Implementation of the MSFD to the

Deep Mediterranean Sea

IDEM

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Report 3.2. Report on the revision of MSFD descriptors/criteria/indicators to be applied on the deep-sea ecosystems

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SUBMISSION DATE

29th March| 2019

This project has received funding from the European Union's DG Environment programme under grant agreement No 11.0661 /2017/750680/SUB/EN V.C2.

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How to cite this document:

IDEM Project[1]. (2019b). Deliverable 3.2: IDEM Report 3.2. Report 3.2. Report on the revision of MSFD descriptors/criteria/indicators to be applied on the deep-sea ecosystems. *IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project*. UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM, UNIVPM.

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TABLE OF CONTENTS

ACRONYMS TABLE

CFP	Common Fisheries Policy
D1-D11	Descriptors 1 to 11
EC	European Commission
EP	Evaluation parameter
ES	Evaluation step
GFCM	General Fisheries Commission for the Mediterranean
GES	Good Environmental Status
HELCOM	Convention for the Protection of the Marine Environment in the Baltic Sea Area
ICES	International Council for the Exploration of the Sea
IDEM	Implementation of the MSFD to the DEep Mediterranean Sea
IMAP	Integrated Monitoring and Assessment Programme
IQ	Indicator Quality criteria (terminology from Queirós et al., 2016)
MED	Mediterranean Sea
MSFD	Marine Strategy Framework Directive
NIS	Non-indigenous species
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
RSC	Regional Sea Conventions
UNEP-MAP	United Nations Environment Programme-Mediterranean Action Plan

1. INTRODUCTION

The IDEM project contributes to the second cycle of the MSFD implementation. This Directive is the main European tool for the conservation of the marine environment by promoting the achievement and maintenance of Good Environmental Status (GES) (Directive 2008/56/EC). The current implementation of the MSFD failed in encompassing all marine systems since it mainly approaches coastal environments. Therefore, the IDEM project focused in the assessment of the deep Mediterranean Sea by defining suitable environmental targets. This objective includes multiple assignments organized in four actions: (1) Review of literature on MSFD implementation, (2) Analysis of the available datasets and mapping of the current knowledge, (3) Identification of the major gaps, the most feasible criteria/indicators together with its thresholds and the key areas to include in monitoring programs, and (4) Dissemination of the outputs.

This deliverable is part of IDEM action 3, consisting of three assignments. Task 3.1 consists of the identification of major gaps (IDEM Project, 2019a). The outcomes of the first task contribute to the development of a comprehensive set of indicators/criteria targeting the main topics described by the MSFD Directive and also the gaps identified in 3.1, thus fulfilling Task 3.2. Finally, Task 3.3 focuses in the identification of feasible thresholds for the selected indicators, together with the description of deep-sea key areas for future monitoring programs. This deliverable reports the development and the outcomes of Task 3.2 on the identification of the most feasible criteria and indicators for describing the deep Mediterranean Sea environmental status. Deliverable 3.2 contents are tightly linked to the information provided in Deliverable 3.1 since there was a need to complement the gaps identified with indicators and appropriate criteria. Accordingly, this document contains information from Deliverable 3.1, and also from other projects and RSC working plans related to GES assessments such as the HELCOM CORESET project (HELCOM, 2012a, 2012b), the OSPAR set of indicators (OSPAR, 2017) or the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast (UNEP-MAP, 2012, 2017). As already mentioned, the main objective of this task and the associated deliverable is the identification, evaluation and description of the most promising criteria/indicators for the deep Mediterranean Sea. The finally selected indicators and criteria should help extend the GES concept to the deep sea. Finally, an accurate integrative analysis of all indicators should enable the revision of the available feasible thresholds, linking Task 3.2 with Task 3.3.

Specific terminology is applied consistently in all the documents encompassed in Task 3.2. So far, terminology is often ambiguous thus enabling distinct interpretations. Additionally, different terms have been used for similar concepts in the revised frameworks (Schroeder, 2010; ICES, 2015; Queirós et al., 2016; Otto et al., 2018). Therefore, the specific terminology applied to this one and to associated documents within the IDEM frame is defined in Box 1 below in order to avoid misunderstandings and inconsistencies.

BOX 1. TERMINOLOGY

Indicator: tool proposed by the MSFD for implementing the monitoring of the topics addressed by the descriptors' criteria.
Evaluating parameter OR parameter (EP): refers to each of the indicators' properties assessed. The IDEM approach contains 10 parameters formulated within IDEM Task 3.2 after the revision of three former evaluation frameworks (Schroeder, 2010; Queirós et al., 2016; Otto et al., 2018). Each parameter focuses in one property or indicator attribute, which needs to be evaluated.
Evaluation step (ES): refers to each of the phases of the evaluation process that need to be followed when assessing every evaluating parameter. The IDEM evaluation system relies on 5 evaluation steps common to all evaluating parameters. Specifications for the actual implementation of each step differ between the 10 evaluating parameters.
Feature, element: synonyms used for referring to indicators' characteristics or attributes that need to be assessed or considered.
Target (and ecosystem target): the monitoring objective of the indicator. It can be a component of the ecosystem, a pressure, an impact, an ecosystem function, an ecosystem response or any other property, behavior or process addressed by an indicator.
Indicator type: defines the indicator class regarding its monitoring objective. Three main options are established: state, pressure and impact.
Single indicator: only indicator for a given monitoring objective. Thus, single indicators are the only option for monitoring a particular target.
Promising indicator: indicator that cannot be used at present but has high potential for future applications.
Selected indicator (accepted): indicator that has succeeded in the evaluation process and that has been classified as accepted in the final decision tree. Thus, it belongs to the group of selected indicators forming the set of indicators for a given descriptor.

2. THE IDEM APPROACH FOR SELECTING DEEP-SEA INDICATORS

Chapter 2 explains the process of developing a suitable approach that enables a consistent selection of deep-sea indicators for each descriptor. It also specifies the documents generated for supporting the approach and the key steps that conform the process.

2.1 STRUCTURE AND BRIEF DESCRIPTION OF THE FRAMEWORK DEVELOPED

Definition of a detailed structured process for the identification, evaluation and description of deep-sea criteria and indicators is needed to ensure consistency amongst project partners. Accordingly, a common structured framework was developed and implemented with the support of several documents. The framework is based on four steps, described below, founded on the general structure of the system defined by Otto et al. (2018) for selecting and validating food web indicators.

The framework, outlined in Figure 1, consists of four steps ordered consecutively that guide the three goals of the process: identification, evaluation and description. Firstly, management objectives to be filled by the indicators need to be defined including both MSFD targets already present in the Directive and the gaps described within Deliverable 3.1 (IDEM Project, 2019a).

This step is crucial since it establishes the basis for the task and connects Task 3.1 with Task 3.2. The second step consists of an extensive screening of potential indicators in the available literature. The formulation of novel indicators, targeting topics currently omitted in the existing ones, is also considered within Step 2. The third step is the critical, decisive part of the approach since it involves the evaluation process of the compiled indicators by a common system developed within the IDEM project. The system is based on evaluating steps that guide the process and on evaluating parameters that determine what is actually assessed. The outcome is a ranked pool of indicators that leads to a final selection of a complete, appropriate set. Finally, Step 4 is basically the definition of each indicator by the generation of an individual data sheet. The compilation of the data sheets has to conform the final database that should be used in future assessments and monitoring programs of the deep Mediterranean Sea.

Several documents have been developed in order to guide and complete all the assignments encompassed in Task 3.2. This document, Deliverable 3.2, is the main report providing a general view of the outcomes obtained for each descriptor. Details of the results of Steps 3 and 4 are provided in two supporting documents. Thus, the task results are reported within three different documents: (i) Task 3.2 Deliverable 3.2, (ii) Task 3.2 Evaluation process spreadsheets, encompassing Step 1, Step 2 and Step 3 outcomes (see attached documents in chapter 3.12: Evaluation process spreadsheets), and (iii) Task 3.2 Database of the IDEM criteria and indicators that gathers the data sheets generated for each selected indicator (IDEM Project, 2019c). Steps 1 and 2 have been implemented with the methodology and format chosen by each partner. Nevertheless, the outcomes of both steps have been incorporated to the spreadsheet document thus guiding and standardizing Step 3. In order to ensure consistency between descriptors, the evaluation system was implemented in a common spreadsheet where each indicator was assessed by each evaluating parameter following all steps described in the system. The spreadsheet also contains the management objectives, the selected initial pool and the final selection of indicators with the specified scores. Additionally, since one of the parameters assessed was the availability of thresholds and/or reference conditions, the ones identified were compiled within one table in the spreadsheet. The guidelines composed for performing the evaluations are presented in Annex I, containing accurate description of the evaluated parameters and of the applied scoring system. Finally, the selected indicators were described through the generation of one page data sheet following a common format. The compilation of all data sheets and a general assessment of the indicators' sets constitute the database document holding the outcomes of Step 4 and fulfilling the objective of Task 3.2 (IDEM Project, 2019c).

2.2 THE KEY STEPS

This section aims at providing relevant information for each of the key steps of the process in order to define their specific context and development process.

No common framework was developed for the performance of Steps 1 and 2. Steps 3 and 4 are complex and more prone to lead to inconsistencies. Accordingly, specific processes, systems and documents were designed for the implementation of Steps 3 and 4. The approach developed for these two last steps is described in detail in the following paragraphs. A brief comment on Step 1 is also included in this section in order to highlight the relevance of the novel criteria described as management objectives based on Task 3.1 disregarded issues (IDEM Project, 2019a).

