent (expressed in square meters or hectares) can be defined. These maps could 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 term of percentage gain or loss of the habitat extension, through the creation of concordance and discordance maps (Canessa et al., 2017).

38. Finally, reliability of the map produced should be evaluated. No evaluation scales of reliability have been proposed for coralligenous and rhodoliths habitat mapping; however, scales of reliability evaluation available for seagrass meadows can be adapted also for these two habitats (see the "Guidelines on marine vegetation in this document for further details). These scales usually take into account 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

39. Monitoring are necessary for conservation purposes, which require efficient management measures to ensure that marine benthic habitats, their constituent species and their associated communities are and remain in a satisfactory ecological status. The good state of health of both coralligenous and rhodoliths 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).

40. Monitoring the condition (i.e., the ecological status) of coralligenous and rhodoliths 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 habitats types" needing rigorous protection by the Protocol concerning the Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD) of the Barcelona Convention

41. According to the EcAp, the CI2 fixed by the IMAP guidelines and related to "biodiversity" (EO1) is aimed at providing information about the condition (i.e., ecological status) of coralligenous and rhodoliths habitats, being 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 rhodoliths seabeds, have been recognized as important biological indicators of environmental quality.

42. 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 monitor during the same season
c. Monitoring over time and analysis is a step where clear 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.

43. The objectives of the monitoring are primarily linked with the conservation of bio-constructed 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 that coralligenous and rhodoliths habitats are in a satisfactory ecological status (GES) and also 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
- Evaluate effects of any coastal activity likely to impact coralligenous and rhodoliths habitats during environmental impact assessment procedures. 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.

44. The objective(s) chosen will influence the choices of the monitoring criteria in the following steps (e.g., duration, sites to be monitored, descriptors, and sampling methods). The duration of the monitoring should be at least medium-long term (minimum 5-10 years long) for heritage conservation and monitoring environmental quality objectives. The interval of data acquisition could be annual, as most of the typical species belonging to coralligenous assemblages and to rhodoliths 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 areas with high pressure related to human activities. 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 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. 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).

Methods

46. Following the preliminary definition of the distributional range and extent of coralligenous and rhodoliths habitats (the previous CI1), the assessment of the condition of the two habitats starts with an overall characterisation of the typical species and communities occurring within each habitat. Monitoring of these two habitats basically relies on underwater diving, although this technique gives rise to many constraints due to the conditions of the environment in which these habitats develop (great depths, weak luminosity, low temperatures, presence of currents, etc.): it can only be done by confirmed and expert scientific divers (for safety) and over a limited underwater

time (Bianchi et al., 2004b; Tetzaff and Thorsen, 2005). Adoption of new investigation tools (e.g., ROVs) allows for a less precise assessment but over larger spatial scales. A first characterisation of the habitat (species present, abundance, vitality, etc.) can be done by direct visual underwater inspections, indirect ROVs or towed camera video recordings, or sampling procedure with dredges, grabs or box corers in the case of rhodoliths seabeds. The acoustic methods that were described above are totally inoperative for detailed characterisations of the habitats, especially for coralligenous. The surveys method depends greatly on the scale of the work and the spatial resolution requested (Tab. 2). The complementarities of these techniques must be taken into account when planning an operational strategy (Cánovas Molina et al., 2016b).

47. The use of ROVs or towed camera can be useful to optimise information obtained and sampling effort (in term of working time) and become essential for monitoring deep coralligenous assemblages and rhodoliths seabeds developing in the upper mesophotic zone (down to 40 m depth), where scuba diving procedures are usually not recommended. High quality photographs recorded 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). Photographs can be then archived to create temporal datasets.

48. At shallower depths (up to about 40 m, and according to local rules for scientific diving), direct underwater visual surveys by scuba diving are strongly suggested. 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 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 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. For a rough and rapid characterisation of the 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 quality and fine characterisation of the assemblages often requires the use of square frames (quadrates) or transects (with or without photographs; Piazzi et al., 2018) to collect quantitative data, or even the sampling by scraping of all the organisms present over a given area for further laboratory analyses (Bianchi et al., 2004b). Destructive procedures by scraping are not usually recommended on coralligenous being a time-consuming technique and due to the limited available time underwater. In situ observation and samples 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. As well as the presence or 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, gorgonians) and signs of necrosis are important elements to be taken into consideration (Garrabou et al., 1998, 2001; Gatti et al., 2012). Finally, the nature of the substratum (silted up, roughness, interstices, exposure, slope), the temperature of the water, the vagile fauna associated, the coverage by epibionta and the presence of invasive species must also be considered to give a clear characterisation of the habitat (Harmelin, 1990; Gatti et al., 2012).

nthesis of the main methods used to characterise coralligenous and rhodoliths habitats in the Mediterranean, as the first necessary step n Indicator 2_Condition of the habitat's typical species and communities. When available, the depth range, the surface area surveyed he efficiency (expressed as area surveyed in km^2 per hour), the main advantages or the limits of each tool are indicated, with some bib

	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits
	From 2 m to over 120 m	Small-Intermediate areas of about 1 km^2	From 1 m to 10 m	0.025 to 0.01 km²/hour	Non-destructive method Possibility of taking pictures Wide bathymetric range Good identification of facies and associations Possibility of semi-quantitative/quantitative evaluation	Need of specialists in taxonomy High cost, major means out at sea Difficulty of observation and access according to the complexity of the habitat (multilayer assemblages) Quantitative assessments only on conspicuous species/taxa
	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 Very good precision for the identification (taxonomy) and characterisation of the habitat (also its 3-D) Low cost, easy to implement Possibility to collect samples Data already available after dive	Need of specialists in taxonomy Small area inventoried Very time-consuming underwater Limited operational depth Highly qualified divers required Subjectivity of the observer Quantitative assessments only on conspicuous species/taxa
y	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 km²/hour	Very good precision for the identification (taxonomy) and characterisation of the habitat All species taken into account *A posteriori* identification Low cost, easy to implement	Destructive method Very small area inventoried Sampling material needed Limited operational depth Highly qualified divers required Very time-consuming underwater Analysis of samples in laboratory very time-consuming

	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits
y	0 m up to 40 m, according to local rules for scientific diving	Small areas (less than 250 m^2)	From 0.1 m	0.0001 to 0.001 km^2/hour	Non-destructive Good precision for the identification (taxonomy) and characterisation of the habitat *A posteriori* identification possible Quantitative assessments only on conspicuous species/taxa Low cost, easy to implement Possibility to collect samples Possibility to create archives	Need of specialists in taxonomy Small area inventoried Photographs or video analysis very time-consuming Limited operational depth Highly qualified divers required Tools to collect photos/video necessary Limited number of species/taxa observed Only 2-D observation allowed
s	0 m to about 120 m (until the lower limit of the rhodoliths habitat)	Intermediate areas (a few km^2)	From 1 to 10 m	0.025 to 0.01 km^2/hour	Very good precision for the identification (taxonomy) and characterisation of the habitat All species taken into account *A posteriori* identification Low cost, easy to implement	Destructive method Small area inventoried Sampling material needed Samples analysis in laboratory very time-consuming

51. An effective monitoring should be done at defined intervals over a period of time, even if it could mean a reduced number of 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 protocol has capital importance. Geographical position of surveys and sampling stations must be located with precision (using buoys on the surface and recording their coordinates with a GPS), and it often requires the use of marking underwater (with fixed pickets into the rock) for positioning the square frames or transects in the exact original position. Finally, even if it cannot be denied that there are logistical constraints linked to the observation of coralligenous and rhodoliths 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. Although destructive methods (total scraping of the substrate and of all organisms present over a given area) 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 (UNEP/MAP-RAC/SPA, 2008), and especially within MPAs. Moreover, identification of organisms needs great taxonomic 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 non-destructive methods, like photographic sampling or direct underwater observation in given areas (using square frames or transects) to collect quantitative data. These methods do not require sampling of organisms and are therefore absolutely appropriate for long-term monitoring. Different methods can be used separately or together according to the aims of the study, the area inventoried and means available (Tab. 3). Non-destructive methods are increasingly used and – mainly for photographic sampling – enjoy significant technological advances.

Table 3: Comparison between 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
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 area inventoried, non-destructive method
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
Use	Exploratory studies, monitoring of populations, bionomic studies

53. Differently from seagrass, the descriptors used to monitor coralligenous assemblages vary greatly from one team to another and from one region to another, as well as their measuring protocol (Piazzi et al., 2019a and references therein). A first standardized sheet for coralligenous monitoring was created in the context of the Natura 2000 programmes, which solved only partially the issues about comparability among data (Fig. 5). However, methods and descriptors taken into account 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).

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…*	

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

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

- **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

54. The protocol STAR (STAndaRdized coralligenous evaluation procedure) (Piazzi et al., 2019a) has been proposed for monitoring the condition of coralligenous reefs to obtain information about most of the descriptors used by the different ecological indices adopted to date on coralligenous reefs, through a single sampling effort and data analysis.

55. Monitoring plans should 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).

56. 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 once per year.

57. Depth and slope: the depth range where coralligenous reefs can develop changes with latitude and characteristics of the water. Moreover, different kind 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 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.

58. 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.

59. 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 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 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;). A comparison between the 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 analysis of the data through both seascape and biocenotic approaches (see the *Ecological Indices* paragraph below).

60. 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 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 the photographic technique, such as the size of colonies of erect species and the thickness and consistency of the calcareous accretion (see *Descriptors* 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.

61. 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 manual contouring techniques through appropriate softwares may be useful in order to reduce the subjectivity of the operator's estimate.

62. 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 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 in photographic samples, as this method showed consistent results with those obtained through techniques measuring directly 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 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 substrata 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 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 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 organism's distribution decreases, and 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 distance from centroids (Piazzi et al., 2017a) through permutational analysis of multivariate dispersion (PERMDISP). Thus, any changes in compositional variability displayed by PERMDISP may be directly interpretable as changes of β-diversity.

Protocol for monitoring mesophotic (down to 40 m depth) coralligenous habitat

63. 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.

64. 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 digital camera, a strobe, a high definition 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 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 end 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.

65. 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 substratum (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 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).

66. 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 substratum: 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)

- Sedimentationlevel, estimated considering the percentage of hard bottom covered by sediments: 0%, <30% (low), 30-60% (medium), >60% (high).

Protocol for monitoring rhodoliths habitat

67. A standardized and common sampling method for monitoring rhodoliths seabeds is not available to date (UNEP/MAP-RAC/SPA, 2008). Mediterranean rhodoliths seabeds appear to possess more diverse species assemblages of coralline and peyssonneliacean algae 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 cannot be applied as such and require calibrating to the Mediterranean specificities.

68. A recent proposal for monitoring rhodoliths beds can be found in Basso et al. (2016). Monitoring the rhodoliths habitat can be done by underwater diving and direct visual observation, with sampling and following taxa identification in laboratory. However, surveys using ROVs, towed cameras, or more usually sampling from vessels using blind grabs, dredges or box corers are often favoured because of the greater homogeneity of these populations (Tab. 4). Monitoring should address all the variables already described for the first descriptive characterisation of the habitat, with the addition of the full quantitative description of the rhodoliths community, through periodical surveys. A decrease in rhodoliths beds extent, live/dead rhodoliths ratio, live rhodoliths percentage cover, associated with change in the composition of the macrobenthic community (calcareous algal engineers and associated taxa) may reveal potential negative impacts acting on rhodoliths 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: compact and nodular pralines, larger and vacuolar box work rhodoliths, and unattached branches (Fig. 5). Each of the three end-members within rhodoliths morphological variability corresponds to a typical (but not exclusive) group of composing coralline species and associated biota and is possibly correlated with environmental variables, among which substratum instability (mainly due to hydrodynamics) and sedimentation rate are the most obvious. Thus, the indication of the percentage cover by the three live rhodoliths categories at the surface of each rhodoliths beds is a proxy of rhodoliths habitat structural and ecological complexity. The high species diversity hosted by rhodoliths beds requires time-consuming and expensive laboratory analysis for species identification. Videos and photos provide no information on rhodoliths composition owing to the absence of conspicuous, easy-to-detect species. Moreover, since most coralline species belong to a few genera only, the use of taxonomic ranks higher than species is not useful.

Table 4: Comparison between four traditional methods used to monitor rhodoliths 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 box corers)	
Advantages	Low cost, easy to implement, taxonomical precision, reference samples, analysis of substratum (granulometry, calcimetry, % of organic matter), large depth-range investigated
Limits	Low precision of observation, several replicates needed, limited area inventoried, destructive method
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 species, large depth-range investigated
Limits	High cost, low taxonomical precision, problem of *a posteriori* interpretation of images, observation only of the superficial layers, little information on the substratum and on the basal layer
Use	Studies on distribution and temporal monitoring, validation of acoustic methods
Acoustic methods	
Advantages	Very large areas inventoried, information on hydrodynamics (sedimentary figures), can be reproduced, non-destructive method, large depth-range investigated
Limits	High cost, interpreting of sonograms, additional validation (inter-calibration), observation only of the superficial layers, no taxonomical information
Use	Studies over large spatial scales, monitoring of populations, bionomic studies

69. A minimum of three box-cores with opening $\geq 0.16\ m^2$ should be collected in each rhodoliths bed at the same depth, and to a depth of about 20 cm of sediment. One box-corer must be collected within the rhodoliths area with the highest percentage of live cover (on the basis of preliminary ROV dives), and the others as far as possible from it, following the depth gradient in opposite directions of the maximum rhodoliths 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 rhodoliths morphologies characterising the sample (Fig. 5); 4) measurement of the thickness of the live rhodoliths layer. The sediment sample is then 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 be identified and quantified, in order to allow for detection of variability in space and time, and any changes 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 rhodoliths morphotypes should be air-dried, and preserved in silica gel. The sediment sample should be analysed for grain-size (mandatory), and carbonate content.

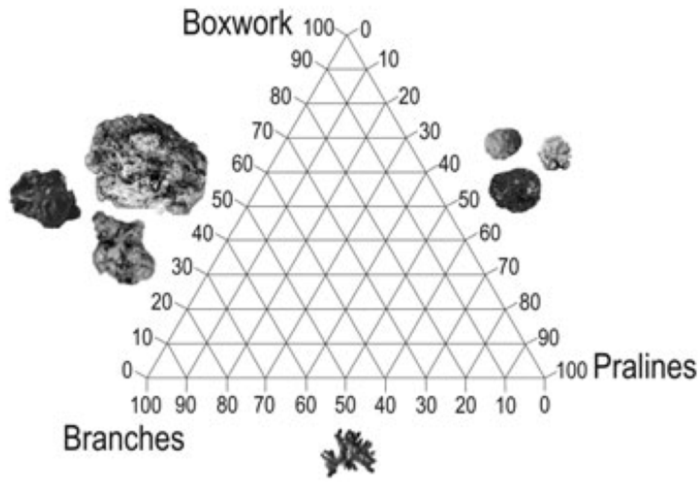

Figure 5: ternary diagram for the description of the rhodoliths bed tridimensionality. The percentage cover of each rhodoliths morphotype, relative to the total rhodoliths cover, can be plotted on the correspondent axis. The three main rhodoliths morphotypes (box work rhodoliths, pralines and unattached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

Ecological Indices

70. 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., 2019), which are summarised in Table 5. Most of the ecological indices available for monitoring shallow 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. Detailed descriptions of the sampling tools and the methodologies adopted for each index listed in Table 5 can be found in the relative bibliographic references.

71. ESCA (Ecological Status of Coralligenous Assemblages; Cecchi et al., 2014; Piazzi et al., 2015, 2017a), 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 biocenotic approach where coralligenous assemblages are investigated in terms of composition and abundance of all species for ESCA and ISLA, and percentage cover of mudand builder organisms (i.e., Corallinales, bryozoans, scleractinians) for CAI.

72. 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.

73. 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 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.

74. 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 status of coralligenous assemblages.

75. 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., 2017b) 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 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 main differences among indices are linked to the different approaches used, and that ESCA and ISLA showed highly consistent results being based on a 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.

76. Few efforts have been made to define 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 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 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 complexity of the investigated ecosystem, whereas the Ii describes the impacts affecting it. Environmental status is the outcome of the status of benthic communities plus the amount of impacts 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 subjected to different environmental conditions and levels of human pressures.

Final remarks

77. Inventorying and monitoring the condition of coralligenous reefs and rhodoliths seabeds in the Mediterranean constitute 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.

78. A standardized approach must be encouraged for monitoring the condition of coralligenous reefs and rhodoliths seabeds, and in particular:

- Knowledge on coralligenous reefs and rhodoliths seabeds distribution should be continuously enhanced at the Mediterranean scale 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 rhodoliths seabeds.

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

Index	Method	Image analysis	Descriptors
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 stress (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 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
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 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 (from 40 m to about 120 m depth) coralligenous habitat 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 s 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
List of the main species to be considered in the inventorying and monitoring coralligenous and rhodoliths habitats (from UNEP/MAP-RAC/SPA, 2015)

Coralligenous
Builders
Algal builders
Lithophyllum cabiochae (Boudouresque & Verlaque) Athanasiadis, 1999
Lithophyllum 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
Myriapora truncata Pallas, 1766
Schizomavella spp.
Turbicellepora spp.
Adeonella calveti Canu & Bassler, 1930
Smittina cervicornis Pallas, 1766
Pentapora fascialis Pallas, 1766
Schizoretepora serratimargo (Hincks, 1886)
Rhynchozoon neapolitanum Gautier, 1962

Polychaeta
Serpula spp.
Spirorbis sp.
Spirobranchus polytrema Philippi, 1844

Cnidaria
Caryophyllia (Caryophyllia) inornata (Duncan, 1878)
Caryophyllia (Caryophyllia) smithii Stokes & Broderip, 1828
Leptopsammia pruvoti Lacaze-Duthiers, 1897
Hoplangia durotrix Gosse, 1860
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)

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

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

OTHER RELEVANT SPECIES (*invasive; **disturbed or stressed environments-usually, when abundant)
Algae
Green algae
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
Cystoseira zosteroides (Turner) C. Agardh, 1821

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
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**

<u>"Yellow" algae (Pelagophyceae)</u>
Nematochrysopsis marina (J. Feldmann) C. Billard, 2000**

<u>Red algae</u>
Osmundaria volubilis (Linnaeus) R.E. Norris, 1991
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*
Lophocladia lallemandii (Montagne) F. Schmitz, 1893*
Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon, 1845*
Womersleyella setacea (Hollenberg) R.E. Norris, 1992*

Animals
<u>Sponges</u>
Acanthella acuta Schmidt, 1862
Agelas oroides Schmidt, 1864
Aplysina aerophoba Nardo, 1843
Aplysina cavernicola Vacelet, 1959
Axinella spp.
Chondrosia reniformis Nardo, 1847
Clathrina clathrus Schmidt, 1864
Cliona viridis (Schmidt, 1862)
Dysidea spp.
Haliclona (Reniera) mediterranea Griessinger, 1971
Haliclona (Soestella) mucosa Griessinger, 1971
Hemimycale columella Bowerbank, 1874
Ircinia oros Schmidt, 1864
Ircinia variabilis Schmidt, 1862
Oscarella sp.
Petrosia (Petrosia) ficiformis (Poiret, 1789)
Phorbas tenacior Topsent, 1925
Sarcotragus fasciculatus (Pallas, 1766)
Spirastrella cunctatrix Schmidt, 1868
Spongia (Spongia) officinalis Linnaeus, 1759
Spongia (Spongia) lamella Schulze, 1879

<u>Cnidaria</u>
Alcyonium acaule Marion, 1878
Alcyonium palmatum Pallas, 1766
Corallium rubrum Linnaeus, 1758
Paramuricea clavata Risso, 1826
Eunicella spp.
Leptogorgia sarmentosa Esper, 1789
Ellisella paraplexauroides Stiasny, 1936
Antipathes spp.
Parazoanthus axinellae Schmidt ,1862
Savalia savaglia Bertoloni, 1819
Callogorgia verticillata Pallas, 1766

<u>Polychaeta</u>
Sabella spallanzanii Gmelin, 1791
Filograna implexa Berkeley, 1835
Salmacina dysteri Huxley, 1855
Protula spp.