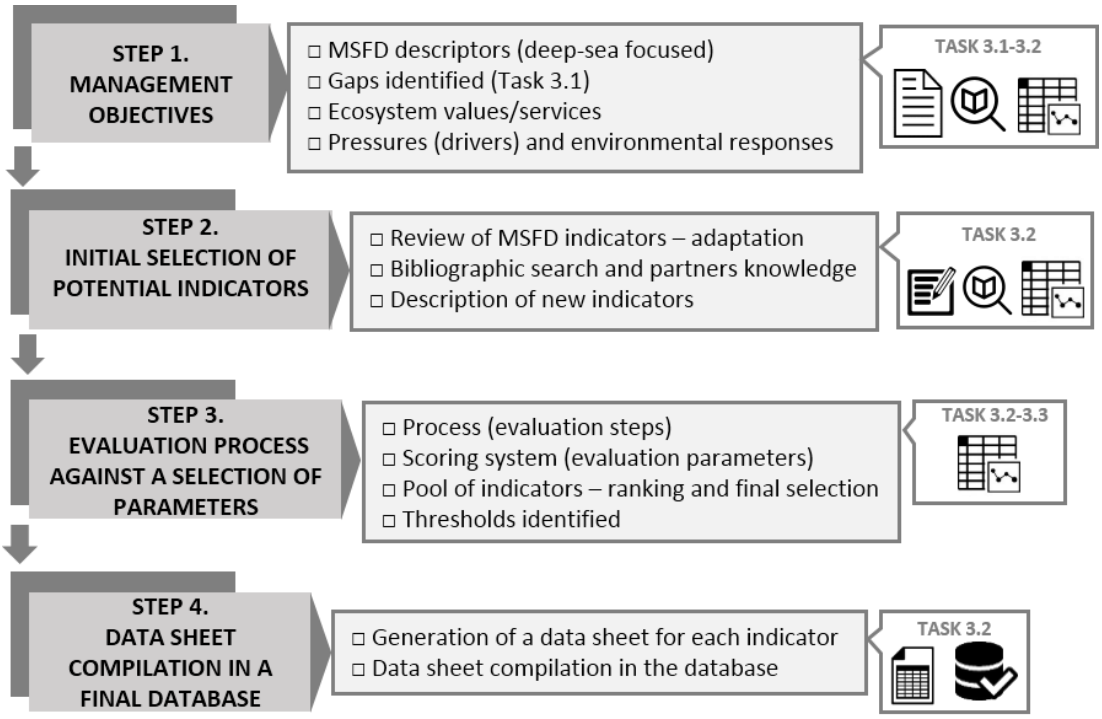

Figure 1. Summary chart of the approach suggested for IDEM Task 3.2. The left panels define the four main steps determined by the assignments demanded for each step, illustrated in the middle panels. The symbols at the right panels represent the actions and documents relevant for each of the steps. For each box, from left to right and from top to bottom: top box: Deliverable 3.1 (IDEM Project, 2019a), bibliographic search and Task 3.2 Evaluation process (chapter 3.12: Evaluation process spreadsheets); second box from top: description of new indicators, bibliographic search and Task 3.2 Evaluation process (chapter 3.12: Evaluation process spreadsheets); third box from top: Task 3.2 Evaluation process (chapter 3.12: Evaluation process spreadsheets); bottom box: indicators' datasheets and Task 3.2 Database of the IDEM criteria and indicators (IDEM Project, 2019c).

Step 1. Management objectives

The only stated requirement for Step 1 was the establishment of a complete set of management objectives encompassing both the MSFD targets already present in the Directive and the gaps described within Deliverable 3.1 (IDEM Project, 2019a). Within the gaps identified in Task 3.1, additional criteria were suggested in order to compensate the neglected issues in the current MSFD. The six following topics, relevant for multiple descriptors, were identified and described in Deliverable 3.1 (IDEM Project, 2019a) within the disregarded issues chapter:

(i) Microbial communities
(ii) Climate change
(iii) Ecosystem functioning and connectivity
(iv) Biological blooms and other episodic events
(v) Ecosystem response, resilience and remediation potential
(vi) Pressures (human activities)

Considering their relevance to each descriptor, these topics have been included as novel criteria within the management objectives and provided with feasible indicators.

Step 3. Evaluation process and scoring system

The third step aims at evaluating the initial pool of indicators following a structured, standardized system developed within the IDEM Task 3.2 and implemented through a common spreadsheet (chapter 3.12: Evaluation process spreadsheets). The IDEM evaluation system is adapted from the one applied for the selection of good indicators in the DEVOTES project (Queirós et al., 2016). This system was chosen as a basis due to a number of reasons. Firstly, the authors already revised a range of published alternatives proposing scoring systems and evaluating parameters. The final selection was based on the ICES quality criteria, an approach already resulting from synthesized published efforts. The DEVOTES system already screened and combined diverse approaches. Secondly, the framework consisted of several steps and indicator quality criteria (IQs) defined in detail within Queirós et al. (2016) and the DEVOTES Deliverable 3.2 (DEVOTES Project, 2014, 2015). The scoring system considering weighting of IQs was objective and widely applicable. However, some weaknesses were identified. The framework focuses in state-indicators and is optimized for local applications, hindering standardized assessments across MSFD regions. In order to make up for these deficiencies, the IDEM evaluation system has been complemented with inputs from other existing systems (Schroeder, 2010; Otto et al., 2018) and experts' opinions.

The IDEM system is based on two evaluating blocks: parameters and steps. **Evaluating steps (ES)** define the common process that need to be followed, whereas **evaluation parameters (EP)** specify the features to be assessed for each indicator. The approach contains in total 5 evaluation steps and 10 evaluation parameters. A detailed description of the system and guidelines for the evaluation process are available in Annex I. The scoring system is adapted from the DEVOTES binary (0, 1) system (Queirós et al., 2016). The DEVOTES system states that

if the indicator meets the parameter tested, it scores 1. If it does not, it scores 0. The ICES approach (used for the development of the DEVOTES framework) also includes 0.5 as an additional score representing the partial fulfilment of the parameter (ICES, 2015). Following this approach, the possible individual scores could be 0, 0.5 or 1 for each evaluating parameter. The total quality score per indicator results from the sum of the individual ones (see formula stated in Figure 2), yielding a maximum of 10 if every parameter is fulfilled. Besides of the scores, the system here proposed includes additional weighting of two parameters, EP.1 and EP.2. The one-out-all-out criterion, defined in Queirós et al. (2016), was stated for EP.1 determining the direct rejection of the indicator if it fails to meet this parameter. The EP.2 was defined as a basic fulfilment. Thus, if an indicator that is finally selected scores 0 in this parameter, the lack of data is highlighted within the indicator data sheet since its applicability is compromised. The approach also defines a minimum score below which the evaluated indicator should be discarded and not incorporated to the final pool. The minimum is set in the value where the indicator meets less than half of the parameters desired (<5 in the IDEM system here described). In order to obtain a complete, non-redundant set of indicators, two additional rules have been incorporated. First, if an indicator is identified as unique for the monitoring of an ecosystem item and scores at least 4 in total, it can be selected also for the final set. Secondly, if an indicator is identified as redundant because of major overlaps it can be discarded despite of scoring higher than 5 in the final step. The system and the rules defined are structured in a decision tree (see Figure 2) in order to facilitate its implementation.

The simplified evaluation process. The approach just described is highly exhaustive, requiring a thorough study of the potential indicators for monitoring the deep Mediterranean Sea. It also requires the performance of a complex, time-consuming process. Due to time constrains within the IDEM project, the initial, exhaustive approach was reconsidered and adapted in order to deliver the expected results in time. Therefore, each of the working groups per descriptor chose one of the two approaches (exhaustive vs. simplified) taking into account the amount of work required and the time left. Although initially the first option described was the preferred one, the two approaches enable the delivery of consistent results in order to ensure equivalent sets of indicators for all descriptors. The second approach simplifies the evaluation process and eases the completion of the data sheets (see documents for descriptors 1, 2, 3, 7, 8, 9 and 10 in chapter 3.12: Evaluation process spreadsheets). Approach 1 was applied for descriptors 4, 5 and 6 (chapter 3.12: Evaluation process spreadsheets). The simplification of the evaluation system was accomplished by compiling the assessment of all ten evaluation parameters (EP) in only one table. The table had to be filled with a score (0, 0.5 or 1) for each EP considering the partner's expert knowledge, relevant references and the composed guidelines (Annex I). Following the score, a brief justification was demanded and equalled to the data sheet sections in order to facilitate the generation of the indicators' data sheets.

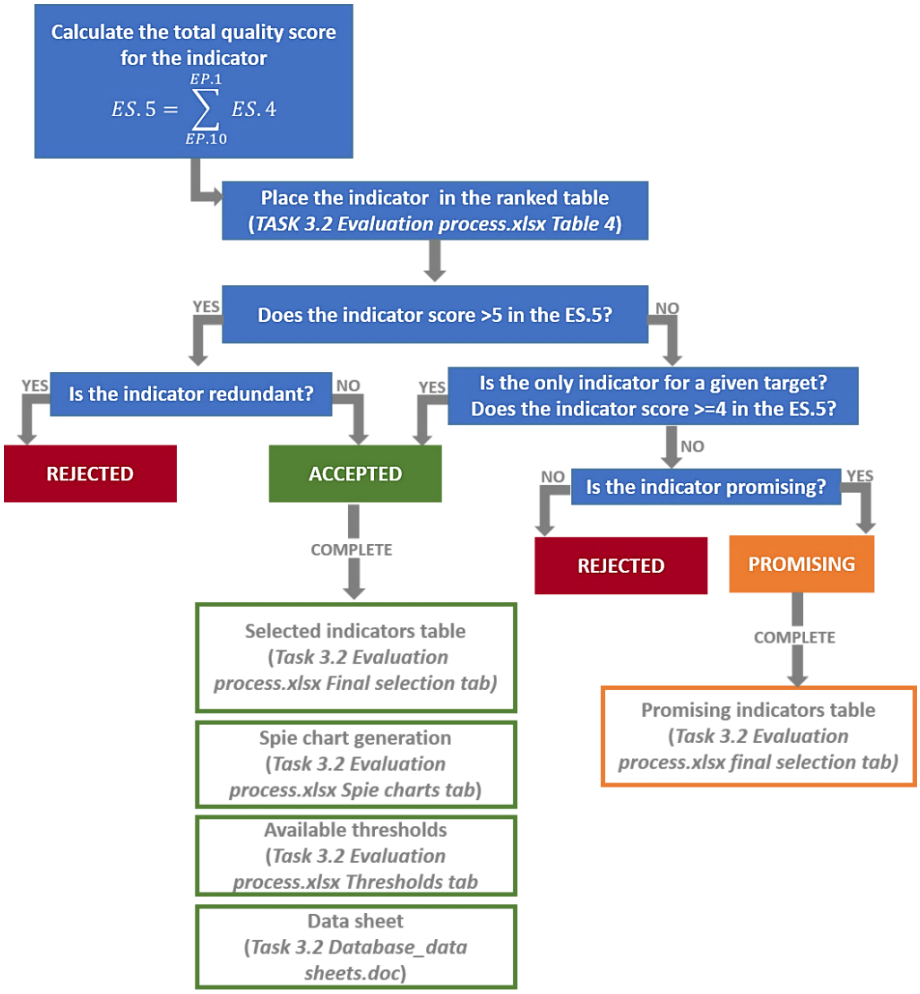

Figure 2. Decision tree establishing the process and the options that define the categorization process of an indicator and its final specifications. Blue rectangles identify the steps and the conditions that need to be done and verified. The outcome of the process is illustrated in colours: red represents the rejection of an indicator, orange differentiates the promising indicators and green the accepted ones. The assignments demanded for the selected and promising indicators are also listed and marked with the corresponding colour.

The evaluation questionnaire for D11 criteria and indicators. D11, focuses on the introduction of energy including underwater noise. Given the lack of expertise within the IDEM consortium, the performance of an evaluation process equivalent to the other descriptors was compromised. Consequently, a contingency plan was applied to achieve at least some degree of evaluation. The plan consisted in preparing and delivering an ad hoc questionnaire to an external collaborator with proven expertise on the topic. The questionnaire (added to this Deliverable as Annex II) consists of ten questions, one per EP, which provided an assessment of D11 indicators and criteria established in the MSFD (European Commission, 2017).