<u>Bryozoans</u>
Chartella tenella Hincks, 1887
Margaretta cereoides Ellis & Solander, 1786
Hornera frondiculata (Lamarck, 1816)

<u>Tunicates</u>
Pseudodistoma cyrnusense Pérès, 1952
Aplidium spp.
Microcosmus sabatieri Roule, 1885
Halocynthia papillosa Linnaeus, 1767

<u>Molluscs</u>
Charonia lampas Linnaeus, 1758
Charonia variegata Lamarck, 1816
Pinna rudis Linnaeus, 1758
Naria spurca (Linnaeus, 1758)
Luria lurida Linnaeus, 1758

<u>Decapoda</u>
Palinurus elephas Fabricius, 1787
Scyllarides latus Latreille, 1803
Maja squinado Herbst, 1788

Echinodermata
Antedon mediterranea Lamarck, 1816
Hacelia attenuata Gray, 1840
Centrostephanus longispinus Philippi, 1845
Holothuria (Panningothuria) forskali Delle Chiaje, 1823
Holothuria (Platyperona) sanctori Delle Chiaje, 1823

Pisces
Epinephelus spp.
Mycteroperca rubra Bloch, 1793
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-usually, when abundant). Species that can be dominant or abundant are preceded by #

Algae
Red algae (calcareous)
#*Lithophyllum racemus* (Lamarck) Foslie, 1901
#*Lithothamnion corallioides* (P.L. Crouan & H.M. Crouan) P.L. Crouan & H.M. Crouan, 1867
#*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 heteromorpha (Zanardini) Athanasiadis, 2016
Sporolithon ptychoides Heydrich, 1897

Red algae (non 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
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

Microdictyon umbilicatum (Velley) Zanardini, 1862
Palmophyllum crassum (Naccari) Rabenhorst, 1868
Umbraulva dangeardii M.J. Wynne & G. Furnari, 2014
<u>Brown algae</u>
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
Nereia filiformis (J. Agardh) Zanardini, 1846
Phyllariopsis brevipes (C. Agardh) E.C. Henry & G.R. South, 1987
Spermatochnus paradoxus (Roth) Kützing, 1843
Stictyosiphon adriaticus Kützing, 1843
Stilophora tenella (Esper) P.C. Silva, 1996
Zanardinia typus (Nardo) P.C. Silva, 2000
Animals
<u>Sponges</u>
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
<u>Cnidaria</u>
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)
Funiculina quadrangularis Pallas, 1766
Leptogorgia sarmentosa Esper, 1789
Nemertesia antennina Linnaeus, 1758
Pennatula spp.
Veretillum cynomorium Pallas, 1766
Virgularia mirabilis Müller, 1776
<u>Polychaetes</u>
Aphrodita aculeata Linnaeus, 1758
Sabella pavonina Savigny, 1822
Sabella spallanzanii Gmelin, 1791
<u>Bryozoans</u>
Cellaria fistulosa Linnaeus, 1758
Hornera frondiculata (Lamarck, 1816)
Pentapora fascialis Pallas, 1766
Turbicellepora spp.
<u>Tunicates</u>
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
<u>Echinodermata</u>
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
<u>Pisces</u>
Mustelus spp.
Pagellus acarne (Risso, 1827)
Pagellus erythrinus (Linnaeus, 1758)
Raja undulata Lacepède, 1802
Scyliorhinus canicula (Linnaeus, 1758)
Squatina spp.
Trachinus radiatus Cuvier, 1829

3. Guidelines for monitoring dark habitats in Mediterranean

Table of contents

Introduction

1. Dark habitats[1] are environments where the luminosity is extremely weak (deep mesophotic zone), or even absent (aphotic zone) distributed throughout the Mediterranean basin from the sea surface (i.e., caves) to the deep-sea realm. The bathymetric extension of this lightless zone depends to a great extent on the turbidity of the water and corresponds to benthic and pelagic habitats starting from the deep circalittoral. Caves, which show peculiar environmental conditions that favour the installation of organisms typical of dark habitats, are also taken into account. Dark habitats are dependent on very diverse geomorphologic structures, e.g. underwater caves, submarine canyons, seamounts, slopes, isolated rocks, abyssal plains, brine anoxic lakes, and chemo-synthetic features such as cold seeps and hydrothermal springs. Dark habitats are considered as sensitive habitats in the Mediterranean Sea requiring protection (Habitat Directive 92/43), supporting peculiar assemblages that constitute veritable reservoirs of biodiversity that, therefore, must be protected and need further attention. Thus, dark habitats were considered under the Action Plan for their conservation adopted in the 18th Ordinary Meeting of the Contracting Parties to the Barcelona Convention (Turkey, December 2013). Among the objectives of the Action Plan (UNEP/MAP-RAC/SPA, 2015) there was the need to improve knowledge about dark populations (e.g., location, specific richness, functioning, and typology) through national and regional programs aimed at establishing a shared knowledge of dark habitats, of their distribution around the Mediterranean in the form of a geo-referenced information system (GIS), and of their condition to implement specific management interventions at the basin scale.

2. In this context, the need of practical guidelines aimed at harmonising existing methods for dark habitats monitoring and for subsequent comparison of results obtained by different countries has been highlighted. In the framework of the Ecosystem Approach implementation, The Specially Protected Areas Regional Activity Centre (SPA/RAC) has been asked to improve the existing inventory tools and to propose a standardization of the mapping and monitoring techniques for dark habitats in the context of the IMAP common indicators and in order to ease the task of the Countries when implementing their monitoring programmes. Thus, the main methods used in the Mediterranean for inventory and monitoring of dark habitats have been recently summarised in the "Draft guidelines for inventorying and monitoring of dark habitats (UNEP/MAP-SPA/RAC, 2017)" and the "Guidelines for inventorying and monitoring of dark habitats in the Mediterranean Sea" (SPA/RAC-UN Environment/MAP OCEANA, 2017). These guidelines are the base for the updating and harmonization process undertaken in this document.

3. The updated guidelines aim to establish common methods for inventorying and monitoring Mediterranean deep-sea habitats and marine caves, in order to settle the basis for a regional-based assessment. Furthermore, they aim at reviewing the known distribution and main characteristics of these ecosystems. Although the Dark Habitats Action Plan covers entirely dark caves[2], inventorying and monitoring initiatives focusing on marine caves should consider the cave habitat as a whole. Therefore, this updated document presents methodologies that cover both semi-dark and dark caves. Notwithstanding the increased scientific knowledge on dark habitats during the last decades, there is still a significant gap today. The number of human activities and pressures impacting marine habitats has considerably increased throughout the Mediterranean Sea, including deep-sea habitats (e.g., destructive fishing practices such as bottom trawling, oil and gas exploration, deep-sea mining); thus, there is an urgent need for establishing a regional monitoring system. Nevertheless, the development of comprehensive inventorying initiatives and monitoring tools becomes extremely challenging due to: (1) the scarcity of information on the current state of these habitats (distribution, density of key species, etc.), (2) the high cost and difficulties for accessing, and (3) the lack of historical data and long-time series. In this context, MPAs and Fishing Restricted Areas (FRAs) may be considered as essential tools for the conservation and monitoring of dark

[1] Dark habitats are those where either no sunlight arrives or where the light that does arrive is insufficient for the development of plant communities. They include both shallow marine caves and deep habitats (usually at depths below 120-200 m).
[2] <0.01% of the light at the sea surface level, according to Harmelin et al. (1985).

habitats. However, to date there is an obvious gap in the protection and monitoring of deep-sea habitats as they are mainly located in offshore areas where information remains limited. This issue should be addressed by CPs at the earliest convenience in order to put in place control systems aiming at the implementation of Ecosystem Approach (EcAp) procedures, and particularly the implementation of the IMAP at the regional and national level.

4. A reviewing process on the scientific literature, taking into account the latest techniques and the recent works carried out by the scientific community at the international level, has been carried out to update the former draft guidelines. If some standardized protocols do exist for seagrass and coralligenous mapping and monitoring (and are also well-implemented in the case of seagrass), this is not the case for dark habitats. In this document a number of "minimal" descriptors to be taken into account for inventorying and monitoring dark habitats in the Mediterranean are described. The main methods adopted for their monitoring, with the relative advantages, restrictions and conditions of use, are presented.

Marine caves

5. Marine caves support well diversified and unique biological communities (Pérès and Picard, 1949; Pérès 1967; Riedl 1966; Harmelin et al., 1985), harbouring a variety of sciaphilic communities, usually distributed according to the following zonation scheme: (a) a (pre-)coralligenous[1] algae-dominated community at the entrance zone, (b) a semi-dark zone dominated by sessile filter-feeding invertebrates (mainly sponges and anthozoans), and (c) a dark zone at the end or at the confined areas of the cave, which is sparsely colonized by sponges, serpulid polychaetes, bryozoans and brachiopods (Pérès, 1967). Nevertheless, there is a lamentable dearth of information on the gradients of physical-chemical parameters acting on the marine cave biota (Gili et al., 1986; Morri et al., 1994a; Bianchi et al., 1998). A general description of the semi-dark and dark cave communities, which are considered in the present document, can be found bellow.

- *Semi-dark cave communities*

6. Hard substrates in semi-dark caves are typically dominated by sessile invertebrates (sponges, anthozoans, and bryozoans) (see Appendix I). The most frequently recorded sponge species are *Agelas oroides*, *Petrosia ficiformis* (often discoloured), *Spirastrella cunctatrix*, *Chondrosia reniformis* (often discoloured), *Phorbas tenacior*, and *Axinella damicornis* (Fig. 1). The sponge *Aplysina cavernicola* has been also described as a characteristic species of the semi-dark community in the north-western Mediterranean basin (Vacelet, 1959). Sponges of the class Homoscleromorpha (e.g., *Oscarella* spp. and *Plakina* spp.) may also significantly contribute to the local sponge assemblages.

7. Three anthozoan facies have been recorded in semi-dark caves (mostly on ceilings) (Pérès, 1967; Zibrowius, 1978): (i) facies of the scleractinian species *Leptopsammia pruvoti*, *Madracis pharensis* (particularly abundant in the eastern basin), *Hoplangia durotrix*, *Polycyathus muellerae*, *Caryophyllia inornata*, and *Astroides calycularis* (in the southern areas of the central and western Mediterranean Sea) (Fig. 1); (ii) facies of *Corallium rubrum*, which is more common in the north-western Mediterranean Sea but can be found only in deep waters (below 50 m depth) in the north-eastern basin (Fig. 1); and (iii) facies of *Parazoanthus axinellae*, which is more common close to the cave entrance or in semi-dark tunnels with high hydrodynamic regime (more common in the Adriatic Sea) (Fig. 1). Facies of erect bryozoans (e.g., *Adeonella* spp. and *Reteporella* spp.) often develop in semi-dark caves (Pérès, 1967; Ros et al., 1985) (Fig. 1).

- *Dark cave communities*

8. The shift from semi-dark to dark cave communities is evidenced through a sharp decrease in biotic coverage, biomass, three-dimensional biotic complexity, species richness, and the

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

appearance of a black mineral coating of Mn-Fe oxides on the substrate (Pérès, 1967; Harmelin et al., 1985). This community is usually sparsely colonized by sponges, serpulids, bryozoans and brachiopods (Pérès, 1967) (see Appendix I). Common sponge species are *Petrosia ficiformis* (usually discoloured), *Petrobiona massiliana* (mainly in Western Mediterranean caves), *Chondrosia reniformis* (usually discoloured), *Diplastrella bistellata*, *Penares euastrum*, *P. helleri*, *Jaspis johnstoni*, *Haliclona mucosa*, and *Lycopodina hypogea*.

9. Serpulid polychaetes are among the dominant taxa in these caves, with the typical species being *Serpula cavernicola* and *Spiraserpula massiliensis* (Zibrowius, 1971; Bianchi and Sanfilippo, 2003; Sanfilippo and Mòllica, 2000). In some caves, the species *Protula tubularia* forms aggregates that constitute the basis for the creation of bioconstructions; these "biostalactites" are constructed by invertebrates (serpulids, sponges, and bryozoans), foraminiferans and carbonate-forming microorganisms (Sanfilippo et al., 2015).

10. Encrusting bryozoans (e.g. *Onychocella marioni*) can also produce nodular constructions in the transitional zone between semi-dark and dark cave communities (Harmelin, 1985). Brachiopods (e.g., *Joania cordata*, *Argyrotheca cuneata*, and *Novocrania anomala*) are common in dark cave habitats (Logan et al., 2004). The species *N. anomala* is frequently found in high numbers, cemented on cave walls and roofs (Logan et al., 2004). A number of deep-sea species belonging to various taxonomic groups (e.g., sponges, anthozoans, and bryozoans) have been recorded in sublittoral dark caves, regardless of depth (Zibrowius, 1978; Harmelin et al., 1985; Vacelet et al., 1994).

11. Several motile species often find shelter in dark caves, such as the mysids *Hemimysis margalefi* and *H. speluncola*, the decapods *Stenopus spinosus*, *Palinurus elephas*, and *Plesionika narval* (more common in southern and eastern Mediterranean areas) and the fish species *Apogon imberbis* and *Grammonus ater* (Pérès, 1967; Ros et al., 1985, Bussotti et al., 2002).

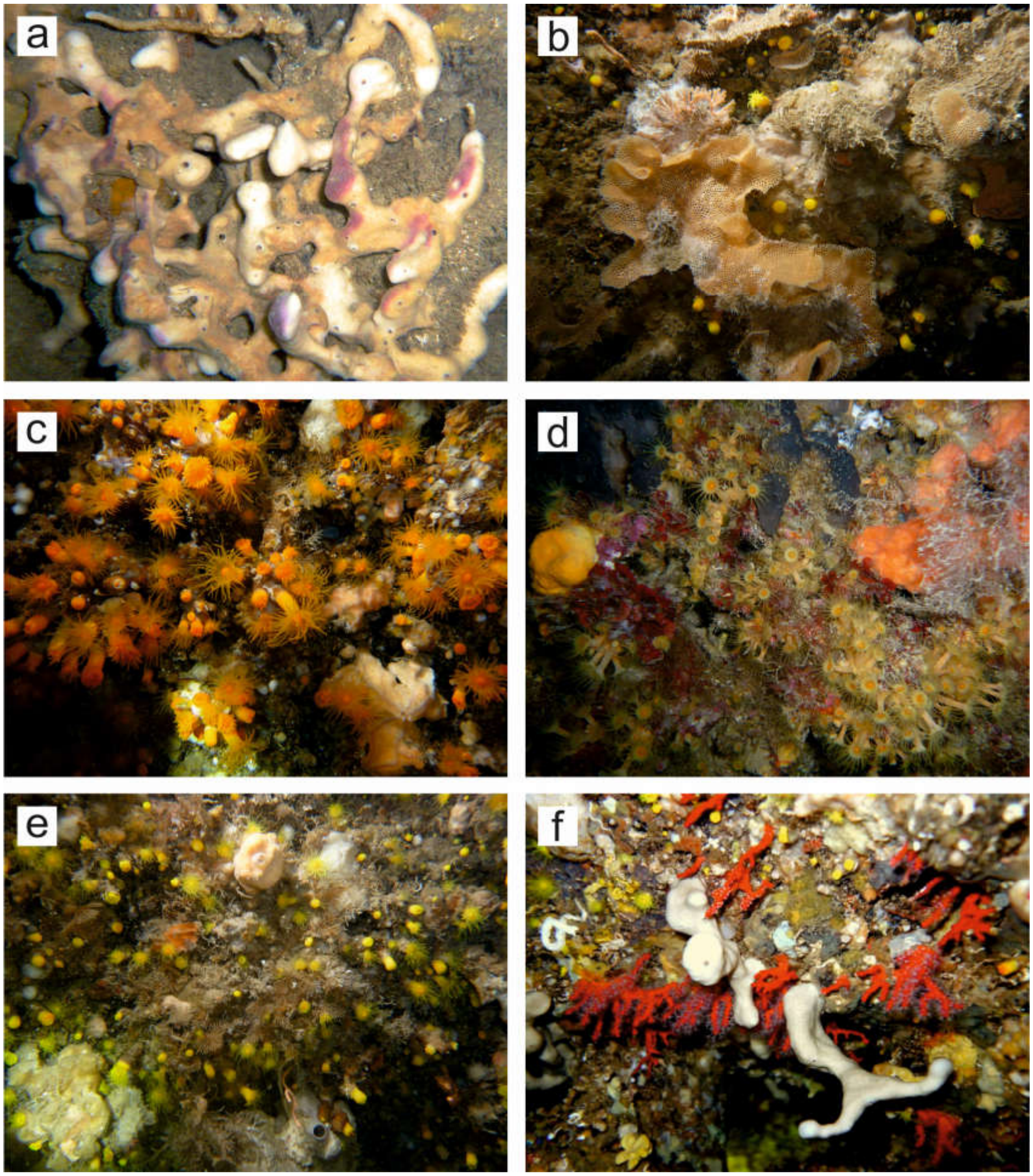

Figure 1: facies with *Petrosia ficiformis* (a), *Reteporella grimaldii* and other bryozoans (b), *Astroides calycularis* (c), *Parazoanthus axinellae* (d), *Leptopsammia pruvoti* (e), and *Corallium rubrum* (f) in semi-dark marine caves. Pictures by Monica Montefalcone (a-e) and Vasilis Gerovasileiou (f).

12. Knowledge on the marine caves distribution and ecology in the different sectors of the Mediterranean Sea can be summarised as follow:

Western Mediterranean Sea

13. A total of 1046 marine caves have been recorded in the western Mediterranean basin (Giakoumi et al., 2013). The rocky coasts of the Tyrrhenian Sea and the Algero-Provençal Basin have been extensively studied for their cave biodiversity, with 822 and 650 taxa recorded from these two areas respectively (Gerovasileiou and Voultsiadou, 2014). The first and some of the most influential studies on the diversity and structure of marine cave communities were carried out in the French, Italian and Catalan coasts (e.g., Pérès and Picard, 1949; Riedl, 1966; Harmelin et al., 1985; Ros et al., 1985; Bianchi and Morri, 1994; Bianchi et al., 1996). A synthesis of the existing

knowledge on Italian marine caves, accumulated in fifty years of research, was compiled by Cicogna et al. (2003). The fully submerged caves of Figuier, Jarre, Riou, Trémies and Triperie in the karstic coasts of Marseille-Cassis area are among the species-richest Mediterranean caves, while the famous Trois Pépés cave has been characterised as a unique "deep-sea mesocosm" in the sublittoral zone, supporting deep-sea faunal elements in its inner dark sectors (Vacelet et al., 1994; Harmelin, 1997). Submarine caves in the region of Palinuro (Tyrrhenian Sea) have been found to host sulphur springs that support trophic webs based on chemosynthesis (Bianchi et al., 1994; Morri et al., 1994b; Southward et al., 1996), presenting analogies with deep-water chemosynthetic ecosystems. The submarine cave of Bergeggi (Ligurian Sea, Italy) provides the longest series of data on the status of benthic communities, being studied regularly since 1986 (Parravicini et al., 2010; Montefalcone et al., 2018).

14. The number of species reported from marine caves decreases towards the insular and southern sectors of the western Mediterranean basin, according to differences in temperature and trophic conditions (Uriz et al., 1993) and to a notable decrease in research effort (Gerovasileiou and Voultsiadou, 2014). For instance, the Alboran Sea is one of the least studied areas regarding its marine cave fauna (but see Navarro-Barranco et al., 2014, 2016). Nevertheless, recent research expeditions in the framework of the MedKeyHabitats project have provided baseline information for the previously understudied Alboran coasts of Morocco (PNUE/PAM-CAR/ASP, 2016).

Ionian Sea and central Mediterranean

15. The western coasts of the Ionian Sea are among the best-studied Mediterranean areas regarding their marine cave biodiversity, with almost 700 taxa reported in this area (Gerovasileiou and Voultsiadou, 2014). To date 375 marine caves are known from the Ionian Sea and the Tunisian Plateau/Gulf of Sidra (Giakoumi et al., 2013). Most of the regional inventories, mapping initiatives and biodiversity studies have taken place in the Salento Peninsula (e.g., Onorato et al., 1999; Bussotti et al., 2002, 2006; Denitto et al., 2007; Belmonte et al., 2009; Bussotti and Guidetti, 2009) and in Sicily (e.g., Rosso et al., 2013, 2014; Sanfilippo et al. 2015). Marine caves in this area were recently studied and evaluated for their ecological status.

Adriatic Sea

16. Up to date 708 marine caves have been recorded in the Adriatic Sea (Giakoumi et al., 2013), supporting approximately 400 taxa (Gerovasileiou and Voultsiadou, 2014). The coasts of Croatia are among the most studied Mediterranean areas concerning their marine and anchialine caves, in terms of geology (e.g., detailed mapping initiatives by Surić et al., 2010) and biodiversity (e.g., Riedl, 1966, Bakran-Petricioli et al., 2007, 2012; Radolovic et al. 2015). Specifically, Y-Cave on Dugi Otok Island is one of the species-richest caves in the Mediterranean basin while deep-sea sponges have been found in caves of the islands Hvar, Lastovo, VeliGarmenjak, IškiMrtovnjak and Fraškerić (Bakran-Petricioli et al., 2007). Recently, inventories for marine cave habitats and their communities have taken place in Montenegro and Albania in the framework of the MedKeyHabitats project.

Aegean Sea and Levantine Sea

17. The coasts of the eastern Mediterranean basin host approximately one third (738) of the marine caves recorded in the Mediterranean Sea, mostly across the complex coastline of the Greek Islands in the Aegean Sea (Giakoumi et al., 2013). A total of 520 taxa have been found in caves of the Aegean and the Levantine seas (324 and 157, respectively) (Gerovasileiou et al., 2015). Lesvos Island in the North Aegean Sea hosts two of the best-studied marine caves with regard to their diversity (approximately 200 taxa recorded in each cave), community structure and function (Gerovasileiou and Voultsiadou, 2016; Sanfilippo et al., 2017). Several caves scattered across the Aegean ecoregion were recently studied for their biodiversity (e.g., Rastorgueff et al., 2014; Gerovasileiou et al., 2015), community structure and ecological quality. One of the most well-known

insular areas concerning their marine cave formations is encompassed within the National Marine Park of Alonissos and Northern Sporades, hosting numerous cave habitats, critical for the survival of the endangered Mediterranean monk seal *Monachus monachus* (Dendrinos et al., 2007). The coasts of Lebanon host most of the studied Levantine caves (e.g., Bitar and Zibrowius, 1997; Logan et al., 2002; Pérez et al., 2004; Vacelet et al., 2007; Morri et al., 2009). Forty-six non-indigenous species have been recorded in 80% of the marine caves and tunnels known to exist in the Levantine Sea, mostly at their entrance and semi-dark zones (Gerovasileiou et al., 2016b), indicating a potential new threat for cave communities that should be further monitored.

Deep-sea habitats

18. Deep-sea habitats are those where either no sunlight arrives (aphotic zone) or where the light that does arrive is insufficient for the development of plant communities (deep mesophotic zone), usually at depths below 120-200 m. Deep-sea habitats display diverse geomorphologic structures: submarine canyons, seamounts, slopes, isolated rocks, abyssal plains, brine anoxic lakes, and chemo-synthetic features such as cold seeps and hydrothermal springs. Given their wide bathymetric range, parts of these geomorphologic formations may start in the upper mesophotic zone (down to 40 m depth). This is the case of the summits of seamounts and the heads of canyons, as well as some offshore isolated rocks. To maintain their integrity, all of these habitats are included within the classification of dark habitats.

19. Deep-sea habitats may host complex three-dimensional animal forests over rocky reefs and detritic or muddy bottoms, and are mainly dominated by arborescent, structuring anthozoans, sponges and bryozoans. As agreed, and set out in the Dark Habitats Action Plan (UNEP/MAP-RAC/SPA, 2015), the existing biological communities characterising deep-sea habitats are the following:

✓ Assemblages of underwater canyons

✓ Assemblages associated with seamounts

✓ Engineering benthic invertebrate assemblages

- Black coral and gorgonian forests on hard substrata
- Beds with *Isidella elongata* and beds with pennatulaceans on detritic substrata
- Associations of sponges on both types of substrata

✓ Deep-sea chemo-synthetic assemblages

20. However, thanks to advances in scientific knowledge, other recently discovered types are being added to the list of deep-sea habitats.

21. The most characteristic habitat-forming species of the deep mesophotic and aphotic zones are sponges and anthozoans, although other phyla and classes, such as molluscs, polychaete tube-worms, bryozoans, and cirriped crustaceans, may also have a predominant role in some cases or be a fundamental part of mixed habitats, also through the formation of complex bioconstructions that provide three-dimensional structures (Fig. 2).

- *Habitats dominated or formed by stony corals (Scleractinia)*

22. The best known are Cold-Water Coral (CWC) reefs, mainly formed by *Desmophyllum pertusum (*ex *Lophelia pertusa*) and *Madrepora oculata* (Orejas and Jiménez, 2019). They usually occur in rocky substrates (e.g., seamounts, canyons or escarpments) although they could also be found in highly silted areas. Their bathymetric range is usually between about 200 m and down to more than 1000 m. They have been found both in the western and eastern central Mediterranean Sea, in areas such as the Cabliers, Chella and Avempace seamounts in the Alboran Sea (Pardo et al., 2011; de la Torriente et al., 2014; Lo Iacono et al. 2014), in canyons in the Gulf of Lion and the surrounding

area such as Cassidaigne and Creus (Bourcier and Zibrowius, 1973; Orejas et al., 2009; Fourt and Goujard, 2012; Gori et al. 2013), in the estern Ligurian Sea (Fanelli et al., 2017), in the southern Catalan canyons (e.g., La Fonera canyon; Lastras et al., 2016; Taviani et al., 2019), south of Sardinia in the Nora Canyon (Taviani et al., 2017), in the Gulf of Naples (Taviani et al., 2017), offshore Santa Maria di Leuca in the Northern Ionian Sea (Taviani et al., 2005a, 2005b; Mastrototaro et al., 2010; Savini et al., 2014; Vertino et al., 2010; D'Onghia et al., 2012), south of Malta and other sites in the Strait of Sicily (Schembri et al., 2007; Freiwald et al., 2009; Taviani et al., 2009, 2011a; Evans et al., 2016), next to the Jabuka-Pomo depression (Županović, 1969), in the Bari canyon and off Apulia in the south-western Adriatic Sea (Freiwald et al., 2009; Angeletti et al., 2014; D'Onghia et al., 2015), in the Montenegrin canyons (Angeletti et al., 2014, 2015a), in the Adriatic Sea, trough off Thassos in northern Aegean Sea (Vafidis et al., 1997), in the Marmara Sea (Taviani et al., 2011a), in the deep waters of the Hellenic Arc in the south of the Aegean/Levantine basin (Fink et al., 2015), among others.

23. Other stony corals that form important marine habitats are the tree corals (*Dendrophyllia* spp.). *D. cornigera* can form dense aggregations in deep seabeds, although in the Mediterranean Sea it is rare to find places with dense populations (Pardo et al., 2011; Bo et al., 2014a). Its bathymetric range can vary from shallow water to depths of more than 600 m. It has been found mainly in the western basin, on seamounts in the Alboran Sea (Pardo et al., 2011; de la Torriente et al., 2014), in submarine canyons in the Gulf of Lion and Corsica (Orejas et al., 2009; Gori et al. 2013; Fourt et al., 2014a), in the Balearic Archipelago continental shelf and slope (Orejas et al., 2014), on seamounts in the Tyrrhenian Sea (Bo et al., 2011), at mesophotic depths in the Ligurian Sea (Bo et al., 2014a), in some areas of the central Mediterranean Sea (Würtz and Rovere, 2015), including the banks of the Ionian Sea (Amendolara Bank, Tursi et al., 2004; Bo et al., 2014a), and in the southern Adriatic Sea (Freiwald et al., 2009; Angeletti et al., 2015a). *D. ramea* is more common in shallower waters, especially at mesophotic depths. Recently, however, *D. ramea* communities have been found in deep waters in the eastern Mediterranean Sea, such as the deep seabeds of Cyprus (Orejas et al., 2017) and the submarine canyons off Lebanon (R. Aguilar, pers. obs.). Both species can occur on rocky and soft seabeds. Furthermore, in the northern part of the Sicilian coast, between 80 and 120 m depth, a huge population of *D. ramea* with several colonies was recently discovered. Many colonies showed severe injure caused by lost fishing gear (Salvati et al., submitted). Probably this species showed a more diffuse abundance and distribution in the past.

24. Other colonial stony corals that have been found forming dense aggregations in certain areas are *Madracis pharensis*, a typical component of cave assemblages that is particularly abundant in the coralligenous outcrops of the eastern Mediterranean basin, which is also abundant in the heads of canyons and coastal waters of Lebanon, at depths down to nearly 300 m, sometimes in mixed aggregations with brachiopods, molluscs and polychaetes (R. Aguilar, pers. obs.). Colonies of *Anomocora fecunda* have been found on the seamounts of the Alboran Sea (de la Torriente et al., 2014) on seabeds at depths between 200 and 400 m.

25. There are also solitary corals that sometimes create important aggregations. This is the case of the pan-Mediterranean *Desmophyllum dianthus*, a solitary coral with a pseudocolonial habit found in both canyons and deep seabeds, alone or even participating in the formation of reefs with *Desmophyllum pertusum* and *Madrepora oculata* (Galil and Zibrowius, 1998; Montagna et al., 2006; Freiwald et al., 2009; Taviani et al., 2011b, 2016a, 2017; de la Torriente et al., 2014; Fourt et al., 2014a).

26. Species of the genus *Caryophyllia* settle on rocky and detritic bottoms and may become important. For example, *Caryophyllia (Caryophyllia) calveri* is one of the most common solitary coral species in deep rocky bottoms, being capable of forming dense communities, sometimes along with other scleractinians such as *Javania cailleti*, *Stenocyathus vermiformis* and other *Caryophyllia* spp. It has been found in seamounts, escarpments or rocky bottoms (Galil and Zibrowius, 1998; Mastrototaro et al., 2010; Aguilar et al., 2013, 2014). In the case of soft bottoms, mainly in detritic sands, beginning in the deep circalittoral sand and extending to depths down to 400-500 m,

Caryophyllia (Caryophyllia) smithii can cover significant areas (de la Torriente et al., 2014), similar to *Flabellum* spp. in the Atlantic (Baker et al., 2012; Serrano et al., 2016).

- *Habitats dominated or structured by black corals*

27. Antipatharians, or black corals, are represented in the Mediterranean by just a few species, although this number may increase with the new deep-sea explorations. They are found on hard bottoms, although they can withstand some sedimentation and may occur on rocky bottoms slightly covered by sediments. They can also occur on seamounts, in canyons or on deep sea environments where hard substrates are present. The species that reach the highest densities are *Antipathella subpinnata*, *Leiopathes glaberrima*, and (in some occasions) *Parantipathes larix* that can form monospecific assemblages (e.g., Bo et al., 2009, 2015, 2019a, 2019b; Ingrassia et al., 2016). *Antipathes dichotoma* can also occur with high densities, but many times are part of other black coral communities alongside gorgonians. They have a wide bathymetric distribution with some species occurring also in the upper mesophotic zone at relatively shallow depths (about 60 m) (Bo et al., 2009, 2019b), and others extending to the superficial bathyal zone and reaching depths of over 2000 m. It is known that some *Leiopathes* sp. inhabit depths down to 4000 m outside the Mediterranean Sea (Molodtsova, 2011). Dense aggregations have been found on seamounts in the Alboran (de la Torriente et al., 2014), the Balearic Archipelago (Grinyó, 2016), the Ligurian Sea (Bo et al., 2014a, 2019a), and the Tyrrhenian Seas (Bo et al., 2011, 2012; Fourt et al., 2014a; Ingrassia et al., 2016), in south-western Sardinia (Bo et al., 2015; Cau et al., 2016a), on the escarpments in the south of Malta (Deidun et al., 2015; Evans et al., 2016), in the Ionian Sea (Mytilineou et al., 2014) and in the eastern Adriatic Sea (Angeletti et al. 2014; Taviani et al., 2016a). Sporadic occurrences have been also reported from the Malta Escarpment and offshore Rhodes (Taviani et al., 2011b; Angeletti et al., 2015b).

28. *Antipathella subpinnata*, similarly to *Antipathes dichotoma*, normally occupies offshore mesophotic rocky elevations or deep coastal bottoms but may thrive also on seamount summits (Bo et al., 2009, 2014; de la Torriente et al., 2014), and reach greater depths. It has a wide distribution in the Mediterranean Sea, being recorded within white coral regions (Bo and Bavestrello, 2019), mainly in the western and central basins but also in the Aegean Sea (Vafidis and Koukouras, 1998; Bo et al., 2008). *A. wollastoni* has also been recorded near the Strait of Gibraltar (Ocaña et al., 2007).

29. Recently other black coral species have also been observed forming dense aggregations. Some examples are *Parantipathes larix* found in some areas of the Alboran Sea (Pardo et al., 2011) and in deep waters off the Tuscan and Pontin archipelago in the Tyrrhenian Sea (Bo et al., 2014b, Ingrassia et al., 2016), also in Corsica and Provence region (Fourt et al., 2014a), and *Phanopathes rigida*, newly reported on seamounts between 180-400 m from the south of the Alboran Sea in the Cabliers Bank (Bo et al., 2019b). *Parantipathes larix* has a wide bathymetric distribution, from 120 m down to over 2000 m (Opresko and Försterra, 2004; Fabri et al., 2011; Bo et al., 2012b).

- *Habitats dominated by gorgonians*

30. Deep Mediterranean gorgonian assemblages (Alcyonacea, excluding Alcyoniina) can be highly diverse and present a wide geographic and bathymetric distribution (Gori et al., 2017, 2019). Most are species that attach to a hard substrate, although some can withstand high levels of sedimentation and a few species can occur in soft bottoms, both detritic and muddy (Mastrototaro et al., 2017). Some of the assemblages that reach high densities are those formed by the Atlanto-Mediterranean gorgonian *Callogorgia verticillata*. Dense forests have been found that can begin in the deep mesophotic zone and extend to a depth of more than 1000 m (de la Torriente et al., 2014; Angeletti et al., 2015a; Evans et al., 2016; Gori et al., 2017, 2019). These forests may be monospecific or may be formed by several gorgonian species (e.g., *Bebryce mollis*, *Swiftia pallida*), antipatharians (e.g., *L. glaberrima* and *A. dichotoma*) or scleractinian white corals (e.g., *Desmophyllum pertusum*, *Dendrophyllia* spp). A frequent association of this species is with the whip

coral (*Viminella flagellum*), especially in the deep circalittoral and upper bathyal zones (Giusti et al., 2012; Lo Iacono et al., 2012; Chimienti et al., 2019), where it is more common.

31. Another species that commonly occurs on hard substrates of the continental slope is *Acanthogorgia hirsuta* that can occur as isolated colonies (Grinyó et al., 2016) or forming dense assemblages (Aguilar et al., 2013; Fourt et al., 2014b), sometimes with other gorgonians such as *Placogorgia* spp., on the slopes of seamounts or on the gently inclining edges of escarpments (de la Torriente et al., 2014; Enrichetti et al., 2019). It is also a species observed as part of the Alcyonacea that grow among coral rubbles or with other communities of deep-seabed corals and gorgonians, usually below 250-300 m.