Step 4. Definition of each indicator by an individual data sheet compiled in the final database

Task 3.2 Database compiles all data sheets describing each of the selected indicators. Model documents for the database and for the data sheets were designed in order to provide the same structure to all partners, thus promoting consistency and clarity in the outcomes. The IDEM proposal for Step 4 consists of a single document named Task 3.2 Database of the IDEM criteria and indicators, encompassing a critical appraisal of the sets of indicators and the compilation of all data sheets characterizing those indicators (IDEM Project, 2019c). The proposed structure of the data sheets was designed taking into account different ideas and proposals already existing in the literature (HELCOM, 2012b; ICG-COBAM, 2013; DEVOTES Project, 2014; European Commission, 2017).

As mentioned above, the IDEM 3.2 Database of indicators is organized in two main sections. Part A contains a summary and a general assessment of the indicators' sets analysing the dimensions of each descriptor's catalogue and highlighting the number of novel indicators and criteria and the number of indicators and criteria shared between descriptors. The general assessment provides an overview of the main deficiencies showing the evaluation parameters with the lowest scores. This analysis enabled the identification of the areas where indicators fail more, and guided the identification of indicators' features that had to be improved. Individual parameters could also be revised separately in order to figure out which descriptors gathered the lowest scores. Part B of the database is filled with the complete sets of indicators organized per descriptor and per criterion. An overview introduces each descriptor. The initial summary contains a table with all indicators listed and linked to their individual data sheets and a graph illustrating the performance of the indicators' set in the evaluation process. If novel criteria have been developed for a descriptor, a brief definition of them is also provided in the introductory overview. Subsequently, all data sheets related to the descriptor are added, duly organized per criteria. All data sheets have the same structure and sections, which are filled with the characteristics of each indicator. The data sheet encompasses firstly a spie chart to summarize evaluation scores. The rest of the content is divided in three main sections, namely (i) a general description of the indicator, (ii) technical considerations for its application, and (iii) suggestions for further work and additional considerations.

3. DESCRIPTOR-SPECIFIC RESULTS

The third chapter of the deliverable provides a brief description of the indicators' evaluation outcomes and a summary of the final sets for each descriptor. The aim of this section is to provide an overview of Task 3.2 results. Details regarding the results of each step are provided in the two supporting documents. The evaluation of each set of indicators is available in the descriptor-specific spreadsheets attached to chapter 3.12: Evaluation process spreadsheets. Accurate definitions of each selected indicator are displayed as data sheets in Task 3.2 Database of the IDEM criteria and indicators (IDEM Project, 2019c).

An illustrated summary of the dimensions of the sets compiled for each descriptor is available in Figure 3. The graph presents the number of indicators selected for each descriptor differentiating between existing indicators and the novel ones described within the IDEM project. In order to depict the existing interrelations between descriptors, the stacked columns graphs use two different colours, blue for descriptor-specific indicators (D-specific) and grey for indicators shared and/or adopted between descriptors. Adopted indicators are the ones compiled and evaluated for a given descriptor, which were applied to another one without any further modification/evaluation required. The shared indicators are those equally proposed, evaluated and selected for several descriptors. Details and identification of shared/adopted indicators for each descriptor are available within the tables placed in each descriptor-specific subsection and in Task 3.2 Database document (IDEM Project, 2019c).

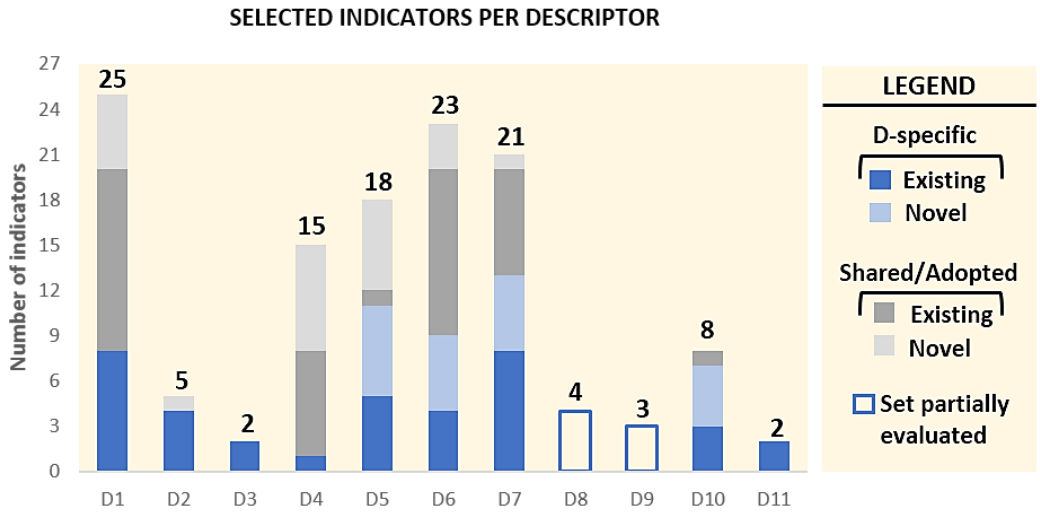

Figure 3. Stacked columns graph displaying the number of indicators selected for each descriptor specifying the existing indicators, obtained from literature (in dark blue and grey colours) and the novel indicators formulated within the IDEM project (in light blue and grey colours). The stacked columns also allow differentiating between descriptor specific indicators (D-specific) in dark and light blue and indicators shared and adopted between descriptors in dark and light grey. The total number of indicators selected per descriptor is stated at the top of each column. D8 and D9 columns are displayed without filling since the evaluation process of the indicators was completed for only one indicator each. Thus, the set illustrated for D8 and D9 is partially evaluated. For details regarding each descriptor set of indicators see Task 3.2 Database document (IDEM Project, 2019c).

As illustrated by Figure 3 the descriptor with the highest number of indicators is D1, followed by D6 and D7. It should be taken into account that D1 and D6 encompass multiple topics and are tightly interrelated with other descriptors, leading to an increased number of shared/adopted indicators. The connexions of D4 with D1, D5 and D6 foster a set of indicators composed by mostly shared indicators. Although D5 also shares a significant amount of indicators with D4, it also encompasses an important number of specific indicators. The same occurs with D7 where

almost half of the set is adopted from D6, even though the number of specific indicators is also substantial. Four specific indicators, obtained by merging existing indicators from two databases (ActionMed database 2017; DEVOTool database, 2017) compose the D2 set of indicators. One shared indicator from D6 was incorporated to the set to highlight the importance of pelagic-benthic interrelations for D2. The sets for D3 and D11 contain only two indicators since the compiled initial pool consisted exclusively of the official MSFD criteria and indicators (European commission, 2011, 2017). D8 and D9 sets of indicators are filled also with official MSFD criteria and indicators only (European Commission, 2011; Borja et al., 2013). The evaluation process of the indicators was solely completed for one indicator in D8 and D9. Thus, in order to outline the partial evaluation of the sets, Figure 3 represents D8 and D9 stacked columns without filling. Finally, D10 set is also quite reduced, encompassing seven descriptor specific indicators with only one shared indicator with D6. Limited knowledge and data scarcity, together with the recent acknowledgment of this pressure, are the main reasons behind the low number of available indicators and the high proportion of novel ones for D10.

In the following subsections a summary of the outcomes obtained for each descriptor is presented. The outline contains a brief descriptive text revising the main characteristics of the selected set. Firstly, the fulfilment of all management objectives and the strongest and weakest points of the set are reviewed. The outline also specifies for each set the novel criteria and/or indicators incorporated and whether the set contains indicators also applied for other descriptors. Finally, a paragraph regarding the identification of promising indicators and its relevance in future monitoring programs is presented at the end. After the brief summary, a table containing all the indicators selected for a given descriptor is provided.

3.1 DESCRIPTOR 1

The final outcome of Task 3.2 for D1 consists of eight indicators that are relevant for monitoring the objectives described in Step 1 themes “Species groups of birds, mammals, reptiles, fish and cephalopods” (criteria D1C1 to D1C5) and “Pelagic habitat” (criterion D1C6), which relate only to D1 (Table 1). In addition, seven indicators from D6 relevant for monitoring the objectives of the theme “Benthic habitats”, related to D1 and D6 and represented by D6C4 and D6C5 criteria were incorporated into the set. Ten indicators from D4 criteria (D4C1-D4C4) were also included in the set in order to target the monitoring objectives of the theme “Ecosystems, including food webs”, relating to both D1 and D4. The addition of these adopted indicator to the set of D1 is illustrated in Table 1 in white. The adopted indicators are treated in more detail under D6 and D4 chapters of Task 3.2 Database (IDEM Project, 2019c).

The selected set of D1-specific indicators covers all the D1-specific criteria (i.e. D1C1 to D1C6), with 1 or 2 indicators per criterion. The main weaknesses revealed by the evaluation of the selected indicators are the lack of data, the absence of monitoring programmes that could generate such data, and the high costs associated with obtaining such data. Consequently, there is a significant lack of thresholds and reference conditions for practically all indicators. On the other hand, the evaluation revealed a robust scientific basis and ecosystem relevance of the

selected indicators. They were also considered to have a wide spatio-temporal applicability, good responsiveness, and a potential implementation with the available monitoring methodologies.

As already indicated, besides the eight D1-specific indicators, an additional set of 17 indicators relevant for D1 are shared with D4 or D6, highlighting the interconnections between these three descriptors in terms of benthic habitats and ecosystems. D1, being focused on the ecosystem elements, does not share any indicator with descriptors 2, 3, 5, 7-11, which are linked to specific anthropogenic pressures.

Finally, it should be noted that the formulation of the D1-specific indicators is rather broad, referring to parameters that could be monitored "for selected species". This resulted from the lack of indicators focused on the deep sea or deep-sea species; most existing indicators were either formulated in broad terms without reference to particular species, or else referred exclusively to shallow-water biota mainly impacted by a specific (and not directly applicable) anthropogenic pressure. The lack of data on deep-sea species and pelagic habitats precludes formulation of the indicators in more specific terms. The next step in terms of implementation of the selected descriptor 1 indicators is therefore further development of the selected indicators in order to select the species that could be targeted through monitoring programmes.