32. *Eunicella cavolini* and *E. verrucosa* are the only species of the genus *Eunicella* that can be found on rocky bottoms from littoral to great depths. *E. cavolini* was observed down to 280 m in the Nice canyon (Fourt and Chevaldonné, pers. obs.); however, they are more common on the tops of seamounts, forming monospecific assemblages or mixed with *Paramuricea clavata* (Aguilar et al., 2013; De la Torriente et al., 2014). The latter is not usually found beyond 140-150 m, but becomes very abundant on the summits of seamounts, like the Palos, the Chella Banks (Aguilar et al., 2013), or in heads of some canyons (Pérez-Portela et al., 2016), such as Cassidaigne canyon where it occurs at a depth around 200 m (Fourt et al., 2014a). It shares this characteristic with *E. cavolini*, which has been found on rocky bottoms in the heads of canyons in the Balearic Sea (Grinyó et al., 2016) and the Gulf of Lion (Fourt and Goujard, 2012).

33. There is a wide range of small gorgonians that can form dense thickets (Angiolillo et al., 2014; Grinyó et al., 2016) or co-occur alongside larger species such as *C. verticillata*, antipatharians or alongside cold-water coral reef building species (Evans et al., 2016; Chimienti et al., 2019). Among these species can be found *Bebryce mollis*, *Swiftia pallida*, *Paramuricea macrospina* and *Villogorgia bebrycoides*, which can occur on unstable substrata and coarse detritic bottoms, from the shelf edge (or even the deep circalittoral zone) to depths of 600-700 m (Bo et al., 2011, 2012b, 2015; Giusti et al., 2012; Aguilar et al., 2013; Angeletti et al., 2014; Grinyó et al., 2015; Evans et al., 2016; Taviani et al., 2017).

34. *Swiftia pallida* forms important single species thickets in the upper bathyal zone, usually between 200 and 700 m, although it may have a greater bathymetric range. It is widely distributed throughout the Mediterranean Sea, having been found on seamounts of the Alboran Sea (de la Torriente et al., 2014) to places as far away as the canyons off Lebanon (R. Aguilar, pers. obs.) and Israel (Zvi Ben Avraham, pers. obs.). It can occur on rocky and deep detritic bottoms, tolerating a certain level of sedimentation.

35. *Muriceides lepida* and *Placogorgia massiliensis*, on the other hand, occur as accompanying species in the assemblages described above, although they can also be the dominant species in some escarpments or in combination with sponge aggregations or other benthic communities (Maldonado et al., 2015; Evans et al., 2016). Both can be found in the western and central Mediterranean Sea in zones ranging from a depth of 300 m to over 1000 m (Sartoretto and Zibrowius, 2018; Chimienti et al., 2019).

36. The case of *Dendrobrachia bonsai* is similar, although it is a species associated with greater depths (usually below 400-500 m). It has been found forming thickets in deep rocky bottoms or as the predominant species in areas of escarpments and canyons with a steep inclination (Sartoretto, 2012; de la Torriente et al., 2014; Evans et al., 2016).

37. In the case of *Nicella granifera*, so far this has only been found in the western Mediterranean Sea, in seamounts between the Alboran and the Balearic Seas (Aguilar et al., 2013). It has a deep bathymetric distribution, usually below 400 m.

38. Finally, the red coral (*Corallium rubrum*) shows a wide bathymetric range that stretches from shallow-water caves in the infralittoral zone to depths greater than 1000 m in the bathyal zone (Rossi et al., 2008; Taviani et al., 2010; Knittweis et al., 2016), with a peak at mesophotic depths (Cattaneo et al., 2016). Although it may form single-species forests on rocky bottoms or be the predominant species on escarpments and in caves (Cau et al., 2016b), it has also been found as part of mixed forests associated with white corals, antipatharians or large gorgonians (Freiwald et al., 2009; Constatini et al., 2010; Evans et al., 2016).

39. On soft bottoms, the most characteristic community is that of the bamboo corals (*Isidella elongata*). It is a species that is almost exclusive to the Mediterranean Sea and that usually

appears in muddy bottoms below depths of 400 m. It has been found on seamounts in the Alboran and Balearic Seas (Aguilar et al., 2013; de la Torriente et al., 2014; Mastrototaro et al., 2017), deep seabeds in the Spanish slope (Cartes et al., 2013), in front of the canyons in the Gulf of Lion (Fabri et al., 2014), over the Carloforte Shoal at 190 m depth (Bo et al., 2015), in the bathyal plain of Malta (R. Aguilar, pers. obs.), and in the Ionian Sea (Mytilineou et al., 2014), among other places.

40. Other soft-bottom species include *Spinimuricea* spp. (Aguilar et al., 2008; Bo et al., 2012b; Topçu and Öztürk, 2016), at depths ranging from the circalittoral zone to the upper bathyal, on detritic bottoms either in coastal areas and in deep-sea areas, sometimes alongside pennatulaceans and Alcyoniidae. The species *Eunicella filiformis* develops freely on detritic seabeds (Templado et al., 1993), with a distribution similar to that of *Spinimuricea* spp.

- *Habitats dominated by pennatulaceans*

41. Since these are species that bury part of the colony in the substrate, they require soft bottoms, either sandy or muddy, between the infralittoral zone and the bathyal zone. They can therefore appear in all kinds of soft bottoms on seamounts and in canyons, on bathyal plains and shelf edges (Chimienti et al., 2019). Species of the genera *Pennatula* and *Pteroeides* can form mixed communities that become numerous on the shelf edges and the beginning of the slope (e.g., Chella Bank) (Gili and Pagès, 1987; Aguilar et al., 2013; de la Torriente et al., 2014). The species may vary according to the depth, with *Pennatula rubra* being more frequent in shallower areas, while *P. phosphorea* occupies deeper seabeds, at depths reaching the muddy areas of the bathyal zone. Their distribution is pan-Mediterranean.

42. *Virgularia mirabilis* and *Veretillum cynomorium* are also species with a wide bathymetric and geographical distribution. Found all over the Mediterranean Sea on seamount slopes, the shelf edges, plains, and in canyons (Gili and Pagès, 1987; Aguilar et al., 2013), they occupy muddy-sandy bottoms, from the infralittoral to the bathyal zones, sometimes also mixing with other pennatulaceans or forming monospecific communities.

43. *Funiculina quadrangularis* also shares characteristics with other pennatulaceans, but it is a species typical of deep soft bottoms, found throughout the Mediterranean Sea, at depths ranging from the circalittoral to the bathyal zone. It forms dense forests in shelf areas, gently sloping areas in canyons, and muddy-sandy interstices on seamounts (Morri et al., 1991; Fabri et al., 2014; de la Torriente et al., 2014). It may appear in mixed communities with other pennatulaceans, bamboo corals, or other soft-bottom species, such as various bryozoans and sponges.

44. Recently, another pennatulacean whose distribution was believed to be exclusively Atlantic has been discovered in several areas of the Mediterranean Sea (Balearic Sea, Central Mediterranean and Ionian Sea). This is *Protoptilum carpenteri* (Mastrototaro et al., 2015, 2017; R. Aguilar, pers. obs.), which has a preference for the same substrate and looks very similar to *Funiculina quadrangularis*, which has sometimes led to it going unnoticed.

45. Finally, *Kophobelemnon stelliferum* is a typical species of deep muddy bottoms (usually below 400-500 m), although sometimes shallower (Fourt and Goujard, 2012), which, like other pennatulaceans, can appear mixed with other biological communities' characteristic of these seabeds (*Isidella elongata*, *Funiculina quadrangualris*, *Kinetoskias* sp.). It has been found on deep seamount summits such as Avempace in the Alboran Sea (Pardo et al., 2011), or in bathyal zones of the Ionian Sea, such as Santa Maria di Leuca (Mastrototaro et al., 2013).

- *Habitats with other anthozoans*

46. Other groups of anthozoans, such as Alcyoniidae, sea anemones (Actinaria) and cerianthids also give rise to communities' characteristic of dark habitats. These include newly discovered or rediscovered species, such as *Chironephthya mediterranea* (López-González et al., 2015) and *Nidalia studeri* (López-González et al., 2012), which create dense aggregations in the lower circalittoral and bathyal zones, between 150 m and 400 m. They can be found on hard bottoms, and on gravel and coarse sediments of seamounts, slope edges and submarine canyons. Their known geographical distribution stretches from the western to the central Mediterranean Sea, although a wider distribution has not been ruled out.

47. Equally important are species such as *Alcyonium palmatum* and *Paralcyonium spinulosum* (Templado et al., 1993; Fava and Ponti, 2007; Bo et al., 2011; Marin et al., 2011b, 2014; UNEP/MAP-RAC/SPA, 2013), since their plasticity in the occupation of both soft and hard bottoms allows them colonising large areas of the Mediterranean basin, in both shallow and dark habitats, usually found on seamounts' summits. It is not uncommon for them to associate with other anthozoans.

48. With regard to anemones, at present only *Actinauge richardii* can be considered as a dark habitat species, which forms communities of importance. Habitual in sedimentary bottoms, preferably sandy, between the circalittoral and the bathyal zones, it is found in large numbers on the gentle slopes of seamounts in the western Mediterranean or in bathyal plains in the central Mediterranean Sea (R. Aguilar, pers. obs.).

49. Finally, tube anemones or cerianthids are another order of anthozoans with colonies that can reach high densities in detritic and muddy bathyal seabeds. Thus, for example, *Cerianthus membranaceus* can occur in compact groups of individuals scattered over a wide area, like in the slopes or around canyons (Aguilar et al., 2008; Lastras et al., 2016), whereas *Arachnanthus* spp. usually appears in groups of hundreds or thousands of individuals slightly separated from each other (Marín et al., 2011a; Aguilar et al., 2014).

- *Sponge grounds with demosponges*

50. Various demosponges give rise to dense aggregations, on some occasions as the dominant species and on others in combination with corals and gorgonians. *Poecillastra compressa* and *Pachastrella monilifera* appear to have the most extensive geographical distribution within the Mediterranean basin and an important role in deep ecosystems (Bo et al., 2012a; Calcinai et al., 2013; Angeletti et al., 2014; Taviani et al., 2016a), while those of the genus *Phakellia* are more common in the western basin (Aguilar et al., 2013; de la Torriente et al., 2014). They may begin to appear in the lower circalittoral, but their presence is more common in the bathyal zone.

51. The eastern Mediterranean is home to large Dictyoceratida of the genera *Spongia*, *Ircinia*, *Sarcotragus*, *Scalarispongia*, as well as *Agelasida* (i.e., *Agelas oroides*), which are common in shallow areas developing on the heads of canyons, shelf edges and in the upper bathyal zones (R. Aguilar, pers. obs.).

52. Both Axinellida and Haplosclerida can also show similar behaviour, becoming abundant in the deep circalittoral and upper bathyal zones, especially on seamounts and other rocky bottoms (Bo et al., 2011, 2012b; Aguilar et al., 2013).

53. Desma-bearing demosponges or Tetractinellida (ex Lithistida), can form large aggregations, even reef formations, in deep zones of the bathyal, like the one of *Leiodermatium pfeifferae* found in a seamount at depths of more than 700 m near the Balearic Islands (Maldonado et al., 2015) and on Mejean bank between 380 and 455 m (Fourt and Chevaldonné, pers. obs.). It is not known whether other "stone sponges" present in the Mediterranean, such as *Leiodermatium lynceus* or *Neophrissospongia nolitangere*, and which give rise to similar formations in the Atlantic, could also do the same in the Mediterranean Sea.

54. In soft bottoms, the presence of sponge aggregations is limited to a few species, such as *Thenea muricata*, which is common in muddy bottoms of the bathyal zone throughout the Mediterranean Sea (Pansini and Musso, 1991; de la Torriente et al., 2014; Fourt et al., 2014a; Evans et al., 2016), sometimes with the presence of the carnivorous sponge *Cladorhiza abyssicola*, while *Rhizaxinella pyrifera* is more common in sandy-detritic bottoms (Bo et al., 2012a), but can also be found in cold seeps on mud volcanoes (Olu-Le Roy et al., 2004).

- *Sponge grounds with hexactinellids*

55. The large glass sponge *Asconema setubalense* is the most important in the formation of these aggregations of sponges in the Aboran Sea, western Mediterranean (Boury-Esnault et al., 2015; Aguilar et al., 2013), mainly on rocky bottoms on seamounts at depths below 200 m but has not been found beyond this area.

56. With a much wider distribution in the Mediterranean, reaching the eastern basin, *Tetrodictyum reiswegi* (Aguilar et al., 2014; Boury-Esnault et al., 2015, 2017) is smaller than the previously mentioned sponge and usually less numerous, although it can form aggregations on hard bottoms on seamounts, escarpments, and in canyons, at depths of 200-2500 m.

57. It is not known whether other species of hexactinellids that inhabit the Mediterranean Sea can form aggregations similar to those that they create in the Atlantic, as in the cases of the genera *Aphrocallistes* or *Farrea* (Boury-Esnault et al., 2017). Another sponge, *Pheronema carpenteri*, can also give rise to important formations of scattered individuals, but in this case on muddy bottoms. In the Mediterranean Sea it has been found from the Alboran to the Tyrrhenian Sea at depths between 350 m and more than 2000 m (Boury-Esnault et al., 2015).

58. All the species of anthozoans and sponges mentioned above, which have a similar bathymetric distribution and substrate preference, may form mixed habitats.

- *Habitats dominated by crustaceans*

59. There are two groups of crustaceans that give rise to deep sea habitats in the Mediterranean Sea: the cirripeds and the Ampeliscidae. In the case of cirripeds, the Balanomorpha *Pachylasma gigantea* is the predominant species, even contributing to deep-sea coral habitats (Schembri et al., 2007; Angeletti et al., 2011; Deidun et al., 2015), also in association with *Errina aspera* (Salvati et al., 2010), although *Megabalanus* spp. may also create a number of communities of some importance, usually together with molluscs and corals (R. Aguilar, pers. obs.). In the case of the Ampeliscidae, their tubes cover vast extensions of sedimentary bottoms. There are several dozens of species of the genera *Ampelisca*, *Haploops* and *Byblis* and they have been found on slope edges, on the gentle slopes of escarpments and in canyons and even on seamounts and hydrothermal fields (Bellan-Santini, 1982; Dauvin and Bellan-Santini, 1990; Marín et al., 2014; Esposito et al., 2015; R. Aguilar, pers. obs.), at depths that range from the edge of shelf or on the seamount summits to down to more than 700 m.

- *Habitats dominated by bryozoans*

60. The bryozoans usually form mixed aggregations with other benthic invertebrate species, but in some cases, they may be dominant, as in the case of large and arborescent species of the genera *Reteporella*, *Hornera*, *Pentapora*, *Myriapora*, and *Adeonella*. All of them attach to rocky substrates, but also to gravel or coarse sediment, and their distribution covers the entire Mediterranean basin. Although these species are common in shallow bottoms, they may extend to deeper areas (Bellan-Santini et al., 2002), including escarpments, deep rocky bottoms and seamount summits (Aguilar et al., 2010; de la Torriente et al., 2014). In soft bottoms, down to 350-400 m depths, some stalked species such as *Kinetoskias* sp. (Harmelin and D'Hondt, 1993; Aguilar et al., 2013, Maldonado et al., 2015), or species from the Candidae family (R. Aguilar, pers. obs.), may begin to appear. These bryozoans living on muddy bottoms have been found in the western and central Mediterranean basin (Mastrototaro et al., 2017).

- *Habitats dominated by polychaetes*

61. Many polychaetes form associations with species such as anthozoans, sponges, bryozoans, and brachiopods on rocky substrates of escarpments and mountains, in canyons and caves, but may also occur in single-species aggregates or as a dominating species on soft bottoms. Sabellids and serpulids are among the most widely distributed tube polychaetes. They have been found forming dense aggregates in deep sedimentary bottoms around Alboran Island, as in the case of *Sabella pavonina* (Gofas et al., 2014); they may create small reefs together with corals, as for *Serpula vermicularis* in the Bari Canyon (Sanfilippo et al., 2013), or they can be found in great numbers occupying extensive areas in detritic beds on the slopes of seamounts, the continental slope or submarine canyons heads, as in the case of *Filograna implexa* (Würtz and Rovere, 2015) that can also collaborate in deep-sea coral reef forming (D'Onghia et al., 2015), such as the eunicidan *Eunice norvegica* (Taviani et al., 2017).

62. As for the terebellids, the sand mason worm (*Lanice conchilega*) creates patches in sandy bottoms and sandy muds of the circalittoral and bathyal zones and has been found in great densities in seamounts such as the Chella Bank in the Alboran Sea or canyons such as La Fonera in Catalonia. No studies have been carried out on their abundance and distribution in the Mediterranean Sea, but data from the North Sea record densities of several hundreds or thousands of individuals per square meter, forming structures with some functions similar to those of some biogenic reefs (Rabaut et al., 2007).

63. The siboglinids, meanwhile, generate important aggregations in mud volcanoes, hypersaline lakes and other structures with chemo-synthetic communities, such as the Amsterdam mud volcano, between the Anaximenes and Anaxagoras marine ranges in the eastern Mediterranean basin (Shank et al., 2011).

- *Habitats dominated by molluscs*

64. The main aggregations, concretions and mollusc reefs in deep bottoms are those formed by oysters of the Gryphidae family. *Neopycnodonte cochlear* can be found in the photic zone, but it also creates beds in the deep-sea, whether on rocky or detritic bottoms, on escarpments and seamounts, and in canyons (de la Torriente et al., 2014; Fabri et al., 2014). *N. zibrowii* is found only on rocky bottoms, also belonging to escarpments, seamounts and canyons, but its distribution is usually at greater depths, from 350 m down to more than 1000 m (Beuck et al., 2016; Taviani et al., 2017). The large limid *Acesta excavata* contributes to hard bottom communities in the Gulf of Naples associated with *N. zibrowii* and the stony corals *M. oculata*, *Desmophyllum pertusum*, *D. dianthus*, and *Javania cailleti* (Taviani et al., 2016b, 2019).

65. There are also other species of molluscs, such as Spondylus gussoni and Asperarca nodulosa, which can occur in large numbers, sometimes co-occurring with deep-sea corals (Foubert et al., 2008; Rosso et al., 2010; Taviani et al., 2017). Their facies may be dominant in some seabeds or be part of other deep-sea dwelling communities, on the rocky bottoms of escarpments and canyons, together with brachiopods or other bivalves.

- *Other habitats*

66. Brachiopods such as *Megerlia truncata*, *Terebratulina retusa*, *Argyrotheca* spp., *Megathyris detruncata*, *Novocrania anomala*, form part of many marine habitats and microhabitats on rocky bottoms, including underwater canyons and stony coral bathyal habitats (Madurell et al., 2012; Angeletti et al., 2015a; Taviani et al., 2017). However, there is another species that forms important facies in soft bottoms, with a wide bathymetric range, although the higher concentrations are usually found in detritic areas on the edge of the shelf and the beginning of the continental slope, which is *Gryphus vitreus* (EC, 2006; Madurell et al., 2012; Aguilar et al., 2014).

67. In other cases, the dominant species are the Ascidiacea such as *Diazona violacea* and *Dicopia antirrhinum* (UNEP/MAP-RAC/SPA, 2013; Mechò et al., 2014) and/or different species of solitary ascidians belonging to the families Molgulidae, Ascidiidae, Pyuridae, and Styelidae (Templado et al., 2012). These aggregations may occur on seamounts or in slope areas, on detritic muddy bottoms (Pérès and Picard, 1964) or rocky bottoms heavily covered by sediments.

68. Worthy of note within the non-sessile species are the communities formed by echinoderms that play a key role in the structuring of soft and hard bottoms. The habitats formed by large aggregations of crinoids (*Leptometra* spp.) are recognised as sensitive because of the abundance of associated species and their importance for some commercial species (Colloca et al., 2004). However, *Leptometra phalangium* is not exclusively restricted to soft bottoms, but can also occur in equal numbers on rocky bottoms (Marín et al., 2011a, b) or even on coral reefs (Pardo et al., 2011; R. Aguilar, pers. obs.). It is also important to note the occurrence of this type of aggregation on soft bottoms involving urchins, such as *Gracilechinus acutus* and *Cidaris cidaris* (Templado et al., 2012; Mastrototaro et al., 2017; R. Aguilar, pers. obs.), holothurians such as *Mesothuria intestinalis* and *Penilpidia ludwigi* (Pagès et al., 2007; Cartes et al., 2009), ophiuroids such as *Amphiura* spp., and also on some rocky bottoms and reefs, with an abundance of specimens of *Ophiothrix* spp. and *Holothuria forskali* (Templado et al., 2012).

69. Equally important are the Archaean communities and microbial mats (Pachiadaki et al., 2010; Pachiadaki and Kormas, 2013; Giovannelli et al., 2016), together with their associated chemo-symbiotic molluscs (e.g., Lucinidae, Vesicomyidae, Mytilidae, Thyasiriidae) or polychaetes (*Lamellibrachia* sp., *Siboglinum* sp.), and ghost shrimps (*Calliax* sp.), which inhabit areas rich in sulphur and methane (Taviani, 2014). Most sites refer to cold seepage and occur in the eastern Mediterranean basin, at the Napoli mud volcano in the abyssal plain between Crete and North Africa (revised by Olu-Le Roy et al., 2004; Taviani, 2011), or in the Osiris and Isis volcanoes in the fluid seepage area in the Nile deep-sea fan (Dupré et al., 2007; Southward et al., 2011), and the Eratosthenes seamount south of Cyprus (Taviani, 2014), but they are also known in the Gela Basin pockmark field to the south of Sicily (Taviani et al., 2013), and in the Jabuka-Pomo area in the Adriatic (Taviani, 2014). Hydrothermal communities are rarer and documented on submarine volcanic apparatuses in the Tyrrhenian and Aegean Seas (Taviani, 2014). These chemo-synthetic communities usually occur at great depths, down to more than 2000 m.

- *Thanatocoenoses*

70. The fossil or subfossil remains of many marine species generate thanatocoenoses (assemblages of dead organisms or fossils), which provide habitats of great importance in dark habitats. These can have very diverse origins but continue to constitute biogenic structures that act as reefs or three-dimensional formations, and which also provide substrate for the settlement of multiple species. Among these formations are the thanatocoenoses dominated by ancient remains and reefs of coral, molluscs, brachiopods, polychaetes and sponges. These bottoms are found on seamounts, bathyal plateaus, escarpments, and in canyons. They include the compacted seabeds of old aggregations of *Gryphus vitreus* (R. Aguilar, pers. obs.), reefs and rubble of *Madrepora oculata*, *Desmophyllum pertusum*, *D. dianthus*, *Dendrophyllia cornigera*, oysters (*Neopycnodonte zibrowii*) (Županović, 1969; Taviani and Colantoni, 1979; Zibrowius and Taviani, 2005; Taviani et al., 2005b; Rosso et al., 2010; Bo et al., 2014c; Fourt et al., 2014b), beds of *Modiolus modiolus* shells (Aguilar et al., 2013; Gofas et al., 2014), subfossil reefs of polychaetes such as *Spirobranchus triqueter* (Domínguez-Carrió et al., 2014), fossilised structures of old sponge aggregations such as *Leiodermatium* sp. (R. Aguilar, pers. obs.), concentrations of hexactinellid spicules, bryozoan remains (Di Geronimo et al., 2001), and even accumulations of algae and plants such as rhizomes and leaves of *Posidonia oceanica* transported from superficial areas to deep-sea bottoms.

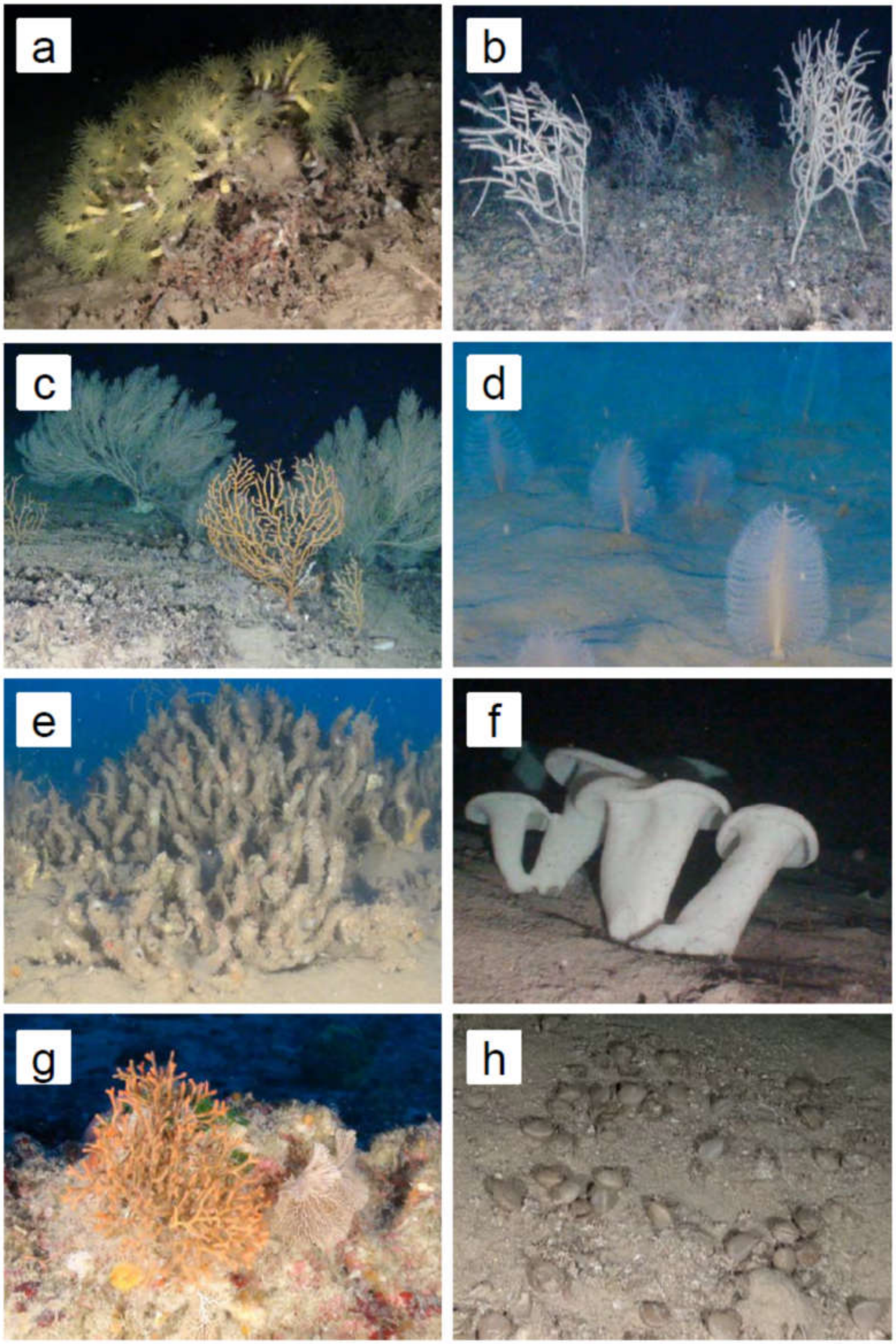

Figure 2: Characteristic species of deep-sea habitats. *Dendrophyllia cornigera*, Catifas Bank (a); *Antipathes dichotoma* and *Leiopathes glaberrima*, Malta (b); *Callogorgia verticillata* and *Placogorgia* sp., Ses Olives Seamount (c); *Pennatula rubra*, Lebanon (d); reef of vermetids, Lebanon (e); *Asconema setubalense*, Chella Bank (f); *Adeonella calveti* and *Hornera frondiculata*, Malta (g); brachiopods *Gryphus vitreus*, Emile Baudot Escarpment (h). Pictures by Oceana (SPA/RAC-UN Environment/MAP OCEANA, 2017).

Monitoring methods

a) COMMON INDICATOR 1: Habitat distributional range and extent

Approach

71. The CI1 is aimed at providing information about the geographical area in which dark habitats occur in the Mediterranean Sea and the total extent of surfaces covered by these habitats. Mapping dark habitats is particularly challenging because of the operational constrains to manage devices (e.g., SSS or ROV) in very deep waters and within caves, and in this latter case it results often impossible to allow the instrument entering the cave, and the overall high costs associated with oceanographic campaigns.

72. Three main steps can be identified for mapping dark habitats:

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
2) Ground survey is the practical phase for data collection, the costliest phase as it generally requires field activities
3) Processing and data interpretation require knowledge and experience to ensure that data collected are usable and reliable.

Resolution

73. 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). An average precision and a lower detail can be accepted when large surface areas have to be mapped and global investigations carried out. On the contrary, a much higher precision and resolution is required when smaller areas have to be mapped. 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 period of time. However, the scarceness of fine-scale cartographic data on the overall distribution of dark habitats is one of the greatest lacunae from the conservation point of view.

Marine caves

74. To date approximately 3000 marine caves (semi- and entirely submerged) have been recorded in the Mediterranean basin (Fig. 3), according to the latest basin scale census by Giakoumi et al. (2013). Most of these caves (97%) are located in the North Mediterranean Sea, which encompasses a higher percentage of carbonate coasts and has been more extensively studied. Nevertheless, the number of underwater caves penetrating the rocky coasts of the Mediterranean basin remains unknown and comprehensive mapping efforts are still necessary to fill distribution gaps, especially in the eastern and southern regions of our sea.

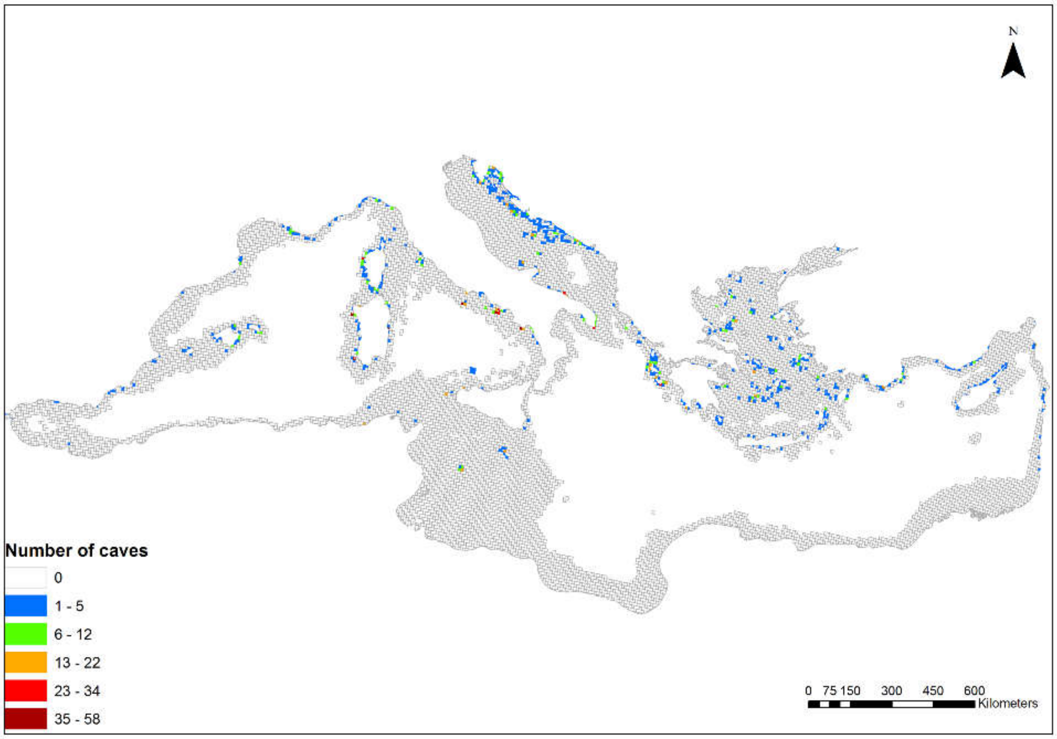

Figure 3: Distribution of marine caves in the Mediterranean Sea; different colours represent the number of caves in 10 km × 10 km cells (from Giakoumi et al., 2013).

Deep-sea habitats

75. Deep-sea habitats can be found in very diverse and extensive areas of the Mediterranean Sea, given that this sea has an average depth of about 1500 m, with many of its seabeds in aphotic zones (Fig. 4).

76. In the Mediterranean, 518 large canyons have been identified (Harris and Whiteway, 2011) (Fig. 5), along with around 242 underwater mountains or seamount-like structures (Würtz and Rovere, 2015) (Fig. 6) and there are some twenty sites where deep-water chemo-synthetic assemblages have been confirmed (Taviani, 2014) (Fig. 7). However, there are still many other canyons, underwater structures and sites involving the release of gas that have not yet been studied, which is certain to change these figures. Also, 80% of the Mediterranean seabeds are at a depth of more than 200 m and could therefore potentially be home to dark habitats.

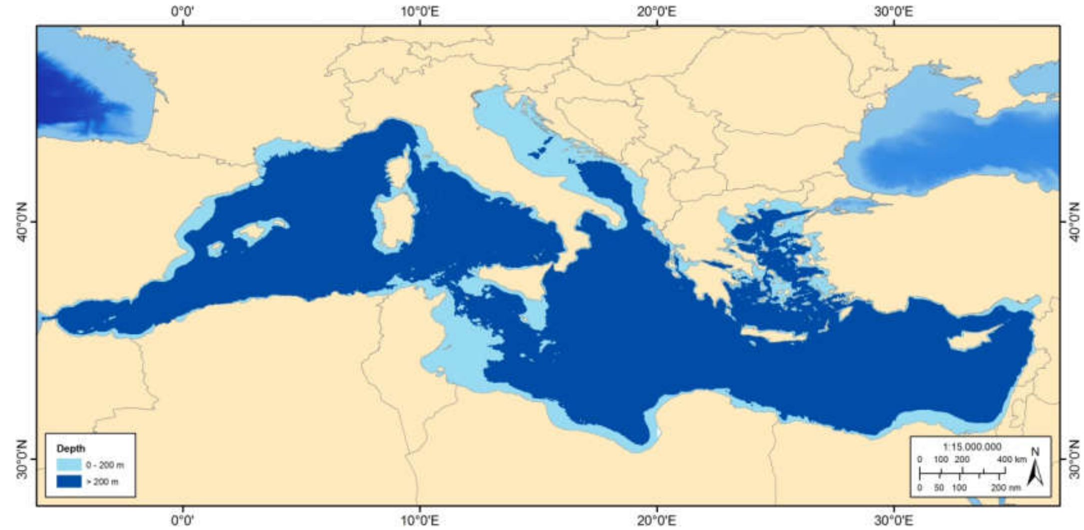

Figure 4: Deep-sea areas in the Mediterranean Sea below 200 m depth (from UNEP/MAP-SPA/RAC, 2017).

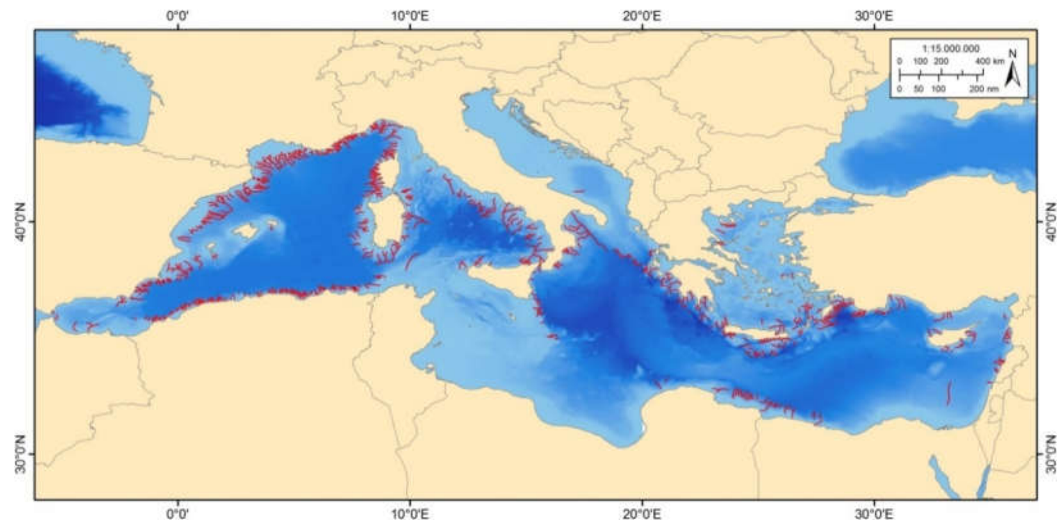

Figure 5: Distribution of Mediterranean submarine canyons (from UNEP/MAP-SPA/RAC, 2017).