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D1_I1	Species distributional range	STATE	D1C4, D1C4.G1, D1C2-4.G1, D1C2-4.G2, D1C2-4.G3, D1C2-4.G4, D1MT.G1, D1MT.G2, D1MT.G3, D1HS.G1, D1HS.G2
IDEM_D1_I2	Species distributional pattern within the range	STATE	D1C4, D1C4.G1, D1C2-4.G1, D1C2-4.G2, D1C2-4.G3, D1C2-4.G4, D1MT.G1, D1MT.G2, D1MT.G3, D1HS.G1, D1HS.G2
IDEM_D1_I3	Species bathymetric range	STATE	D1C4, D1C4.G1, D1C2-4.G1, D1C2-4.G2, D1C2-4.G3, D1C2-4.G4, D1MT.G1, D1MT.G2, D1MT.G3, D1HS.G1, D1HS.G2
IDEM_D1_I4	Population abundance and/or biomass, as appropriate	STATE	D1C1, D1C2, D1C1.G1, D1C1.G2, D1C1.G3, D1C1.G4, D1C2-4.G1, D1C2-4.G2, D1C2-4.G3, D1C2-4.G4, D1MT.G1, D1MT.G2, D1MT.G3, D1HS.G1, D1HS.G2
IDEM_D1_I5	Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival /mortality rates)	STATE	D1C1, D1C3, D1C1.G1, D1C1.G1, D1C1.G2, D1C1.G3, D1C1.G4, D1C2-4.G1, D1C2-4.G2, D1C2-4.G3, D1C2-4.G4, D1C3.G1, D1C3.G2, D1C6.G1, D1C6.G2, D1C6.G3, D1MT.G1, D1MT.G2, D1MT.G3, D1HS.G1, D1HS.G2

IDEM_D1_I6	Habitat distributional range/area for selected species (fish/cephalopods)	STATE	D1C5, D1C5.G1, D1C5.G2, D1MT.G1, D1MT.G2, D1MT.G3, D1HS.G1, D1HS.G2
IDEM_D1_I8	Habitat distributional pattern for selected species (fish/cephalopods)	STATE	D1C5, D1C5.G1, D1C5.G2, D1MT.G1, D1MT.G2, D1MT.G3, D1HS.G1, D1HS.G2
IDEM_D1_I13	Pelagic habitats Relative proportions (abundance/biomass ratio) of selected species, taxa, and functional groups	STATE-IMPACT	D1C6, D1C6.G1, D1C6.G2, D1C6.G3, D1MT.G1, D1MT.G2, D1MT.G3, D1HS.G1, D1HS.G2
IDEM_D4_I1	Composition and relative proportions of ecosystem components (habitats and species) (MSFD 1.7.1).	STATE	D4C1; D4C2; D4C2.G1; D4C2.G2; D4C2.G3; D4C2.G1; D4C2.G2; D4C2.G3.
IDEM_D4_I2	Composition and relative proportions of higher, intermediate and lower trophic levels; (NEW)	STATE	D4C1, D4C2; D4C1.G1; D4C1.G2; D4C1.G3.
IDEM_D4_I3	Abundance and taxonomic composition of microbial communities in the water column (NEW)	STATE	D4C1; D4C2; D4C1.G1; D4C1.G2; D4C1.G3; D4C2.G1; D4C2.G2; D4C2.G3.
IDEM_D4_I4	Abundance and taxonomic composition of microbial communities in the sediments (NEW)	STATE	D4C1; D4C2; D4C1.G1; D4C1.G2; D4C1.G3; D4C2.G1; D4C2.G2; D4C2.G3.
IDEM_D4_I6	Abundance/distribution of key trophic groups/species (MSFD 4.3.)	STATE	D4C2; D4C6; D4AG.G1; D4HS.G1; D4C2.G1; D4C2.G2; D4C2.G3; D4AG.G1; D4HS.G1
IDEM_D4_I7	Abundance trends of functionally important selected groups/species (MSFD 4.3.1).	STATE	D4C2; D4C6; D4C2.G1; D4C2.G2; D4C2.G3
IDEM_D4_I8	Proportion of selected species at the top of food webs (MSFD 4.2.)	STATE	D4C3; D4C3.G1; D4C3.G2; D4C3.G3
IDEM_D4_I9	Large fish (by weight) (MSFD 4.2.1)	STATE	D4C3; D4C3.G1; D4C3.G2; D4C3.G3
IDEM_D4_I11	Performance of key predator species using their production per unit biomass (productivity) (MSFD 4.1.1).	STATE	D4C4; D4C3.G1; D4C4.G2; D4C4.G3
IDEM_D4_I12	Performance of key trophic component at higher, intermediate and lower trophic levels; (NEW)	STATE	D4C4; D4C3.G1; D4C4.G2; D4C4.G3
IDEM_D6_I1	Type, abundance, biomass and areal extent of relevant biogenic substrate (MSFD 6.1.1)	STATE	D6C3-C5 D6C3-C5.G1, D6C3-5.G3, D6HS.G1, D6HS.G2, D6HS.G3

IDEM_D6_I19	Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species (MSFD 6.2.2)	STATE	D6C3-C5, D6C6 D6HS.G1, D6HS.G3, D6C3-C5.G1, D6C3-C5.G3, D6AG.G1, D6MT.G4
IDEM_D6_I21	Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community (MSFD 6.2.4)	STATE	D6C3-C5, D6HS.G1, D6HS.G3, D6C3-C5.G1
IDEM_D6_I23	Community change: spatial extent of the change and community parameters (abundance, biomass, diversity, composition)	STATE-IMPACT	D6C3-C5, D6C8 D6C3-C5.G3, D6HS.G1, D6HS.G2, D6HS.G3
IDEM_D6_I29	Biological traits analysis for ecosystem functioning and anthropogenic impact responses. Changes in functional traits	STATE-IMPACT	D6C3-5, D6C6, D6C8 D6C3-C5.G1, D6C3-C5.G3, D6HS.G3
IDEM_D6_I30	Regional connectivity: changes in turnover of community composition (beta-diversity) and average species richness (alpha-diversity)	STATE	D6C6, D6C7, D6C8 D6C3-C5.G1, D6C3-C5.G3, D6C3-C5.G4, D6HS.G3, D6MT.G4
IDEM_D6_I32	Identification of the interrelations between benthic and pelagic habitats	STATE	D6C6, D6C7, D6C8 D6C3-C5.G1, D6C3-C5.G4, D6MT.G4

Table 1. Set of indicators selected within IDEM Task 3.2 for D1. The set includes D1-specific indicators (in black) and D4 and D6 indicators that are also relevant for D1 (in white). Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v2_D1).

3.2 DESCRIPTOR 2

The final outcome of Task 3.2 for D2 consists of a selection of 5 indicators, described in Table 2. The indicators enable targeting the three criteria defined in the last MSFD update (European Commission, 2017). The set is quite reduced and highly circumscribed by the lack of monitoring programs of NIS in the deep Mediterranean Sea. Indicator IDEM_D6_I32 was adopted from D1 in order to highlight the importance of the connection between shelf and upper water column ecosystems with deep-sea habitats. Accordingly, most impacts and pressures occurring on the shelf and upper water systems affect deep-sea habitats and processes. Thus, this descriptor and its indicators refer to both the seabed and the deep-water column biota in acknowledgment of the strong connectivity between the pelagic and demersal part of the life history of many species.

The evaluation of the set of indicators exposes their stronger points and main weaknesses. The lack of thresholds is one of the most important deficiencies, together with the low specificity of the indicators' targets. This is due to the scarcity of knowledge regarding NIS impacting the deep-sea and the lack of monitoring programs focused in the deep Mediterranean Sea. The strongest point of the set was methodology, since methods and technologies are already available and implemented from shallow waters studies.

Regarding interrelations with other descriptors, D2 is connected to nearly all MSFD descriptors. Its influence on biodiversity (D1) encompasses the possible incorporation of NIS to local assemblages where they might outcompete native species and other impacts on local habitats causing an alteration of the biodiversity (Goren and Galil, 2005; Sala et al., 2011). Regarding D3, NIS already constitute commercially important fish and shellfish resources in the Eastern Mediterranean Basin replacing native species in some cases. For instance, Erythrean penaeid prawns replaced the native *Penaeus kerathurus* and Erythrean mullids have partially replaced native mullids (Goren and Galil, 2005; Stern et al., 2014). As expected from the two last interrelations, NIS also impact the local food web influencing D4 GES (Goren et al., 2016; Gilaad et al., 2017). Some pressure-based descriptors like D5 and D7 are connected to D2 by fostering the establishment and/or the dispersion and delivery of NIS. Eutrophic zones are prone to establishment of NIS (van Tussenbroeak et al., 2016; Guarnieri et al., 2017). Alterations of the hydrographical conditions and processes such as oceanic currents affect the delivery of propagules, including NIS (Jaspers et al., 2018; Rech et al., 2018). Additionally, pressures and impacts encompassed within D6 such as maritime infrastructures or damaged and eroded seafloor also influence D2 by enabling the establishment of NIS (Bulleri and Airoldi, 2005; Airoldi and Bulleri, 2011; Innocenti et al., 2017). Finally, D8 and D10 impacts may foster NIS establishment. Highly polluted zones are prone to NIS invasions (Piola and Johnston, 2009; Crooks et al., 2011; Guarnieri et al., 2017) and litter has been proven as a significant vector of NIS introduction, both on chronic and catastrophic scales (Carlton et al., 2017, 2018; Rech et al., 2018; Ivkić et al., 2019).

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D2_I1	Rate of arrival of new NIS [= Number of new NIS recorded per defined time-period]	PRESSURE	D2C1, D2C1-3.G1
IDEM_D2_I2	Trends in the abundance of NIS (especially invasive ones) [i.e. Abundance changes with time]	PRESSURE	D2C2, D2C1-3.G1
IDEM_D2_I3	Trends in the spatial extent of NIS (especially invasive ones) [Change in spatial extent over time]	PRESSURE	D2C2, D2C1-3.G1
IDEM_D2_I4	Relative proportion (abundance/biomass ratio) of NIS and native species (in selected well-known taxonomic groups)	PRESSURE-IMPACT	D2C3, D2C1-3.G1

IDEM_D6_I32	Identification of the interrelations between benthic and pelagic habitats	STATE	D6C6, D6C7, D6C8 D6C3-C5.G1, D6C3-C5.G4, D6MT.G4

Table 2. Set of indicators selected within IDEM Task 3.2 for D2. The set includes D2-specific indicators (in black) and one D6 indicator that is also relevant for D2 (in white). Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v2_D2).

3.3 DESCRIPTOR 3

The final outcome of Task 3.2 for D3 consists of a selection of three indicators enabling the monitoring of all the criteria listed in Table 3. Aside from assuring at least one indicator for each criterion, all the gaps identified were also supplemented for each of them.

The main deficiency in the indicators' set is that many deep-water fishery resources are shared with non-EU countries, which may lead to lack of quantitative data needed for sound stock assessments as well as for calculating specific indicators (e.g. biomass index trend). Lack of thresholds is also an important deficiency. The strong point of the indicators is that they can provide a direct idea of the distance between the status quo and the target foreseen by each MS. In any case, the scientific and management basis, as well as the ecosystem relevance of the indicators, are fully demonstrated. Additionally, the set could be defined as highly cost-effective, as the indicators corresponding to the first two criteria are already in use within the Common Fishery Policy (CFP) and the GFCM. The last criteria describing the demographic status of commercial species is more problematic, as there is no established methodology or agreed metrics to compute the indicator to this day, even though there are data available.