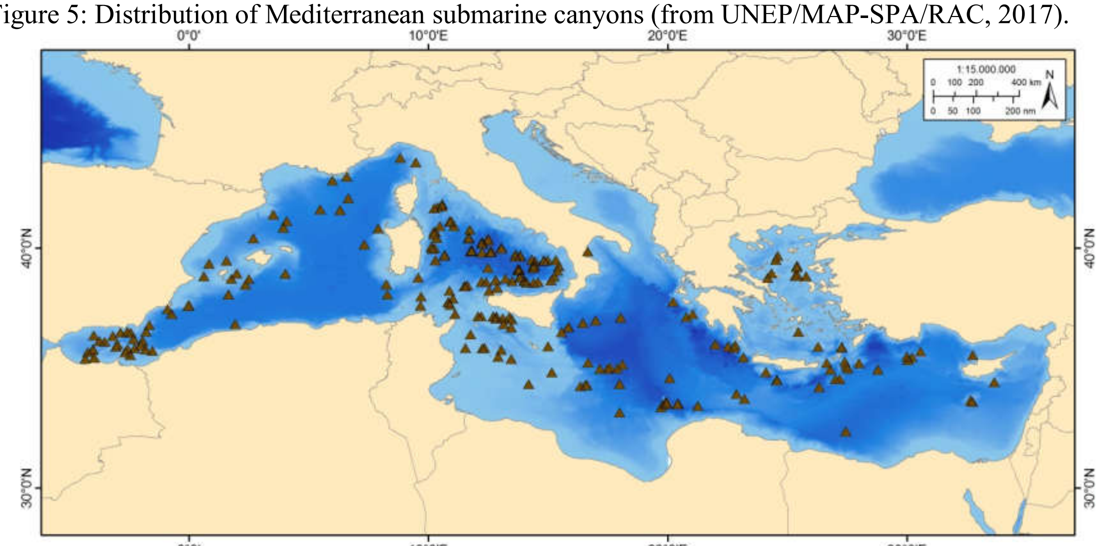

Figure 6: Distribution of Mediterranean seamounts (from UNEP/MAP-SPA/RAC, 2017).

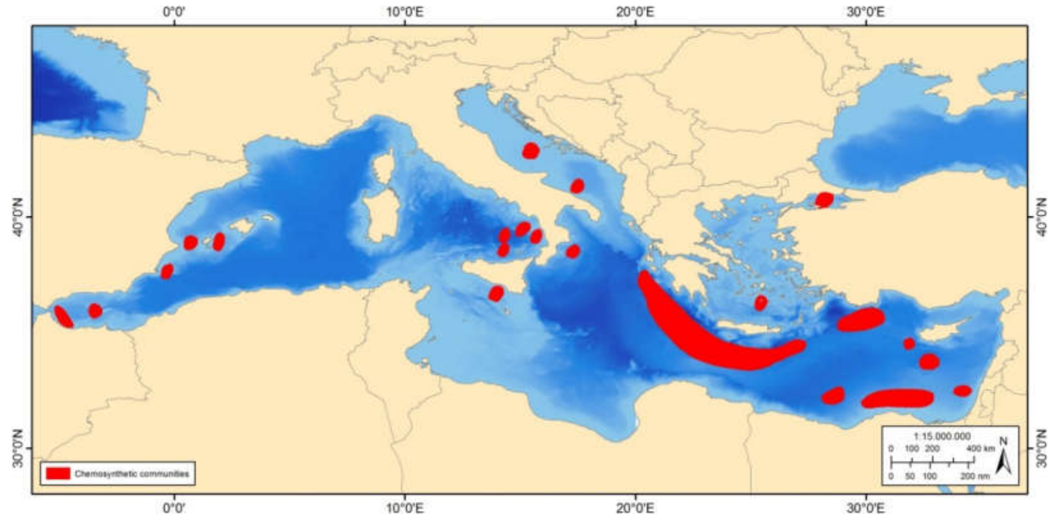

Figure 7: Identified areas with chemo-synthetic assemblages (from UNEP/MAP-SPA/RAC, 2017).

Methods

<u>Marine caves</u>

77. Inventorying of marine cave communities requires two steps:

- ✓ Locating the marine caves (geo-referencing, topography, mapping, etc.)
- ✓ Characterization of the communities (diversity, structure, species cover, etc.)

Underwater diving

78. For marine caves up to 40 m depths (and according to local rules for scientific diving) diving is necessary for the exploration, mapping and inventorying, except for shallow caves of the semi- submerged type, which can be often spotted and accessed at the sea surface level. To a certain level, basic information on the location, depth and morphology of marine caves could be derived from local diving and fishing communities, prior to any cave mapping initiative. Diving in marine caves, even in the shallower ones, is logistically challenging and requires the adoption of appropriate safety measures under the precautionary approach, even for experienced divers. The cave bottom is often covered by silty sediment, which could easily be stirred up by divers reducing visibility and making it difficult – or impossible – to locate the cave entrance. Therefore, a dive reel with calibrated line (e.g., distance markers every 1 m) is necessary along with standard scuba equipment (e.g., dive computer, lights, magnetic compass, slate) (Barbieri, 2014). Additional equipment is needed for taking distance measurements (e.g., tape measure, portable echosounder, compass and waterproof range finder for semi-submerged caves).

79. Topography plays a crucial role in structuring marine cave communities and, thus, recording of basic topographic features is important for cave inventories, as well as for the design of appropriate sampling schemes and monitoring protocols. Good knowledge of the cave's topography prior to underwater fieldwork is important for safety reasons (Rastorgueff et al., 2015). The most striking topographic features to be considered during marine cave inventorying are: i) depth; ii) orientation and dimensions of the cave entrance(s); iii) cave morphology (e.g., blind cave or tunnel); iv) submersion level (e.g., semi-submerged or submerged cave); v) maximum and minimum water depth inside the cave; and vi) total length of the cave. Definitions for these topographic attributes are available in the World Register of marine Cave Species (WoRCS) thematic species database of the World Register of Marine Species (Gerovasileiou et al., 2016a). Unique abiotic and biotic features, such as micro-habitats that could support distinct communities and rare species (e.g., sulphur springs, freshwater springs, bioconstructions, etc.) should be also recorded. A useful protocol for inventorying semi-submerged caves has been provided by Dendrinos et al. (2007); however, in areas supporting the Mediterranean monk seal (*Monachus monachus*) populations, such initiatives should

be undertaken during periods with low in-cave seal activity (e.g., late spring or early summer) to minimize potential disturbance.

80. Most of the Mediterranean marine caves studied are semi-submerged or shallow and very few exceed the maximum depth of 30 m, probably due to the logistic constraints in underwater work. The inventorying of deeper and complex cave formations requires highly specialized skills and diving equipment (e.g., Close Circuit Underwater Breathing Apparatus – CCUBA), inducing a greater extent of risks than conventional scuba diving. The exploration of deep-sea caves and overhangs requires the use of ROVs, even though several limitations linked with the possibility to penetrate into these confined habitats (Fairfield et al., 2007; Stipanov et al., 2008).

Deep-sea habitats

Acoustic and video surveys

81. The necessary technology for research and expeditions in deep-sea habitats (e.g., ROVs, submarines) has high costs that must be taken into account when planning oceanographic campaigns. Research vessels, suited to work in bathyal zones, are necessary to manage many of the instruments used for deep-sea habitat mapping. High resolution bathymetric maps (e.g., produced by multi-beam echosonar) are very useful tools for location and description of deep-sea habitats; however, they are not usually available. Also, seafloor irregularities make sometimes difficult to explore some geomorphologic features, such as seamounts, submarine canyons, and deep caves.

82. Definition of distributional range and extent of deep-sea habitats requires "traditional" habitat mapping techniques, similar to those used for deep coralligenous reefs (Tab. 1). Being the deep-sea habitats distributed in deep waters (down to 120 m depth), the use of bathyscaphes, submarines, landers, etc., provide visual and georeferenced information on the geological formations and benthic communities on these seabeds. Acoustic techniques (e.g., side scan sonar, multi-beam echosounder) or underwater video recordings (ROV) are usually recommended. Sonar provides topobathymetric images of the seafloor through the emission and reception of ultrasounds; it creates a three-dimensional map that allows the identification of potential sites with deep habitats, especially reefs and aggregations of corals and sponges. The use of remote sensing allows characterising extensive areas for the assessment of the overall spatial patterns of deep-sea habitats. From maps obtained through remote sensing surveys, the presence/absence of the habitat, its distributional range and the total habitat extent can be easily obtained. Acoustic methods are presently the most convenient technique for mapping deep-sea habitats, associated with ground-truthing by ROV and, sometimes, box-coring. The simultaneous use of two or more methods makes it possible to optimize the results being the information obtained complementary. The strategy to be adopted will thus depend on the aim of the study and the area concerned, means and time available. Multi-beam sonar, side scan sonar, and sub-bottom profilers like TOPAS (Topographic parametric sonar) provide an important overview of the seabed, making it possible to identify and locate the presence of specific geomorphologic features such as seamounts, canyons, mud volcanoes, pockmarks, carbonated mounds, reefs, etc.

83. For all remote sensing techniques, distinguishing habitats from each other and from the surrounding seabed depends on the resolution of the sampling method, higher resolution will provide better data to distinguish habitats, but covers smaller areas and is more expensive to collect and process than lower resolution data. All the acoustic mapping techniques are intrinsically affected by uncertainties due to manual classification of the different acoustic signatures of substrate types on sonograms. Errors in sonograms 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 also time-requiring, several processing techniques were proposed in order to rapidly automate the interpretation of sonograms and make this interpretation more reliable (Montefalcone et al., 2013

and references therein). These methods allow a good discrimination between soft sediments and rocky reefs. Human eye, however, always remains the final judge.

84. Observations from the surface can be made by using imagery techniques such as video recordings by ROVs. ROVs have their own propulsion system and are remotely controlled from the surface. The use of 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 this preliminary video survey may be also useful to locate monitoring and sampling stations. Recorded images are then reviewed to obtain a cartographical restitution on a GIS platform for each of the areas surveyed. Seabed inspection by ROV visual methods provides key information for the detection of potential areas where other dark habitats, more difficultly detected using acoustic methods, might occur.

Sampling methods

85. To obtain a better description of the deep-sea habitats and for ground-truthing acoustic surveys, sampling methods are sometimes necessary. Special equipments are available for sediment sampling and characterisation from vessels at great depths, varying from grabs, gravity cores, piston cores, box cores, and multiple corers, used in a number of randomly selected points within a study area (Tab. 1) (Danovaro et al., 2010).

Table 1: Synthesis of the main survey tools used for defining the Common Indicator 1_Habitat distributional range and extent for dark 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 (only for marine caves)	0 m to 40 m (according to local rules for scientific diving)	Small areas, less than 250 m^2	From 0.1 m	0.0001 to 0.001 km^2/hour	Very great precision for the identification (taxonomy) and distribution of species (micro-mapping) Non-destructive Low cost, easy to implement	Method adapt only for marine caves characterisation Small area inventoried Very time-consuming Limited operational depth Highly qualified and expert divers required (safety constraints)	Gerovasileiou et al. (2013, 2015); Montefalcone et al. (2018)
Sampling from vessels with grabs, gravity cores, box cores, multiple corers, trawls	Down to 1500 m	Intermediate areas (a few km^2)	From 1 to 10 m	0.025 to 0.01 km^2/hour	Very great precision for the identification (taxonomy) and distribution of species (micro-mapping) All species taken into account Possibility of *a posteriori* identification	Destructive method Small area inventoried Sampling material needed Difficulty to manage sampling devices at great depths Laboratory analyses very time consuming High costs of the research vessels	Danovaro et al. (2010)
Side scan sonar	Down to 4000 m	From intermediate to large areas (50-100 km^2)	From 1 m	1 to 4 km^2/hour	Wide bathymetric range High resolution and good identification of the nature of the bottom Quick execution Non-destructive	Flat (2-D) picture to represent 3-D complex habitats Possible errors in sonograms interpretation Acquisition of field data necessary to validate sonograms High cost of instruments and research vessels	Palmiotto and Loreto (2019)

Survey tool	Depth range	Surface area	Resolution	Efficiency	Advantages	Limits	References
Multi-beam echosounder	Down to 4000 m	From small (a few hundred square meters) to large areas (50-100 km²)	From 50 cm (linear) and lower than few centimeters	0.5 to 6 km²/hour	Possibility of obtaining 3-D picture Double information collected (bathymetry and seafloor image) Very precise and wide bathymetric range Realistic representation of the seafloor Quick execution Non-destructive Very big mass of data	Less precise imaging (nature of the bottom) than side scan sonar Acquisition of field data necessary to validate sonograms High cost of instruments and research vessels High resolution maps not usually available	Palmiotto and Loreto (2019)
Remote Operating Vehicle (ROV), bathyscaphes, or submarines	Down to 4000 m	Small-intermediate areas (a few km²)	From 1 m to 10 m	0.025 to 0.01 km²/hour	Non-destructive Possibility of taking pictures Good identification of habitat and species Wide bathymetric range	High cost Difficult to handle at great depths High cost of instruments and research vessels	Enrichetti et al. (2019); Rogers (2019)

Data interpretation

86. Once the field survey is completed, data collected need to be organized so 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 to ensure future integration with similar data from other sources. Acoustic data must be always integrated by a great number of samplings or video recordings by ROVs for ground-truthing, especially given the wide distribution and complexity of deep-sea habitats.

87. Four important steps for the production of a habitat map must be followed:

a. Processing, analysis, interpretation and classification of field biological data, to be integrated with acoustic data 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 information
d. The map produced must then be evaluated for its accuracy, i.e. its capacity to represent reality, and therefore its reliability.

88. During the processing analysis and classification step, the updated list of benthic marine habitat types for the Mediterranean region[12] should be consulted (UNEP/MAP-SPA/RAC, 2019) to recognize any specific dark habitat type (e.g., marine cave, circalittoral rock, bathyal sand) and its main characteristic associations and facies. A complete description of these habitats and the criteria for their identification are also available in Bellan-Santini et al. (2002). Dark habitats that must be reported on maps are the following (UNEP/MAP-SPA/RAC, 2019):

LITTORAL

MA1.5 Littoral rock

MA1.52 Mediolittoral caves

MA1.521 Association with encrusting Corallinales or other Rodophyta

INFRALITTORAL

MB1.5 Infralittoral rock

MB1.56 Semi-dark caves and overhangs (see MC1.53)

CIRCALITTORAL

MC1.5 Circalittoral rock

MC1.53 Semi-dark caves and overhangs

MC1.53a Walls and tunnels

MC1.531a Facies with sponges (e.g. *Axinella* spp., *Chondrosia reniformis*, *Petrosia ficiformis*)

MC1.532a Facies with Hydrozoa

[12] 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.

MC1.533a Facies with Alcyonacea (e.g. *Eunicella* spp., *Paramuricea* spp., *Corallium rubrum*)

MC1.534a Facies with Scleractinia (e.g. *Leptopsammia pruvoti*, *Phyllangia mouchezii*)

MC1.535a Facies with Zoantharia (e.g. *Parazoanthus axinellae*)

MC1.536a Facies with Bryozoa (e.g. *Reteporella grimaldii*, *Pentapora fascialis*)

MC1.537a Facies with Ascidiacea

MC1.53b Ceilings

See MC1.53a for examples of facies

MC1.53c Detritic bottom

See MC3.51 for examples of associations and facies

MC1.53d Brackish water caves or caves subjected to freshwater runoff

MC1.531d Facies with Heteroscleromorpha sponges

OFFSHORE CIRCALITTORAL

MD1.5 Offshore circalittoral rock

MD1.51 Offshore circalittoral rock invertebrate-dominated

MD1.511 Facies with small sponges (sponge ground, e.g. *Halicona* spp., *Phakellia* spp., *Poecillastra* spp.)

MD1.512 Facies with large and erect sponges (e.g. *Spongia lamella*, *Axinella* spp.)

MD1.513 Facies with Alcyonacea (e.g. *Alcyonium* spp., *Callogorgia verticillata*, *Ellisella paraplexauroides*, *Eunicella* spp., *Leptogorgia* spp., *Paramuricea* spp., *Swiftia pallida*, *Corallium rubrum*)

MD1.514 Facies with Antipatharia (e.g. *Antipathella subpinnata*)

MD1.515 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madracis pharensis*)

MD1.516 Facies with Ceriantharia (e.g. *Cerianthus* spp.)

MD1.517 Facies with Zoantharia (e.g. *Savalia savaglia*)

MD1.518 Facies with Polychaeta

MD1.519 Facies with Bivalvia

MD1.51A Facies with Brachiopoda

MD1.51B Facies with Bryozoa (e.g. *Myriapora truncata*, *Pentapora fascialis*)

MD1.52 Offshore circalittoral rock invertebrate-dominated covered by sediments

See MD1.51 for examples of facies

MD1.53 Deep offshore circalittoral banks

MD1.531 Facies with Antipatharia (e.g. *Antipathella subpinnata*)

MD1.532 Facies with Alcyonacea (e.g. *Nidalia* spp.)

MD1.533 Facies with Scleractinia (yellow corals forest, e.g. *Dendrophyllia* spp.)

MD2.5 Offshore circalittoral biogenic habitat

MD2.51 Offshore reefs

MD2.511 Facies with Vermetidae and/or Serpulidae

MD2.52 Thanatocoenosis of corals, or Brachiopoda, or Bivalvia (e.g. *Modiolus modiolus*)

See MD1.51 for examples of facies

MD3.5 Offshore circalittoral coarse sediment

MD3.51 Offshore circalittoral detritic bottoms

MD3.511 Facies with Bivalvia (e.g. *Neopycnodonte* spp.)

ME2.512 Facies with Brachiopoda

MD3.513 Facies with Polychaeta

MD3.514 Facies with Crinoidea (e.g. *Leptometra* spp.)

MD3.515 Facies with Ophiuroidea

MD3.516 Facies with Echinoidea

MD4.5 Offshore circalittoral mixed sediment

MD4.51 Offshore circalittoral detritic bottoms

See MD3.51 for examples of facies

MD5.5 Offshore circalittoral sand

MD5.51 Offshore circalittoral sand

See MD3.51 for examples of facies

MD6.5 Offshore circalittoral mud

MD6.51 Offshore terrigenous sticky muds

MD6.511 Facies with Pennatulacea (e.g. *Pennatula* spp., *Virgularia mirabilis*)

MD6.512 Facies with Polychaeta

MD6.513 Facies with Bivalvia (e.g. *Neopycnodonte* spp.)

MD6.514 Facies with Brachiopoda

MD6.515 Facies with Ceriantharia (e.g. *Cerianthus* spp., *Arachnanthus* spp.)

UPPER BATHYAL

ME1.5 Upper bathyal rock

ME1.51 Upper bathyal rock invertebrate-dominated

ME1.511 Facies with small sponges (sponge ground; e.g. *Farrea bowerbanki*, *Halicona* spp., *Podospongia loveni*, *Tretodictyum* spp.)

ME1.512 Facies with large and erect sponges (e.g. *Spongia lamella*, *Axinella* spp.)

ME1.513 Facies with Antipatharia (e.g. *Antipathes* spp., *Leiopathes glaberrima*, *Parantipathes larix*)

ME1.514 Facies with Alcyonacea (e.g. *Acanthogorgia* spp., *Callogorgia verticillata*, *Placogorgia* spp., *Swiftia pallida*, *Corallium rubrum*)

ME1.515 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madrepora oculata*, *Desmophyllum cristagalli*, *Desmophyllum pertusum*, *Madracis pharensis*)

ME1.516 Facies with Cirripeda (e.g. *Megabalanus* spp., *Pachylasma giganteum*)

ME1.517 Facies with Crinoidea (e.g. *Leptometra* spp.)

ME1.518 Facies with Bivalvia (e.g. *Neopycnodonte* spp.)

ME1.519 Facies with Brachiopoda

ME1.52 Caves and ducts in total darkness

ME2.5Upper bathyal biogenic habitat

ME2.51 Upper bathyal reefs

ME2.511 Facies with small sponges (sponge ground)

ME2.512 Facies with large and erect sponges (e.g. *Leiodermatium* spp.)

ME2.513 Facies with Scleractinia (e.g. *Madrepora oculata*, *Desmophyllum cristagalli*)

ME2.514 Facies with Bivalvia (e.g. *Neopycnodonte* spp.)

ME2.515 Facies with Serpulidae reefs (e.g. *Serpula vermicularis*)

ME2.516 Facies with Brachiopoda

ME2.52 Thanatocoenosis of corals, or Brachiopoda, or Bivalvia, or sponges

See ME1.51 for examples of facies

ME3.5 Upper bathyal coarse sediment

ME3.51 Upper bathyal coarse sediment

ME3.511 Facies with Alcyonacea (e.g. *Alcyonium* spp., *Chironephthya mediterranea*, *Paralcyonium spinulosum*, *Paramuricea* spp., *Villogorgia bebrycoides*)

ME4.5 Upper bathyal mixed sediment

ME4.51 Upper bathyal mixed sediment

ME4.511 Facies with Bivalvia (e.g. *Neopycnodonte* spp.)

ME4.512 Facies with Brachiopoda

ME5.5 Upper bathyal sand

ME5.51Upper bathyal detritic sand

ME5.511 Facies with small sponges (sponge ground, e.g. *Rhizaxinella* spp.)

ME5.512 Facies with Pennatulacea (e.g. *Pennatula* spp., *Pteroeides griseum*)

ME5.513 Facies with Crinoidea (e.g. *Leptometra* spp.)

ME5.514 Facies with Echinoidea

ME5.515 Facies with Bivalvia (e.g. *Neopycnodonte* spp.)

ME5.516 Facies with Brachiopoda

ME5.517 Facies with Bryozoa

ME5.518 Facies with Scleractinia (e.g. *Caryophyllia cyathus*)

ME6.5 Upper bathyal muds

ME6.51 Upper bathyal muds

ME6.511 Facies with small sponges (sponge ground, e.g. *Pheronema* spp., *Thenea* spp.)

ME6.512 Facies with Pennatulacea (e.g. *Pennatula* spp., *Funiculina quadrangularis*)

ME6.513 Facies with Alcyonacea (e.g. *Isidella elongata*)

ME6.514 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madrepora oculata*, *Desmophyllum cristagalli*)

ME6.515 Facies with Crustacea Decapoda (e.g. *Aristeus antennatus*, *Nephrops norvegicus*)

ME6.516 Facies with Crinoidea (e.g. *Leptometra* spp.)

ME6.517 Facies with Echinoidea (e.g. *Brissopsis* spp.)

ME6.518 Facies with Bivalvia (e.g. *Neopycnodonte* spp.)

ME6.519 Facies with Brachiopoda

ME6.51A Facies with Ceriantharia (e.g. *Cerianthus* spp., *Arachnanthus* spp.)

ME6.51B Facies with Bryozoa (e.g. *Candidae* spp., *Kinetoskias* spp.)

ME6.51C Facies with giant Foraminifera (e.g. Astrorhizida)

LOWER BATHYAL

MF1.5 Lower bathyal rock

MF1.51 Lower bathyal rock

MF1.511 Facies with small sponges (e.g. *Stylocordyla* spp.)

MF1.512 Facies with Alcyonacea (e.g. *Dendrobrachia* spp.)

MF1.513 Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madrepora oculata*, *Desmophyllum cristagalli*, *Desmophyllum pertusum*)

MF1.514 Facies with chemiosynthetic benthic species (e.g. Siboglinidae, *Lucinoma* spp.)

MF2.5 Lower bathyal biogenic habitat

MF2.51 Lower bathyal reefs

MF2.511Facies with Scleractinia (e.g. *Dendrophyllia* spp., *Madrepora oculata*, *Desmophyllum cristagalli*, *Desmophyllum pertusum*)

MF2.52 Thanatocoenosis of corals, or Brachiopoda, or Bivalvia, or sponges

See MF1.51 for examples of facies

MF6.5 Lower bathyal muds

MF6.51 Sandy muds

MF6.511 Facies with small sponges (e.g. *Thenea* spp.)

MF6.512 Facies with Alcyonacea (e.g. *Isidella elongata*)

MF6.513 Facies with Echinoidea (e.g. *Brissopsis* spp.)

MF6.514 Facies with Pennatulacea (e.g. *Pennatula* spp., *Funiculina quadrangularis*)

MF6.515 Facies with bioturbations

ABYSSAL

MG1.5 Abyssal rock

MG1.51 Abyssal rock

MG1.511 Facies with small sponges

MG1.512 Facies with Alcyonacea

MG1.513 Facies with Polychaeta

MG1.514 Facies with Crustacea (Amphipoda, Isopoda, Tanaidacea)

MG6.5 Abyssal muds

MG6.51 Abyssal muds

MG6.511 Facies with small sponges

MG6.512 Facies with Alcyonacea (e.g. *Isidella elongata*)

MG6.513 Facies with Polychaeta

MG6.514 Facies with Crustacea (Amphipoda, Isopoda, Tanaidacea)

MG6.515 Facies with bioturbations

89. Although the selection of physical layers to be shown on maps and to be used for following predictive statistical analyses might be a promising approach within the general framework of mapping dark habitats, no examples of prediction of the distribution of dark habitats are reported in literature to date. Inspiring from the examples of habitat predictions performed on coralligenous reefs (see the "Guidelines on coralligenous" in this document for further details), the following physical attributes could be investigated in the future research for predicting potential deep-sea habitat types starting from a general geomorphologic data: bathymetry, slope of the seafloor, seafloor types, currents, and nutrient input (Giannoulaki et al., 2013; Martin et al., 2014).

90. The data integration and spatial interpolation is often a necessary step because indirect visual or remote sensing surveys from vessels are often limited due to time and costs involved, and only rarely allow obtaining a complete coverage of the study area. Spatial interpolation is a statistical procedure for estimating data values at unsampled sites between actual data collection locations. For elaborating the final distribution map of dark 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.

91. On the resulting maps the habitat distributional range and its total extent (expressed in square meters or hectares) can be defined. These maps could be also compared with previous historical available data from literature (very scarce for deep-sea habitats) to evaluate any changes experienced by the habitat over a period of time. 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). Mapping of protected habitats (e.g., under SPA/BD) is a necessary step to evaluate habitat loss or increase in the total area covered. Conservation targets require that the habitat maintains stable and Member States have generally adopted a 5% tolerance above the baseline to represent a 'stable' situation. However, in some cases a more stringent <1% tolerance has been used for the maintenance of the habitat extent. For protected habitats that have historically been reduced, the target should be that the total area increases towards the size of the baseline. However, for most of the deep-sea habitats, no information on their reference state is available.

92. Various software platforms have been developed for three-dimensional (3D) cave modelling (e.g., Sellers and Chamberlain, 1998; Boggus and Crawfis, 2009; Gallay et al., 2015; Oludare Idrees and Pradhan, 2016). A rapid and cost-effective protocol for the 3D mapping and

visualization of entirely and semi-submerged marine caves with a simple, non-dendritic morphology, has been developed and described by Gerovasileiou et al. (2013), using handheld echosounder. The method can be applied by two divers in 1-2 dives and enables the automatic production of 3D depictions of cave morphology using the accompanying "cavetopo" software. A GPS device is necessary for geo-referencing the location of the access point to the surveyed marine cave at the sea surface level. Recently, in the framework of the Grotte-3D Project, three submerged caves in Parc National des Calanques (France) were depicted in high-resolution 3D models using photogrammetry (Chemisky et al., 2015).

93. Finally, reliability of the map produced should be evaluated. No evaluation scales of reliability have been proposed for dark habitats mapping; however, scales of reliability evaluation available for seagrass meadows can be adapted also for these habitats (see the "Guidelines on marine vegetation" in this document for further details). These scales usually take into account 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

94. Monitoring the condition (i.e., the ecological status) of dark habitats is today mandatory for conservation and management purposes, to ensure dark habitats, their constituent species and their associated communities to maintain a satisfactory ecological status in terms of structure and functions. The good state of health of dark 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).

95. According to the EcAp and following the Integrated Monitoring and Assessment Programme (IMAP) recommendations, it is suggested that future monitoring schemes for marine caves and deep-habitats should mainly consider common indicators related to biodiversity (EO1), and in particular the Common Indicator 2 - Condition of the habitat's typical species and communities. Being important biodiversity hotspots in the Mediterranean Sea, dark habitats have been recognized as biological indicators of environmental quality.

96. Defined and standardized procedures for monitoring the status of marine caves and deep-sea habitats are not available to date. For planning an effective monitoring program, however, the following three main steps must be undertaken:

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 monitor during the same season
c. Monitoring over time and analysis, where clear scientific competences are needed because acquired data must be interpreted. Duration of the monitoring, in order to be useful, must be mediumtime at least.

97. The objectives of the monitoring are primarily linked with the conservation of dark habitats, to maintain their ecological status (GES) and also to identify, as early as possible, any degradation or any change 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 areas and of fisheries activities. The IMAP requires a regional integrated monitoring system of the quality of the environment, which can be reached through reliable quantitative and updated data on the status of Mediterranean dark habitats.

98. The sites chosen must be: i) representative of the portion of the seafloor 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 and especially low fishing pressure and areas with high pressure related to human activities. The selection of sites to be monitored must be done to keep the monitoring effort cost-effective. Special habitats essential for the early developmental stages of mobile fauna (e.g., spawning, feeding grounds) or hosting benthic assemblages considered as key components of the deep-sea assuring ecosystem functioning (e.g., engineer species or species listed in the Red List), must be included among the selected sites. The duration of the monitoring should be at least medium-long term (minimum 5-10 years long). An effective monitoring should be done at defined intervals over a period of time, even if it could mean a reduced number of sites being monitored. The interval of data acquisition could be annually, as most of the typical species belonging to deep-sea habitats (e.g., animal forests) display slow grow rates and long generation times (> 1 year). In general, and irrespective of the objective advocated, it is judicious to focus initially on a small number of sites and that can be regularly monitored after short intervals of time. Then, with the experience gained by the surveyors and the means (funds) available, this network could be extended to a larger number of sites.

99. The reference “zero-state” will be contrasted with data coming from subsequent monitoring periods, always assuring reproducibility of data over time. Geographical position of surveys and sampling stations must therefore be located with precision.

100. 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).

101. The lack or scarcity of quantitative data and long-time-series from marine caves and deep-sea habitats in most of the Mediterranean areas is a major impediment to evaluate changes in their ecological status. There is evidence of alterations through time in caves of the north-western Mediterranean Sea, suggesting that there might be an unregarded decrease in quality at a broader scale (Parravicini et al., 2010; Rastorgueff et al., 2015; Gubbay et al., 2016; Nepote et al., 2017; Montefalcone et al., 2018). The most important pressures affecting marine cave communities are: mechanical damage of fragile species caused by unregulated diving activities, physical damage and siltation due to coastal and marine infrastructure activities, marine pollution (e.g., sewage plant outflow, marine litter), extractive human activities (e.g., red coral harvesting), water temperature rise, and potentially non-indigenous species (Chevaldonné and Lejeusne, 2003; Guarnieri et al., 2012; Giakoumi et al., 2013; Gerovasileiou et al., 2016b). Main threats to deep-sea habitats include climate change-related pressures (e.g., ocean warming, changes in primary production, hypoxia, and ocean acidification) and deep-water fishing, including bottom trawling (Rogers, 2019). Increased temperatures can lower oxygen thresholds and reduce the tolerance of species to acidification, while, in turn, hypoxia and acidification can reduce thermal tolerance. Physical disturbances caused by

bottom trawling, deep-sea mining, and oil and gas extraction can increase physiological stress due to climate change factors.

Methods

Monitoring marine cave communities

102. Following the preliminary definition of the localisation and topography of a marine cave (the previous CI1), assessment of its condition starts with an overall characterisation of the typical species and communities occurring within each cave. Monitoring of this habitat basically relies on underwater diving, although this technique gives rise to many constraints due to the peculiar conditions of this habitat (weak luminosity, complex topography, etc.). Good experience in underwater diving is requested to operate an effective work within submerged caves.

103. The general principles and methods for the characterisation of hard substrate cave communities are similar to those described in the guidelines for coralligenous monitoring (see "Guidelines for monitoring coralligenous" in this document). The use of non-destructive quantitative visual survey methods for studying the structure and the status of cave sessile communities is highly recommended (e.g., Martí et al., 2004; Bussotti et al., 2006; Gerovasileiou and Voultsiadou, 2016; Montefalcone et al., 2018). Direct *in situ* visual census techniques or photographic methods, associated with determination of taxa and/or morphological groups, can be adopted. Scientific divers annotate on their slates the list of the main conspicuous species/taxa characterising the assemblages. Divers must be specialists in the taxonomy of the main species that can be found in these habitats, to ensure the validity of the information recorded underwater. 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 such a complex and confined habitat at small spatial scales. The latter method, using square 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 when working within caves. Both methods minimise human impact on these fragile communities, still providing reference conditions for monitoring at given sites (Bianchi et al., 2004). For the study of sessile communities, a minimum of 3 replicated photographic samples (photo-quadrates) of about 0.16 m^2 each should be collected at each sampling station, covering a total surface of about 1-4 m^2. Positioning and number of sampling stations depend on the cave topography and its bathymetric range (Nepote et al., 2017). Being benthic assemblages of marine caves highly variable, even at small scales, and subjected to strong gradients, a systematic sampling method must be adopted, with stations regularly spaced from one another starting from the entrance and moving to the terminal part of the caves. All replicates must be taken on the vertical walls of the caves and at the same depth.

104. Given the limitations of the visual identification of several benthic taxa, the collection of supplementary qualitative samples is often necessary. The use of operational taxonomical units (OTUs), or taxonomical surrogates such as morphological groups (lumping species, genera or higher taxa displaying similar morphological features; Parravicini et al., 2010), may represent a useful compromise for the study of cave sessile benthos when a consistent species distinction is not possible (either underwater or on photographs), or to reduce the surveying/analysis time (Gerovasileiou and Voultsiadou, 2016; Nepote et al., 2017; Montefalcone et al., 2018). Semi-quantitative evaluations through underwater visual census could also provide valuable information in certain cases.

105. A list of the main conspicuous species/taxa or morphological groups recognisable underwater, or on images, is then produced. A list of species that are frequently reported in Mediterranean marine caves is presented in Appendix 1. This species list is not exhaustive but includes species reported from a considerable number of semi-dark and dark caves at the Mediterranean scale according to data from the Mediterranean marine cave biodiversity database (Gerovasileiou and Voultsiadou, 2012, 2014). Most of the present knowledge concerns the biota associated with the rocky walls and vaults of caves, while less information is available about the infauna in cave floor sediments (Bianchi and Morri, 2003). Marine caves are characterised by a high

degree of natural heterogeneity and their communities present qualitative and quantitative differences in species composition across different Mediterranean eco-regions (Gerovasileiou and Voultsiadou, 2012). For instance, species that have been traditionally considered cave characteristic in the western basin (e.g., *Corallium rubrum*) may be rare or even absent in the eastern basin and vice versa. Thus, the list is annotated with comments on the distribution of certain taxa. Advanced image processing softwares dedicated to marine biological research integrate methods and tools for the following accurate extraction of species coverage (%) or abundance (cm^2) from photo-quadrates (e.g., Teixidó et al., 2011; Trygonis and Sini, 2012). Monitoring of marine cave communities and sessile invertebrates with slow growth rates could be also benefited from methods quantifying 3D features, using photogrammetry (e.g., Chemisky et al., 2015).

106. Visual census methods can be also applied for studying the structure of mobile cave fauna; specifically, a modified transect visual census method (Harmelin-Vivien et al., 1985) adapted to cave habitats has been developed and applied in several Mediterranean caves for the study of fish assemblages (Bussotti et al., 2002, 2006; Bussotti and Guidetti, 2009), as well as for decapods crustaceans (Denitto et al., 2009). The number of species and individuals observed at 5 minutes interval must be recorded on the slate.

107. Sampling with hand-held corers is necessary for studying soft sediment communities of the cave bottom (Todaro et al., 2006; Janssen et al., 2013; Navarro-Barranco et al., 2012, 2014).

108. The disappearance of fragile sessile invertebrates (e.g., the bryozoans *Adeonella* spp. and *Reteporella* spp.) or particular growth forms (e.g., massive and erect invertebrates) and the replacement of endemic cave mysids by thermo-tolerant congeners are among the most striking examples of negative alterations on cave communities (Chevaldonné and Lejeusne, 2003; Guarnieri et al., 2012; Nepote et al., 2017). Growth forms are used to investigate different strategies of substratum occupation, which are strictly influenced by environmental conditions. For instance, the shift from a flattened morphology to a peduncolated one observed in some sponges of the genus *Petrosia* and *Chondrosia* in two marine caves of the Liguria Sea affected by costal constructions, is a clear strategy to counteract silting in environments with low water exchanges because it allows a greater efficiency in the elimination of catabolites (Nepote et al., 2017). Similarly, the use of trophic guilds can effectively show any change in the functioning of the eosysystem, providing information about trophic organization (which depends on light penetration and particulate matter availability) (Montefalcone et al., 2018).

109. An ecosystem-based index (CavEBQI) for the evaluation of the ecological quality of marine cave ecosystems has been recently developed and tested in the western Mediterranean basin (Rastorgueff et al., 2015). According to this approach, the following features could be indicative of high quality status: high spatial coverage of suspension feeders with a three-dimensional form (e.g., *Corallium rubrum*) and large filter feeders (e.g., the sponges *Petrosia ficiformis* and *Agelas oroides*) along with the presence of mysid swarms and several species of omnivorous and carnivorous fish and decapods. In the framework of a recent evaluation of ecological quality status in 21 western Mediterranean caves using the CavEBQI index, 14 caves were found in favourable status (good/high ecological quality) and no cave was found to be of bad ecological quality (Rastorgueff et al., 2015). However, a comparison of data obtained in 1986 and 2004 from the Bergeggi cave (Ligurian Sea, Italy) revealed a decrease in ecological quality attributed to summer heat waves (Parravicini et al., 2010; Rastorgueff et al., 2015; Montefalcone et al., 2018). Piccola del Ciolo cave, which is one of the most studied Mediterranean marine caves, was evaluated to be of high ecological quality using CavEBQI index (Rastorgueff et al., 2015).