After the evaluation process, two indicators were classified as fully operational, whereas the third one still requires methodological development and scientific consensus. Data availability and monitoring is certainly sufficient in most instances but the computation of the two first indicators required analytical stock evaluations and longer time series, both of which are not often available in the deep environment. In order to improve this situation for the next MFSD evaluation, more stock evaluations should be carried out on deep-sea species. Those often require to be backed by biological studies to better understand and describe the species life cycle and population dynamics.

The indicators of D3 are very specific for exploited species monitoring and generally present few interconnections with other descriptors, although trophic cascade alterations and by-catch species mortality is expected. Accordingly, interrelations with D4 and D1, respectively, should be considered.

D3 does not require novel criteria/indicators in the framework of MFSD deep-sea assessment in the Mediterranean Basin.

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D3_I1	Fishing mortality (MSFD 3.1.1).	IMPACT	D3C1, D3C1.G5, D3C1.G6
IDEM_D3_I2	Spawning Stock Biomass, SSB (MSFD 3.2.1)	STATE	D3C2, D3C2.G7, D3C2.G8
IDEM_D3_I3	Demographic characteristics	STATE	D3C3, D3C3.G9

Table 3. Set of indicators compiled within IDEM Task 3.2 for D3. The two first indicators have been selected while the third one is classified as promising. Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v2_D3).

3.4 DESCRIPTOR 4

The outcome of Task 3.2 for D4 is expressed by 22 indicators, which may allow monitoring all the objectives described in Step 1 Table 4). The different criteria encompass a diverse number of indicators, from 1 to 6, depending on the number of targets that need to be addressed. Each criterion was filled out with at least one indicator and, in general, all the gaps identified as objectives have been supplemented with at least one indicator.

During the evaluation process, the main strengths and weaknesses of the indicators stand out. As for the other descriptors, scarcity/absence of data and thresholds are the most important lacks. The scientific basis and ecosystem relevance of the indicators was completely confirmed. Further, the set of indicators proposed is considered cost-effective and widely applicable at all spatial and temporal scales.

Regarding novel criteria and indicators, we propose two criteria to be added to the current D4 frame (D4C5 and D4C6). Also, eight new indicators are formulated and described based on the existing ones or on relevant literature (IDEM_D4_I2, IDEM_D4_I3, IDEM_D4_I4, IDEM_D4_I12, IDEM_D4_I14, IDEM_D4_I20, IDEM_D4_I21 and IDEM_D4_I22). The targets of the new criteria and indicators respond to either overlooked indications of the state of the food web or to other issues identified as gaps in Deliverable 3.1 (IDEM Project, 2019a). Descriptions of the new criteria and indicators are available within the D4 chapter of the database (IDEM Project, 2019c).

As for other descriptors, D4 involves indicators that are suitable for the monitoring of other descriptors, mirroring the strict relationship among some of them and, specifically, with the other two “state” descriptors, D1 and D6, and also with D5. Explicitly, D4 shares five indicators with D5 and one (IDEM_D4_I14) with D5 and D6 (see Table 4, indicators in italics). Additionally, ten D4 indicators are also relevant for D1 (see Table 1). Details regarding the shared individual indicators and the used equivalent codes are provided in the database (IDEM Project, 2019c).

After the evaluation process, two indicators were classified as promising instead of being rejected. Promising indicators are defined as indicators that cannot be used at present but have high potential for future application. Since most of these indicators cannot be currently applied due to data insufficiency or limited monitoring possibilities, they are quite common in deep-sea focused sets of indicators. Their application should be considered in future assessments and monitoring programs when more suitable methods, data and knowledge are available. Both of these two indicators are state-related and consider, respectively, the connectivity between higher, intermediate and lower trophic levels (IDEM_D4_21) and the relative weight of those three trophic levels (IDEM_D4_10). Specifically, IDEM_D4_10 reached a high score (9.5) as it is essentially related to ecosystem functioning, a strong reason to claim for its further development and implementation.

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D4_I1	Composition and relative proportions of ecosystem components (habitats and species) (MSFD 1.7.1).	STATE	D4C1; D4C2; D4C2.G1; D4C2.G2; D4C2.G3; D4C2.G1; D4C2.G2; D4C2.G3.
IDEM_D4_I2	Composition and relative proportions of higher, intermediate and lower trophic levels; (NEW)	STATE	D4C1, D4C2; D4C1.G1; D4C1.G2; D4C1.G3.
IDEM_D4_I3	Abundance and taxonomic composition of microbial communities in the water column (NEW)	STATE	D4C1; D4C2; D4C1.G1; D4C1.G2; D4C1.G3; D4C2.G1; D4C2.G2; D4C2.G3.
IDEM_D4_I4	Abundance and taxonomic composition of microbial communities in the sediments (NEW)	STATE	D4C1; D4C2; D4C1.G1; D4C1.G2; D4C1.G3; D4C2.G1; D4C2.G2; D4C2.G3.
IDEM_D4_I6	Abundance/distribution of key trophic groups/species (MSFD 4.3.)	STATE	D4C2; D4C6; D4AG.G1; D4HS.G1; D4C2.G1; D4C2.G2; D4C2.G3; D4AG.G1; D4HS.G1
IDEM_D4_I7	Abundance trends of functionally important selected groups/species (MSFD 4.3.1).	STATE	D4C2; D4C6; D4C2.G1; D4C2.G2; D4C2.G3
IDEM_D4_I8	Proportion of selected species at the top of food webs (MSFD 4.2.)	STATE	D4C3; D4C3.G1; D4C3.G2; D4C3.G3
IDEM_D4_I9	Large fish (by weight) (MSFD 4.2.1)	STATE	D4C3; D4C3.G1; D4C3.G2; D4C3.G3
IDEM_D4_I11	Performance of key predator species using their production per unit biomass (productivity) (MSFD 4.1.1).	STATE	D4C4; D4C3.G1; D4C4.G2; D4C4.G3
IDEM_D4_I12	Performance of key trophic component at higher, intermediate and lower trophic levels; (NEW)	STATE	D4C4; D4C3.G1; D4C4.G2; D4C4.G3

IDEM_D4_I13	Presence of particularly sensitive and/or tolerant species (MSFD 6.2.1)	STATE	D4C6; D4AG.G2
IDEM_D4_I14	Changes in functional traits. Ratio of functional traits (e.g. suspension feeders/ scavengers biomass ratio) (NEW)	STATE /IMPACT	D4C5, D4C6; D4AG.G1; D4AG.G2
IDEM_D4_I20	Quantity of sedimentary organic matter (NEW)	STATE /IMPACT	D4C6; D4AG.G1; D4HS.G3
IDEM_D4_I21	Biochemical composition of sedimentary organic matter (NEW)	STATE	D4C6; D4AG.G1; D4HS.G3
IDEM_D4_I22	Bioavailability of sedimentary organic matter (NEW)	STATE	D4C6; D4AG.G1; D4HS.G3

Table 4. Set of indicators selected within IDEM Task 3.2 for D4. Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v1_D4). The codes written in italics represent the indicators shared with other descriptors.

3.5 DESCRIPTOR 5

The outcome of Task 3.2 for D5 consists of a selection of 18 indicators enabling the monitoring of all the objectives described in Step 1 (Table 5). The different criteria encompass a variable number of indicators, from 1 to 4, depending on the number of targets that need to be addressed. Each criterion was filled with at least one indicator and, in general, all gaps identified as objectives have been supplemented with at least one indicator.

During the evaluation process, the stronger points and the main weaknesses of the indicators stood out. Precautionary capacity, thresholds and the scarcity/absence of data are the main lacks. Apart from these gaps, the scores of the remaining evaluation parameters are all quite high, thus pointing to a set of indicators characterized by high scientific basis, cost-effectiveness, ecosystem relevance and target suitability. The indicators are not redundant, and are sustained by a well-defined and scientifically performing methodology in term of sensitivity and robustness of the results. Additionally, the proposed set of indicators could be considered cost-effective and widely applicable at different spatial and temporal scales.

Among with the original criteria of the MSFD, some have been excluded because of their inapplicability to the deep sea as they have been defined. This has been balanced by the outcomes of IDEM Tasks 3.1 and 3.2, which led to the formulation of novel criteria and indicators encompassing important topics that are disregarded in the current MSFD frame.

Concerning novel criteria and indicators, we propose five new criteria to be added to the current D5 frame, together with thirteen new indicators that have been formulated and described based on existing ones or on relevant literature. The five novel criteria focus in the following disregarded issues: microbial communities, quantity and quality of organic matter, ecosystem

functioning, blooms, and episodic events and ecosystem response (D5C9, D5C10, D5C11, D5C12 and D5C13, respectively). The thirteen novel indicators are proposed for D5 in order to generate a set of indicators targeting the defined objectives. Seven of the novel indicators fill the gaps identified within the existing MSFD criteria (i.e. IDEM_D5_I3, 4, 5, 6, 7, 9 and 11). The remaining six novel indicators (i.e. IDEM_D5_I18, 19, 20, 21, 22, 23 and 28) directly related to the new criteria are postulated to cover targets that are unconsidered within the current MSFD frame for D5. Descriptions of the new criteria and indicators are available within D5 chapter of Task 3.2 Database (IDEM Project, 2019c).

There are indicators reported under D5 frame that are suitable for the monitoring of other descriptors, such as D1, D4 and D6, thus underlining once more the strict relationship among them. Specifically, D5 shares five indicators (IDEM_D5_I18, 19, 20, 21 and 22) with D4, one with D4 and D6 (IDEM_D5_I23) and one with D6 (IDEM_D5_I6). Two of the shared indicators with D4 (IDEM_D5_I18 and 19) and one of the shared with D6 (IDEM_D5_I23) were adopted in the D1 set (Table 1, under the codes set from D4 and D6). Table 5 presents shared indicators in italics. Details regarding shared individual indicators and the equivalent codes used are provided in the database (IDEM Project, 2019c).

After the evaluation process, two indicators have been classified as promising instead of being rejected. Promising indicators are defined as those that cannot be used at present but have high potential for future application. These indicators cannot be currently applied due to data insufficiency or limited monitoring possibilities. Their application should be considered in future assessments and monitoring programs when more suitable methods, data and knowledge are available. The first promising indicator (IDEM_D5_6) is related to spatial and temporal distribution of blooms. The second one (IDEM_D6_7) focuses in the presence of cysts of harmful algae in sediments. Considering that water column processes are crucial for deep-sea ecosystems and that the deep-sea sediments can be repositories of cysts of harmful algae, their further development and implementation should be fostered.

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D5_I1	Nutrient concentration in the water column (MSFD 5.1.1)	STATE - PRESSURE	DC5C1, D5C1_G4, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I2	Nutrient ratios (silica, nitrogen and phosphorus), where appropriate* (MSFD 5.1.2)	STATE - PRESSURE	DC5C1, D5C1_G4,[D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I3	Nutrient concentration in the sediment	STATE - PRESSURE	DC5C1, D5C1_G4,[D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3,

			D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I4	Nutrient ratios in the sediment, where appropriate	STATE-PRESSURE	DC5C1, D5C1_G4, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I5	Concentration of chlorophyll-a in the sediment	STATE	D5C2, D5C1 - 8.G3,[D5C1 -8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I6	Spatial and temporal distribution of blooms and other episodic events in the upper water column as sources of matter and energy to the deep seafloor	STATE-IMPACT	D5C3, D5C12, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I7	Presence of cyst of harmful algae in the sediments	STATE	D5C3, D5AG.G2, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I8	Dissolved oxygen in the bottom of the water column (MSFD 5.3.2)	STATE	D5C5, D5AG.G3, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I9	Oxygen concentration in the sediments	STATE	D5C5, D5AG.G3, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I10	Abundance and taxonomic composition of macrofaunal communities of benthic habitats	STATE	D5C5, D5C8, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I11	Abundance and taxonomic composition of meiofaunal communities	STATE	D5C5, D5C8, D5AG.G4, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I18	Abundance and composition of microbial communities in the water column	STATE	D5C9, D5AG.G6, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]

IDEM_D5_I19	Abundance and composition of microbial communities in the sediments	STATE	D5C9, D5AG.G6, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I20	Quantity of the sedimentary organic matter	STATE-IMPACT	D5C10, D5AG.G5, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I21	Biochemical composition of the sedimentary organic matter	STATE	D5C10, D5AG.G5, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I22	Bioavailability of sedimentary organic matter	STATE	D5C10, D5AG.G5, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I23	Changes in functional traits. Ratio of functional traits (e.g. filters/scavengers biomass ratio)	STATE - IMPACT	D5C11, D5C13, D5C5, D5C8, D5AG.G4, D5C9, D5AG.G6, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]
IDEM_D5_I28	Presence of particularly sensitive and/or tolerant species (MSFD 6.2.1)	STATE-IMPACT	D5C13, [D5C1 - 8.G1, D5C1 - 8.G2, D5C1 - 8.G3, D5AG.G1, D5GG.G1, D5BG.G1, D5HS.G1, D5HS.G2, D5HS.G3, D5MT.G1, D5MT.G2, D5MT.G3, D5MT.G4]

Table 5. Set of indicators selected within IDEM Task 3.2 for D5. Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v1_D5). The codes written in italics represent the indicators shared with other descriptors.

3.6 DESCRIPTOR 6

The final outcome of Task 3.2 for D6 consists of a selection of 23 indicators enabling the monitoring of all objectives described in Step 1 (Table 6). The different criteria encompass a diverse number of indicators, from 4 to 12, depending on the number of targets that need to be addressed. Apart from assuring that each criteria is filled with enough indicators, all gaps identified as objectives have been supplemented with at least one indicator.

During the evaluation process, the stronger points and the main weaknesses of the indicators stood out. As expected, lack of data and thresholds were the most important deficiencies. Apart

from these, the scientific basis and ecosystem relevance of the indicators is fully demonstrated. Additionally, the set could be defined as highly cost-effective and widely applicable in all spatial and temporal scales.

Regarding novel criteria and indicators, three criteria are proposed to be added to the current D6 frame (D6C6, D6C7 and D6C8) together with eight new indicators that have been formulated and described based on existing ones or on relevant literature (IDEM_D6_I8, 9, 11, 14, 16, 17, 31 and 32). The targets of the new criteria and indicators are either overlooked pressures or other issues formulated as gaps in Deliverable 3.1. The three novel criteria (D6C6, D6C7 and D6C8) focus, respectively, in the three following disregarded issues: ecosystem functioning; blooms, episodic events and ecosystem response; and resilience and remediation potential. Descriptions of the new criteria and indicators are available within the D6 chapter of Task 3.2 Database document (IDEM Project, 2019c).

The number of indicators of D6 that are also applied to the monitoring of other descriptors reflects existing interconnections and are worth highlighting. Specifically, D6 shares two indicators with D4 and D5 (IDEM_D6_I29 and 31) and one with D10 (IDEM_D6_I6). Additionally, seven D6 indicators have been adopted by D1 and eight by D7 (see Tables 1 and 7, respectively). Details regarding individual shared indicators and the equivalent codes used are provided in the database (IDEM Project, 2019c).

Finally, after the evaluation process, four indicators have been classified as promising instead of being rejected. Promising indicators are defined as indicators that cannot be used at present but have high potential for future applications. These indicators cannot be currently applied due to data insufficiency or limited monitoring possibilities, as commonly occurs in deep-sea focused sets of indicators. Their application should be considered in future assessments and monitoring programs when more suitable methods, data and knowledge are available. Regarding D6, four promising indicators have been identified. Three (IDEM_D6_7, IDEM_D6_I12 and IDEM_26_I28) are related to pressures and impacts, including fishing gear, hydrocarbon-related activities and waste accumulation sites. The fourth one (IDEM_D6_I15) focuses in a general description of sea-floor stability. Whereas all of these indicators could be useful for assessing deep sea systems, the one targeting the impacts of hydrocarbon exploration and production activities (IDEM_26_I28) and the one centred on monitoring the potential recovery after waste disposal events (IDEM_D6_I12) are much needed. Therefore, their further development and implementation should be fostered.

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D6_I1	Type, abundance, biomass and areal extent of relevant biogenic substrate (MSFD 6.1.1)	STATE	D6C3-C5 D6C3-C5.G1, D6C3-5.G3, D6HS.G1, D6HS.G2, D6HS.G3
IDEM_D6_I3	Extent of the seabed significantly affected (permanent change) by human activities for the different substrate types (MSFD 6.1.2)	IMPACT	D6C1, D6C2 D6C1.G1, D6C1.G2, D6C1.G3, D6C1.G4, D6C1.G5, D6AG.G1

IDEM_D6_I5	Size of area exposed to pressures known to alter substrate	PRESSURE	D6C1, D6C2 D6C1.G1, D6C1.G2, D6C1.G3, D6C1.G4, D6C1.G5, D6AG.G1
IDEM_D6_I6	Distribution and aggregation (intensity) of fishing activities. Footprint per unit of landings	PRESSURE	D6C1, D6C2 D6C1.G1, D6AG.G1
IDEM_D6_I8	Number and location of artificial hard structures installed in the deep Mediterranean Sea for hydrocarbon exploration and exploitation activities	PRESSURE	D6C1, D6C2 D6C1.G2, D6AG.G1
IDEM_D6_I9	Distribution and aggregation of direct physical damage and disturbance during and after hydrocarbon exploration and exploitation activities	IMPACT	D6C1, D6C2 D6C1.G2, D6AG.G1
IDEM_D6_I10	Number of artificial hard structures installed and ratio of area affected (cables and pipelines)	PRESSURE	D6C1, D6C2 D6C1.G3, D6AG.G1
IDEM_D6_I11	Distribution and aggregation of physical damages and disturbances during and after the installation (cables and pipelines)	IMPACT	D6C1, D6C2 D6C1.G3, D6AG.G1
IDEM_D6_I13	Ratio of area potentially affected by discharges of materials (waste disposal)	PRESSURE	D6C1, D6C2 D6C1.G4, D6AG.G1
IDEM_D6_I14	Number and size of the areas potentially exposed to future mining activities	PRESSURE	D6C1, D6C2 D6C1.G5, D6AG.G1
IDEM_D6_I16	Assessment of the interaction between natural factors and human-induced disturbances	STATE	D6C2, D6C6, D6C7 D6C2.G1, D6MT.G4
IDEM_D6_I17	Distribution (size of the areas) and number of bioprospecting activities	PRESSURE	D6C2, D6C3-C5, D6C2.G3, D6AG.G1
IDEM_D6_I19	Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species (MSFD 6.2.2)	STATE	D6C3-C5, D6C6 D6HS.G1, D6HS.G3, D6C3-C5.G1, D6C3-C5.G3, D6AG.G1, D6MT.G4
IDEM_D6_I21	Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community (MSFD 6.2.4)	STATE	D6C3-C5, D6HS.G1, D6HS.G3, D6C3-C5.G1
IDEM_D6_I23	Community change: spatial extent of the change and community parameters	STATE-IMPACT	D6C3-C5, D6C8 D6C3-C5.G3, D6HS.G1, D6HS.G2, D6HS.G3

	(abundance, biomass, diversity, composition)		
IDEM_D6_I24	Cumulative impacts on benthic biotopes Impact index value (anthropogenic cumulative impact)	IMPACT	D6C1, D6C2, D6C3-5 D6C1.G1, D6C1.G2, D6C1.G3, D6C1.G4, D6C1.G5, D6C3-C5.G2, D6C3-C5.G3, D6AG.G1 D6HS.G1, D6HS.G2, D6HS.G3, D6MT.G4
IDEM_D6_I25	Ecological impact of bottom trawling on the benthic community: seabed integrity, functionality and recoverability	IMPACT	D6C3-C5, D6C8 D6C1.G1, D6AG.G1, D6HS.G2, D6C3-C5.G3
IDEM_D6_I27	Benthic communities sensitivity to trawling activities	STATE	D6C3-C5, D6C8 D6C1.G1, D6AG.G1, D6HS.G2, D6C3-C5.G3
IDEM_D6_I29	Biological traits analysis for ecosystem functioning and anthropogenic impact responses. Changes in functional traits	STATE-IMPACT	D6C3-5, D6C6, D6C8 D6C3-C5.G1, D6C3-C5.G3, D6HS.G3
IDEM_D6_I30	Regional connectivity: changes in turnover of community composition (beta-diversity) and average species richness (alpha-diversity)	STATE	D6C6, D6C7, D6C8 D6C3-C5.G1, D6C3-C5.G3, D6C3-C5.G4, D6HS.G3, D6MT.G4
IDEM_D6_I31	Spatial and temporal distribution of blooms and other episodic events in the upper water column as sources of matter and energy to the deep-sea	STATE	D6C7 D6C2.G1, D6C3-C5.G4
IDEM_D6_I32	Identification of the interrelations between benthic and pelagic habitats	STATE	D6C6, D6C7, D6C8 D6C3-C5.G1, D6C3-C5.G4, D6MT.G4
IDEM_D6_I33	Ratio of area affected by changes in seafloor topography (natural 3D structure)	IMPACT	D6C1, D6C3-5.G1, D6AG.G1

Table 6. Set of indicators selected within IDEM Task 3.2 for D6. Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v1_D6). The codes written in italics represent the indicators shared with other descriptors.

3.7 DESCRIPTOR 7

The final outcome of Task 3.2 for D7 consists of a selection of 13 indicators enabling the monitoring of all the objectives described in Step 1 (Table 7). The two criteria encompass a variable number of indicators, from 10 to 13, depending on the number of targets that need to be addressed.

The indicators' scores for each parameter were summed up together to determine the main deficiencies of the entire set of indicators, mostly related to a significant lack of thresholds and reference conditions. The other two weak points refer to the precautionary capacity and to the availability of data and monitoring programs. Thus, data and threshold gaps are the main problems of indicators for D7. On the other hand, spatial-temporal applicability, specificity and acceptable levels of indicators' responsiveness are the strongest points for the set of selected indicators.