110. A fill-in form that could be used as a basis for recording (a) basic topographic features, (b) characteristic species from different functional components of the ecosystem-based approach by Rastorgueff et al. (2015), (c) protected species, and (d) pressures and threats is shown in Figure 8.

Figure 8: Modified example of fill-in sheet developed in the context of monitoring studies by V. Gerovasileiou (HCMR). The form was based on the approach for the evaluation of the ecological quality of marine cave habitats developed by Rastorgueff et al. (2015). In addition to the species data included in the form, photo-quadrates covering a total surface of about 1-4 m^2 should be acquired for the study of sessile communities.

Area:	**Date:**		**Observer:**	
Latitude:	**Longitude:**			
Submersion level: Submerged / Semi-submerged	**Cave morphology:** Blind cave / Tunnel No. of entrances:			
Total length of cave:	**Maximum water depth:**		**Minimum water depth:**	
Entrance A – Max depth (m):	Height (m):		Width (m):	Orientation:
Entrance B – Max depth (m):	Height (m):		Width (m):	Orientation:
Other topographic features: Internal beach / Air pockets / Speleothems /				
Micro-habitats:				
Detritivorous / omnivorous species (number of species and individuals observed at 5 min interval)				
Herbstia condyliata	1–2	3–4	5–10	>10
Galathea strigosa	1–2	3–4	5–10	>10
Scyllarus arctus	1–2	3–4	5–10	>10
	1–2	3–4	5–10	>10
	1–2	3–4	5–10	>10
	1–2	3–4	5–10	>10
	1–2	3–4	5–10	>10
	1–2	3–4	5–10	>10
Mysids	0	few		swarm
Fish species observed/ cave zone (CE: entrance, SD: semi-dark zone, DZ: dark zone)	**Decapods species observed / cave zone** (CE: entrance, SD: semi-dark zone, DZ: dark zone)			
/	/			
/	/			
/	/			
/	/			
/	/			
/	/			
/	/			
/	/			
***Cerianthus membranaceus* (number of individuals)**	0	1-2		>2
***Arachnanthus oligopodus* (number of individuals)**	0	1-2		>2
Other typical and/or protected species	**Threats and pressures**			
	Broken bryozoans			
	Air bubbles			
	Marine litter			
	Non-indigenous species			
	Other comments			

Monitoring deep-sea habitats

111. Following the preliminary definition of the distributional range and extent of deep-sea habitats (the previous CI1), assessment of the condition of these habitats starts with an overall

characterisation of the typical species and communities occurring within each habitat. Methodologies to monitor the condition of deep-sea dark habitats include a wide array of technologies and equipment (see Tab. 1). Selection of the methods for monitoring depends on the habitat type (and selected target species) to be addressed. Large sessile epibenthic species on hard substrates are preferably monitored using optical, non-destructive methods, such as ROVs. Living specimens can be collected by ROV arm. Endobenthic communities are sampled using standardized grabs or corers. The use of ROVs, bathyscaphes, or submarines provide visual and georeferenced information on the benthic communities on these habitats. Data about the presence of species, distribution patterns, estimates of densities, biological associations, etc., can be obtained. In the case of the ROVs and submarines, these allow the completion of video transects and the selective collection of samples, which greatly facilitates the identification of key species in the habitat formation, as well as the species associated with them. High quality photographs and video recorded will then 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). Photographs can be archived to create temporal datasets. A selection of target species should be defined per sub-region (or bioregion) to allow for the consistent assessment of their state/condition. Long-lived species and species with high structuring or functional value for the community should preferably be included; however, the list should also contain small and short-lived species if they characteristically occur in the habitat under natural conditions, as they can also be functionally very important for the community. This list should be updated every six years.

112. Although destructive methods are not desirable for long-term regular monitoring (UNEP/MAP-RAC/SPA, 2008), they become indispensable for a high-resolution characterisation of deep-sea communities on soft bottoms. A variety of sampling gears has been used to collect sediment samples from vessels to identify the type of substrate, the granulometry, the organic matter content, and for the study of deep-sea organisms (Danovaro et al., 2010). Common devices are grabs, gravity cores, piston cores, box cores, and multiple corers, used in a number of randomly selected points within a study area. The use of grabs allows more extensive sampling in large areas, also providing information on species of infauna and on small organisms that it is not possible to detect/identify with other methods. Sometimes benthic trawling has been recommended as appropriate for sampling benthic habitats; however, despite they can provide useful data, these methods are forbidden for assessment of highly sensitive habitats to the impact of physical damage such as rocky reefs, and must be avoided on soft bottom communities dominated by long-lived species (e.g., large sponges, gorgonians, bamboo corals).

113. Deep-sea macrofauna has been sampled in the western Mediterranean by different methods, depending on the depth considered and the research teams (Danovaro et al., 2010 and references therein). Commercial trawls can be used, having horizontal mouth openings of 20-25 m and 3-5 m of vertical opening, with a 40 mm stretched mesh in the codend liner, which are trawled over the seafloor at about 3 knots. The otter semiballoon trawl gear (OTSB: 8 m horizontal spread and 0.8 vertical mouth opening) has been also used in the Mediterranean Sea. This sampling device was subsequently transformed into the otter trawl Maireta System (OTMS: 12 m horizontal spread and 1.4 m vertical opening approximately). The OTMS is equipped with SCANMAR sensors that provide information on bottom contact time and vertical and horizontal opening of the trawl's mouth down to 1500 m depth, allowing calculation of sampled area. Furthermore, the Agassiz benthic trawl has been commonly used to sample the deep western and eastern Mediterranean benthos since the late 1980s. A modified Agassiz trawl (2.3 m wide and 0.9 m high), a 14.76 m Marinovich-type deep-water trawl (codend mesh 6 mm) with a 0.5 mm plankton net secured on top, and different types and sizes of box corers have also been used. A 0.062 m^2 box corer with an effective penetration of 40 cm (Ocean Instruments model 700 AL) has been used in the Levantine Sea. The samples are typically preserved in 10% buffered formalin aboard the vessel. In the laboratory, samples are washed and sieved through 250 µm mesh (Danovaro et al., 2010).

114. The use of AUVs, CTDs, Niskin bottles and other methods to analyse the water column provides complementary information on water masses, currents, and physicochemical data, which combined with all the other information allows a better interpretation of deep ecosystems. Regarding AUVs, those equipped with multi-beam echosounder (or with side scan sonar) and cameras are also widely used to explore and map large areas in deep-sea environments. The initial costs of these instruments usually prevent their use by small research institutes, but the large amount of data collected, and the large area surveyed makes them a very advantageous approach with respect to use large vessels for several days.

115. New techniques of DNA analysis, besides providing information on populations and species, can shed light on the species inhabiting the area that have not been detected with other methods and can also supply information on their abundance.

Protocol for monitoring deep rocky reefs habitats down to 120 m depth

116. Although no standardized protocols exist to date for monitoring deep-sea habitats, the protocol recently proposed for monitoring mesophotic coralligenous reefs (down to 40 m depth) (Enrichetti et al., 2019) can be applied and adapted for monitoring deep-sea rocky habitats in the offshore circalittoral and the bathyal zones. The proposed protocol (all details can be found in Cánovas-Molina et al., 2016; Enrichetti et al., 2019) suggests a standard sampling design conceived to gather various quantitative components, such as the occurrence and extent of the rocky habitat, 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, through ROVs surveys.

117. Three replicated video-transects, each at least 200 m long, should be collected in each area investigated. Footages can be obtained by means of a ROV, equipped with a high definition digital camera, a strobe, a high definition 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 guarantee the best quality of video footages, ROVs are 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 end 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.

118. From each transect the following parameters are measured from videos:

- Extent of hard bottom, calculated as percentage of total video time showing this type of substratum (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. Organisms are identified to the lowest taxonomic level and counted. Fishes and encrusting organisms are not considered, as well as typical soft-bottoms 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 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).

119. 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 substratum: 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)
- Sedimentationlevel, estimated considering the percentage of hard bottom covered by sediments: 0%, <30% (low), 30-60% (medium), >60% (high).

120. All the above listed parameters allow the application of the seascape ecological index namely MACS (Mesophotic Assemblages Conservation Status; Enrichetti et al., 2019). MACS is a new multi-parametric index that is composed by 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 Is depicts the biocoenotic complexity of the deep-sea habitat, whereas the Ii describes the impacts affecting it. Environmental status is the outcome of the status of benthic communities plus the amount of impacts upon them: the integrated MACS index measures the resulting environmental status of deep-sea rocky habitats reflecting the combination of the two units and their ecological significance.

Final remarks

121. Inventorying and monitoring dark habitats in the Mediterranean constitute a unique challenge given the ecological importance of their communities and the threats that hang over their continued existence. Long neglected due to their remote location and the limited means to investigate these areas, today these habitats must be the subject of priority programs. There is a huge necessity to improve knowledge of dark habitats and their distribution in the Mediterranean Sea, in order to establish international cooperation networks and also to facilitate sharing of experiences among Mediterranean countries. The existing scientific information on the distribution, biodiversity, functioning and connectivity of dark habitats on seamounts, in canyons, caves and escarpments must be continuously improved. Nevertheless, there are still obvious gaps of knowledge with regard to the distribution and diversity of dark habitats from the eastern and the southern parts of the Mediterranean Sea. The available scientific databases must be updated and integrated setting up collaborative tools and/or platforms to help scientists in exchanging data and experience. The assessment of associated ecosystem services should be also undertaken. Common monitoring protocols have to be defined, shared, and applied at the Mediterranean scale. The process of designation of new protected areas, aiming at the conservation of deep-sea habitats, must be enforced, as well as the existing regulatory measures, particularly to avoid the impact of destructive fishing practices over identified deep-sea sensitive habitats, vulnerable marine ecosystems or essential fish habitats (spawning and nursery grounds).

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Annex . List of the most common species in Mediterranean marine caves. From SPA/RAC-UN Environment/MAP OCEANA, 2017.
*** rare or endangered species**

Foraminiferans
Miniacina miniacea (Pallas, 1766)

Sponges
Aaptos aaptos (Schmidt, 1864)
Acanthella acuta Schmidt, 1862
Agelas oroides (Schmidt, 1864) – more abundant in the Eastern Mediterranean
Aplysilla rosea (Barrois, 1876)
Aplysina cavernicola (Vacelet, 1959)
Axinella damicornis (Esper, 1794)
Axinella verrucosa (Esper, 1794)
Chondrosia reniformis Nardo, 1847 – often discoloured
Clathrina coriacea (Montagu, 1814)
Clathrina clathrus (Schmidt, 1864)
Cliona viridis (Schmidt, 1862)
Cliona schmidti (Ridley, 1881)
Cliona celata Grant, 1826
Crambe crambe (Schmidt, 1862)
Dendroxea lenis (Topsent, 1892)
Diplastrella bistellata (Schmidt, 1862)
Dysidea avara (Schmidt, 1862)
Dysidea fragilis (Montagu, 1814)
Erylus discophorus (Schmidt, 1862)
Fasciospongia cavernosa (Schmidt, 1862)
Geodia cydonium (Linnaeus, 1767)
Haliclona (Halichoclona) fulva (Topsent, 1893)
Haliclona (Reniera) cratera (Schmidt, 1862)
Haliclona (Rhizoniera) sarai (Pulitzer-Finali, 1969)
Haliclona (Soestella) mucosa (Griessinger, 1971)
Hemimycale columella (Bowerbank, 1874)
Ircinia dendroides (Schmidt, 1862)
Ircinia oros (Schmidt, 1864)
Ircinia variabilis (Schmidt, 1862)
Jaspis johnstoni (Schmidt, 1862)
Lycopodina hypogea (Vacelet & Boury-Esnault, 1996)
Myrmekioderma spelaeum (Pulitzer-Finali, 1983)
Oscarella spp.
Penares euastrum (Schmidt, 1868)
Penares helleri (Schmidt, 1864)
Petrobiona massiliana Vacelet & Lévi, 1958 – more common in the Western Mediterranean
Petrosia (Petrosia) ficiformis (Poiret, 1789) – often discoloured
Phorbas tenacior (Topsent, 1925)
Plakina spp.
Pleraplysilla spinifera (Schulze, 1879)
Scalarispongia scalaris (Schmidt, 1862)
Spirastrella cunctatrix Schmidt, 1868
Spongia (Spongia) officinalis Linnaeus, 1759 *
Spongia (Spongia) virgultosa (Schmidt, 1868)
Terpios gelatinosus (Bowerbank, 1866)

Cnidarians
Arachnanthus oligopodus (Cerfontaine, 1891)
Astroides calycularis (Pallas, 1766) * – in southern areas of the Western Mediterranean
Caryophyllia (Caryophyllia) inornata (Duncan, 1878)
Cerianthus membranaceus (Gmelin, 1791)
Corallium rubrum (Linnaeus, 1758) *
Eudendrium racemosum (Cavolini, 1785)
Eunicella cavolini (Koch, 1887) – more common in the Western Mediterranean
Halecium spp.
Hoplangia durotrix Gosse 1860
Leptopsammia pruvoti Lacaze-Duthiers 1897
Madracis pharensis (Heller, 1868) – more abundant in the Eastern Mediterranean
Obelia dichotoma (Linnaeus, 1758)
Paramuricea clavate (Risso, 1826) * – more common in the Western Mediterranean
Parazoanthus axinellae (Schmidt, 1862) – more common in the Adriatic and the Western Mediterranean
Phyllangia americana mouchezii (Lacaze-Duthiers, 1897)
Polycyathus muellerae (Abel, 1959)

Decapods
Athanas nitescens (Leach, 1813)
Dromia personata (Linnaeus, 1758)
Eualus occultus (Lebour, 1936)
Galathea strigosa (Linnaeus, 1761)
Herbstia condyliata (Fabricius, 1787)
Lysmata seticaudata (Risso, 1816)
Palaemon serratus (Pennant, 1777)
Palinurus elephas (Fabricius, 1787)
Plesionika narval (Fabricius, 1787) – more common in the Eastern Mediterranean
Scyllarides latus (Latreille, 1803)
Scyllarus arctus (Linnaeus, 1758)
Stenopus spinosus Risso, 1826

Mysids
Harmelinel lamariannae Ledoyer, 1989
Hemimysis lamornae mediterranea Bacescu, 1936
Hemimysis margalefi Alcaraz, Riera & Gili, 1986
Hemimysis speluncola Ledoyer, 1963 *
Siriella jaltensis Czerniavsky, 1868

Polychaetes
Filograna implexa Berkeley, 1835
Filogranula annulata (O. G. Costa, 1861)
Filogranula calyculata (O.G. Costa, 1861)
Filogranula gracilis Langerhans, 1884
Hermodice carunculata (Pallas, 1766)
Hydroides pseudouncinata Zibrowius, 1968 [original]
Janita fimbriata (Delle Chiaje, 1822)
Josephella marenzelleri Caullery & Mesnil, 1896
Metavermilia multicristata (Philippi, 1844)
Protula tubularia (Montagu, 1803)
Semivermilia crenata (O. G. Costa, 1861)
Serpula cavernicola Fassari & Mollica, 1991
Serpula concharum Langerhans, 1880
Serpula lobiancoi Rioja, 1917

Serpula vermicularis Linnaeus, 1767
Spiraserpula massiliensis (Zibrowius, 1968)
Spirobranchus polytrema (Philippi, 1844)
Vermiliopsis labiata (O. G. Costa, 1861)
Vermiliopsis infundibulum (Philippi, 1844)
Vermiliopsis monodiscus Zibrowius, 1968

Molluscs
Lima lima (Linnaeus, 1758)
Lithophaga lithophaga (Linnaeus, 1758) *
Luria lurida (Linnaeus, 1758) *
Neopycnodonte cochlear (Poli, 1795)
Peltodoris atromaculata Bergh, 1880
Rocellaria dubia Pennant, 1777

Bryozoans
Adeonella calveti (Canu & Bassler, 1930) – mainly in the Western Mediterranean
Adeonella pallasii (Heller, 1867) – endemic to the Eastern Mediterranean
Celleporina caminata (Waters, 1879)
Corbulella maderensis (Waters, 1898)
Crassimarginatella solidula (Hincks, 1860)
Hippaliosina depressa (Busk, 1854) – more common in the Eastern Mediterranean
Myriapora truncata (Pallas, 1766)
Onychocella marioni (Jullien, 1882)
Puellina spp.
Reteporella spp.
Schizomavella spp.
Schizotheca spp.
Turbicellepora spp.

Brachiopods
Argyrotheca cistellula (Wood, 1841)
Argyrotheca cuneata (Risso, 1826)
Joania cordata (Risso, 1826)
Megathiris detruncata (Gmelin, 1791)
Novocrania anomala (O.F. Müller, 1776)
Tethyrhynchia mediterranea Logan & Zibrowius, 1994

Echinoderms
Amphipholis squamata (Delle Chiaje, 1828)
Arbacia lixula (Linnaeus, 1758)
Centrostephanus longispinus (Philippi, 1845) *
Hacelia attenuata Gray, 1840
Holothuria spp.
Marthasterias glacialis (Linnaeus, 1758)
Ophioderma longicauda (Bruzelius, 1805)
Ophiothrixfragilis (Abildgaard in O.F. Müller, 1789)
Paracentrotus lividus (de Lamarck, 1816)

Ascidians
Cystodytes dellechiajei (Della Valle, 1877)
Didemnum spp.
Aplidium spp.
Halocynthia papillosa (Linnaeus, 1767)
Microcosmus spp.
Pyura spp.

Pisces
Apogon imberbis (Linnaeus, 1758)
Conger conger (Linnaeus, 1758)
Corcyrogobius liechtensteini (Kolombatovic, 1891)
Didogobius splechtnai Ahnelt & Patzner, 1995
Gammogobius steinitzi Bath, 1971
Gobius spp.
Grammonus ater (Risso, 1810)
Parablennius spp.
Phycis phycis (Linnaeus, 1766)
Sciaena umbra Linnaeus, 1758
Scorpaena maderensis Valenciennes, 1833 – more common in the Eastern Mediterranean
Scorpaena notata Rafinesque, 1810
Scorpaena porcus Linnaeus, 1758
Scorpaena scrofa Linnaeus, 1758
Serranus cabrilla (Linnaeus, 1758)
Serranus scriba (Linnaeus, 1758)
Thorogobius ephippiatus (Lowe, 1839)