Regarding novel indicators, five of them are proposed for D7, based on existing ones or on relevant literature, in order to generate a set of indicators targeting all defined objectives. Two of these indicators focus in possible pressures and/or their impacts (e.g. hydrocarbon and mining exploration and production activities for IDEM_D7_I2, and thermal discharges for IDEM_D7_I7). The remaining three novel indicators (i.e. IDEM_D7_I12, 13 and 14) are suggested to cover issues neglected within the current MSFD frame, thus completing existing criteria. Descriptions of the new indicators are available within D7 chapter of the database (IDEM Project, 2019c).

As stated in the previous section referred to D6, eight D6 indicators are adopted by D7, thus reflecting the tight interconnections between both descriptors. Details regarding the adopted indicators are provided in the database (IDEM Project, 2019c).

Finally, after the evaluation process, one indicator has been classified as promising instead of being rejected. The indicator (IDEM_D7_I11) is related to state and impacts focusing in the size distribution of long-lived benthic species. It cannot be currently applied due to data insufficiency, but could be considered in future assessments and monitoring programs when more suitable methods, data and knowledge will be available.

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D7_I1	Extent of area affected by permanent alterations (MSFD 7.1.1) /Extent of physical damage to predominant and special habitats	IMPACT	D7C1, D7C2
IDEM_D7_I2	Impact on hydrographical conditions caused by anthropogenic activities (including hydrocarbon and mining exploration and production activities and the installation of cables and pipelines)	IMPACT	D7C1, D7C2, D7C1.G1
IDEM_D7_I3	Extent of changes in hydrographical conditions like currents, waves, bottom shear stress, salinity, pH, turbidity, chlorophyll– a concentration, dissolved oxygen, inorganic nutrients, phytoplankton and zooplankton assessed by numerical modelling	STATE	D7C1, D7C2, D7C1.G1, D7C1.G2

IDEM_D7_I4	Existence of national system of surveillance for hydrographical changes and ocean hydrodynamics, and a warning and recording system for massive and extreme events	STATE	D7C1, D7C2, D7C1.G2
IDEM_D7_I5	Percentage of environmental impact assessment studies of projects affecting marine environment contemplating hydrographical changes	STATE	D7C1, D7C2, D7C1.G1
IDEM_D7_I6	Temperature, salinity and oxygen trends in deep basins referring to long-term means	STATE	D7C1, D7C2, D7C1.G2
IDEM_D7_I7	Ratio of area potentially affected by thermal discharges	PRESSURE	D7C1, D7C2, D7C1.G1
IDEM_D7_I8	Mixing Indicator	STATE	D7C1, D7C2, D7C1.G2
IDEM_D7_I9	Spatial extent of habitats affected by the permanent alteration (MSFD 7.2.1)	IMPACT	D7C2
IDEM_D7_I10	Changes in habitats, in particular the functions provided (e.g. spawning, breeding and feeding areas and migration routes of fish, birds and mammals), due to altered hydrographical conditions (MSFD 7.2.2)	IMPACT	D7C2
IDEM_D7_I12	Chlorophyll-a concentration (as tracer for hydrographical features such as eddies, upwelling or currents)	STATE	D7C1, D7C2, D7C1.G2
IDEM_D7_I13	Early-warning signals of tipping points/indicators of tipping points	IMPACT	D7C2, D7C2.G1
IDEM_D7_I14	Frequency, intensity and location of deep water formation events: DSWC (Dense Shelf Water Cascading) and open sea convection	PRESSURE	D7C1, D7C2, D7C1.G1
IDEM_D6_I2	Natural range, area covered (and specific structure and necessary functions) of natural habitat types of community interest	STATE	D7C1, D7C2
IDEM_D6_I5	Size of area exposed to pressures known to alter substrate	PRESSURE	D7C1, D7C2
IDEM_D6_I8	Number and location of artificial hard structures installed in the deep Mediterranean Sea for hydrocarbon exploration and production activities	PRESSURE	D7C1, D7C2, D7C1.G1
IDEM_D6_I10	Number of artificial hard structures installed and ratio of area affected by cables and pipelines	PRESSURE	D7C1, D7C2, D7C1.G1
IDEM_D6_I22	Change in distribution and abundance of indicator species in priority habitats	STATE-IMPACT	D7C2
IDEM_D6_I23	Community change: spatial extent of the change and community parameters (abundance, biomass, diversity, composition)	STATE-IMPACT	D7C2

IDEM_26_I24	Cumulative impacts on benthic biotopes. Impact index value (anthropogenic cumulative impact)	IMPACT	D7C2
IDEM_D6_I29	Biological traits analysis for ecosystem functioning and anthropogenic impact responses. Changes in functional traits	STATE-IMPACT	D7C2, D7C2.G1

Table 7. Set of indicators selected within IDEM Task 3.2 for D7. The set included D7-specific indicators (in black) and D6 indicators that are also relevant for D7 (in white). Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v2_D7).

3.8 DESCRIPTOR 8

Four indicators have been determined for D8 covering the following basic points: (i) concentration levels of pollutants in sediments and biota, which should allow setting new threshold directives, now only available for coastal and shallow sea regions closer to human population settlements; (ii) effects of contaminants in organisms, with few cases reported in the literature on enzyme activities; (iii) a broader scope encompassing effects on dwelling organisms from deep-sea ecosystems, and (iv) how to react when acute pollution events occur in the open sea and their effects on deep-sea benthic communities.

Deficiencies or weaknesses of the indicators are related to the remoteness of deep-sea sites, which require expensive sampling logistics. On the other hand, the cost of reliable and sensitive analytical techniques to measure pollution levels of different chemicals in sediments and organisms is moderate.

Novel criteria may soon emerge when enough data on deep-sea pollution is available and statistically significant. So far, little data has been published on the deep Mediterranean Sea, and is scattered in time, with non-existing or not significant time series as to sparse in time.

D8 encompasses D9, which is specific for human consumption marine organisms, and maybe complementary to D10 on marine litter, which may be univocally associated with chemical pollution. As far as toxic effects of pollutants in organisms and their interaction with the sediment in deep-sea ecosystems are discovered, it may be of relevance for other IDEM descriptors too. For example, D4 (ecosystems, including food webs), D3 (populations of commercially exploited species) or even D1 (biodiversity) might be affected since pollutants might cause alterations of metabolism, reproduction and adaptability of species in the environmental conditions of the deep sea.

Indicator D8_I1, is a reference level which may give surprises when compared to more commonly studied coastal Mediterranean regions, but the most promising are D8_I2-4, which may reflect the true effect of pollutants on life forms exposed to extreme environmental conditions, such as those of the deep sea, and may consequently lead to new and highly significant knowledge. The indicators have been designed to fill the gaps described in detail in

Deliverable 3.1 (IDEM Project, 2019a) and listed in Table 8. Fulfilment will require monitoring programs that must be accommodated to each specific region and its specific technical demands.

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D8_I1	Concentration of the contaminants measured in matrices such as biota, sediment and water (MSFD 8.1.1)	STATE	D8C1, D8C2, D8C3, D8C4 D8C1.G1, D8C2.G1, D8GG.G1, D8MT.G1, D8MT.G2, D8MT.G3, D8MT.G4, D8MT.G5
IDEM_D8_I2	Effects of contaminants (MSFD 8.2)	IMPACT	D8C1, D8C2, D8C3, D8C4 D8C1.G1, D8C2.G1, D8GG.G1, D8MT.G1, D8MT.G2, D8MT.G3, D8MT.G4, D8MT.G5
IDEM_D8_I3	Levels of pollution effects on the ecosystem components concerned, having regard to the selected biological processes and taxonomic groups where a cause/effect relationship has been established (MSFD 8.2.1)	PRESSURE	D8C1, D8C2, D8C3, D8C4 D8C1.G1, D8C2.G1, D8GG.G1, D8MT.G1, D8MT.G2, D8MT.G3, D8MT.G4, D8MT.G5
IDEM_D8_I4	Occurrence, origin, extent of significant acute pollution events and their impact on biota physically affected by this pollution (MSFD 8.2.2)	IMPACT	D8C1, D8C2, D8C3, D8C4 D8C1.G1, D8C2.G1, D8GG.G1, D8MT.G1, D8MT.G2, D8MT.G3, D8MT.G4, D8MT.G5

Table 8. Set of indicators selected within IDEM Task 3.2 for D8. Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v2_D8). The set includes four indicators but the evaluation process was performed for the first one only (IDEM_D8_I1).

3.9 DESCRIPTOR 9

The three indicators listed in Table 9, two state-based and one pressure-based, have been chosen based on criterion D9C1 (contaminants listed in EC Regulation No 1881/2006) to be analysed in commercial fish and sea food species. All three indicators are suitable for its implementation in the deep Mediterranean Sea although scarcity of available data is still relevant.

Measurement of actual contaminant levels can be achieved with state of the art analytical methodology. Mercury is the most widely and intensively studied pollutant in fish, including human consumption species, but data from deep-sea is rare, but promising as indicator, as EC

levels are commonly exceeded. However, the data is scarce in space and time and frequency values cannot be obtained with sufficient confidence levels as representative of the deep-sea.

The main deficiency is of practical nature, i.e. the non-availability of statistically sound numbers of samples obtained using costly sampling equipment, while analysis cost is moderate and more affordable. The strongest points of analytically based indicators are the robustness and reliability of values obtained using state-of-the-art analytical techniques.

The three indicators are designed to cover the main gap D9C1.G1 found after the literature survey performed within IDEM, which is the lack of data on contaminants on fish in the deep Mediterranean Sea regions.

Since D9 is a subset of the broader in scope D8, focused in pollutants in deep-sea sediments and biota, its coverage does not represent a significant increase in cost or difficulties added to sampling campaigns.

Although no promising indicators have been devised specifically for D9, it will not be difficult to transfer knowledge obtained from D8, such as for indicators D8_I2-4 dealing with toxic effects of pollutants on biota, pollution levels in deep-sea ecosystem communities, and mechanisms of pollution transport to the deep sea during acute polluting events

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D9_I1	Actual levels of contaminants that have been detected (MSFD 9.1.1a)	STATE	D9C1 D9C1.G1
IDEM_D9_I2	Number of contaminants which have exceeded maximum regulatory levels (MSFD 9.1.1b)	IMPACT	D9C1 D9C1.G1
IDEM_D9_I3	Frequency of regulatory levels being exceeded (MSFD 9.1.2)	PRESSURE	D9C1 D9C1.G1

Table 9. Set of indicators selected within IDEM Task 3.2 for D9. Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v2_D9). The set includes four indicators but the evaluation process was performed for the first one only (IDEM_D9_I1).

3.10 DESCRIPTOR 10

An extensive literature review of existing and potential indicators for D10 followed by the proposal of novel ones defined within the IDEM project has been carried out in Task 3.2 as part of the above-described Steps 1 and 2. A total of 110 existing, operational, applied and/or conceptual indicators (including relevant bio-indicators) have been identified and either prioritized or rejected in function of the available knowledge, applicability and uniqueness. The final result of Task 3.2 consists of a selection of 8 indicators that meet most of the criteria and gaps identified as monitoring objectives described in Step 1. Exceptions were given to six of the gaps identified as management objectives (D10AG.G1, D10AG.G2, D10AG.G5, D10AG.G7, D10AG.G9 and D10AG.G12), which could not be satisfied by any of the selected indicators.

Steps 2 and 3 of Task 3.2 exhibit the overall research needs that should be tackled in the coming years in order to comply with the weaknesses of the selected indicators. Most of the selected indicators lack of defined baselines and thresholds. Indeed, the only litter baselines have been suggested by the UNEP/MAP Barcelona Convention (COP19 IMAP Decision IG.22/7) for seafloor macro-litter although without discrimination by depth range, particular geographical areas (e.g. basins and sub-basins), hotspots or marine provinces. The main cause is a general lack of available spatiotemporal data covering the deep Mediterranean Sea, including areas where litter may potentially accumulate (e.g. submarine canyons). The latter also applies to data regarding interactions of litter with marine organisms. Standardized methods, protocols and reporting standards have been only recently developed or are under development, thus precluding current and historical data comparability. In many cases, sampling strategies are mostly bounded to an opportunistic approach, which may increase the cost-effectiveness but hinders the acquisition of standardized and reproducible spatiotemporal seafloor data.

Within IDEM, a set of 3 novel indicators (IDEM_D10_I2, IDEM_D10_I3 and IDEM_D10_4) and 1 criterion (D10C5) has been defined for D10. Novel indicators and criteria have been considered based on relevant literature (i.e. peer-reviewed articles and project reports) or adapted from existing ones, and target some of the main gaps identified and described in Deliverable 3.1. Nonetheless, novel criteria could not be fulfilled by any of the selected indicators and should serve to encourage progress towards future knowledge concerning these topics. Descriptions of the new criteria and indicators are available within D10 chapter of the database document (IDEM Project, 2019c). One indicator formulated initially for D6 was proposed, evaluated and finally selected too for D10 (IDEM_D10_I1).

In addition to novel suggested indicators, the 4 indicators defined within the MSFD (Decision 2017/848/EC) have been also evaluated. In the aggregate, 4 pressure indicators (IDEM_D10_I1, IDEM_D10_I2, IDEM_D10_I6, and IDEM_D10_I7) and 4 impact indicators (IDEM_D10_I3, IDEM_D10_I4, IDEM_D10_I8, and IDEM_D10_I9) complete the selected pool of indicators for D10.

The selected indicators within D10 address quite specific targets but often share the same monitoring strategy and methodology with other descriptors. The main interconnections are found among descriptors 1, 2, 3, 6, 8, 9 and 11. For instance, trawling and ROVs that are used to

monitor D3 (commercial fish and shellfish) and D6 (sea-floor integrity) can be used simultaneously to monitor D10. This interconnections might foster the application of other descriptors' indicators for the monitoring of D10. Accordingly, D10 shares one indictor with D6 (IDEM_D10_I1) targeting the distribution and aggregation of fishing activities. Details regarding the shared individual indicators and the equivalent codes used are provided in the database (IDEM Project, 2019c).

Finally, after the evaluation process, one indicator was classified as promising instead of being rejected (IDEM_D10_I5). Promising indicators are defined as indicators that cannot be used at present but have high potential for future application. This particular impact-related indicator is novel in many ways as it has only been applied by some authors in particular species groups (e.g. cetaceans) and environmental matrices (e.g. biota inhabiting the upper water column). However, their application should be considered in future assessments and monitoring programs when more suitable methods, data and knowledge are available for the deep-sea.

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D10_I1	Distribution, aggregation (intensity) of fishing activities.	PRESSURE	D10C1, D10C1.G3, D10AG.G6, D10AG.G10
IDEM_D10_I2	Identification and assessment of marine "litter hotspots" focusing on relevant deep-sea habitats (e.g. coastal canyons, seamounts, banks and ridges)	PRESSURE	D10C1, D10C1.G1, D10C1.G2, D10C1.G3
IDEM_D10_I3	Habitat use of marine litter by marine animals and microbes and detection of change in ecosystem structure, if possible.	IMPACT	D10C3-4, D10AG.G3, D10AG.G8, D10HS.G1
IDEM_D10_I4	Entangled and smothered species in marine animal forests (considering different groups and ecosystem compartments)	IMPACT	D10C3-4, D10HS.G1, D10AG.G4, D10AG.G8
IDEM_D10_I6	D10C1 amount of litter per category in number of items on the coastline, for the surface layer of the water column and for the seabed, including information on the source and pathway, where feasible.	PRESSURE	D10C1, D10C1.G1, D10C1.G2, D10C1.G3, D10AG.G6
IDEM_D10_I7	D10C2 amount of micro-litter per category in number of items and weight in grams for the surface layer of the water column, and sediment for the coastline and seabed, including information on point sources, where feasible.	PRESSURE	D10C2, D10C2.G1, D10C2.G2 D10C2.G3

IDEM_D10_I8	D10C3 amount of litter/micro-litter in grams and number of items per individual for each species in relation to size (weight, length, as appropriate) of the individual sampled.	IMPACT	D10C3-4, D10C3-4.G1, D10AG.G8, D10HS.G1
IDEM_D10_I9	D10C4 number of individuals affected (lethal; sub-lethal) per species.	IMPACT	D10C3-4, D10AG.G4, D10AG.G10, D10AG.G8

Table 10. Set of indicators selected within DEM Task 3.2 for D10. Management objectives are defined in the spreadsheet used for the evaluation process (see chapter 3.12, document: Task 3.2 Evaluation process_v2_D10). The codes written in italics represent the indicators shared with other descriptors.

3.11 DESCRIPTOR 11

D11 suffers from a significant scarcity of data but, more generally, of basic knowledge in the scientific community and also within the IDEM consortium. This fact could have considerably impacted the results of Task 3.2 for D11. Consequently, the approach applied followed the same framework than the rest of descriptors but in a simpler form. The approach consisted of a questionnaire to assess each evaluation parameter (EP) for the two indicators/criteria suggested in the last update of the MSFD (European Commission, 2017). The questionnaire included at the end two brief descriptions of the indicators' performance. This contingency plans allowed as to obtain the results presented in Table 11, which are consistent with the rest of outcomes from the other descriptors. This approach permitted the evaluation of the two above-referred indicators and their description within a data sheet that is incorporated to Task 3.2 Database document (IDEM Project, 2019c).

The strongest points of the two indicators are the vast spatial-temporal applicability to the deep Mediterranean Sea and a high specificity thanks to a concrete formulation. Additionally, D11 already targets specifically and unambiguously one pressure, avoiding multiple and different interpretations. However, the lack of basic knowledge implies multiple deficiencies that might compromise the implementation of the indicators. The difficulties of establishing targets due to the data gap influence the development and standardization of potential methods. Consequently, the lack of a standard methodology hinders obtaining more data and a reliable evaluation of the impacts on ecosystems, ultimately leading to the absence of thresholds and/or reference conditions (TG Noise, 2018).

CODE	NAME	TYPE	MANAGEMENT OBJECTIVES
IDEM_D11_I1	Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that	PRESSURE	D11C1

	are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1µPa2.s) or as peak sound pressure level (in dB re 1µPapeak) at one meter, measured over the frequency band 10 Hz to 10 kHz (MSFD 11.1.1)		
IDEM_D11_I2	Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1µPa RMS: average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate (MSFD 11.2.1)	PRESSURE	D11C2

Table 11. Indicators defined in the MSFD for monitoring D11, which have been revised within IDEM Task 3.2 (see chapter 3.12, document: Task 3.2 Questionnaire_D11).

3.12 EVALUATION PROCESS SPREADSHEETS

As explained in chapter 2.2, the evaluation process of the initial pool of indicators was designed as a structured, standardized system developed within IDEM Task 3.2 and implemented through a common spreadsheet applied to each descriptor. Although the ideal evaluation process should follow the first described approach, the practical application required the generation of a second simpler version of the approach. Accordingly, each of the working groups based on expert knowledge assembled for the considered particular descriptors the two versions and chose one of them taking into account the amount of work required and the time left.

This chapter contains the spreadsheets generated for the evaluation process of each descriptor. Descriptors 1, 2, 3, 7, 8, 9 and 10 implemented the second version of the approach, whereas version 1 was applied to descriptors 4, 5 and 6. The performance of an equivalent evaluation process for D11 was dismissed due to the lack of expertise within IDEM and, more generally, data. The questionnaire filled in order to deliver at least an evaluation is also attached to this chapter.

FILES:

D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11

4. SUPPLEMENTARY INFORMATION

This chapter includes additional information and all considerations and clarifications found relevant during the process of developing and/or implementing the system designed for IDEM Task 3.2. The first subsection focuses in introducing the available knowledge regarding thresholds and reference conditions for the deep Mediterranean Sea.

4.1 KNOWLEDGE ON THRESHOLDS OF THE SELECTED INDICATORS

The identification of workable thresholds for the selected indicators is set as one of the objectives of Task 3.3. However, Task 3.2 spreadsheet for the evaluation process already includes a summary of available thresholds for the selected indicators because of to two main reasons. Firstly, during the evaluation process of the indicators a revision of the existing thresholds and/or reference conditions per each indicator was required by EP.10. Secondly, this revision performed under Task 3.2 evinced the unmissable interconnection between the three tasks encompassed by Action 3. Accordingly, the gaps identified within Task 3.1 have been incorporated as management objectives of Task 3.2. Subsequently, the thresholds for the selected indicators have been revised in Task 3.2 in order to set the basis for Task 3.3.

The detailed outcomes of the revision of thresholds in Task 3.2 is included in Deliverable 3.3 together with a description of the missing ones and an additional section about general guidelines and possible methodologies for settings and for identifying thresholds, reference conditions and related concepts (IDEM Project, 2019d). In this chapter we provide an overview of the compiled thresholds as an introduction to Deliverable 3.3.

The first clear outcome of the revision carried out within IDEM is the general lack of available thresholds for the majority of the indicators compiled for the different descriptors. This gap was expected due to the previously known data scarcity regarding deep-sea systems (IDEM Project, 2018a, 2018b, 2018c and 2019a). Additionally, when the available thresholds were revised, the number of them that could be applied was even lower. Again, the identification of thresholds was hindered by the limited knowledge and data on deep-sea ecosystems.

Taking into account limitations on thresholds' availability and applicability and the impossibility of defining new ones, we decided to focus the revision on methods that could be used for its implementation following the framework proposed by the TG Noise workshop (2018). This second approach was much more rewarding since we could detect several methods and formulas that could be used for setting up thresholds for different indicators. Of course, these methods depend on the existence of data that is currently unavailable. Another concept influencing the definition of thresholds is the existence of baselines and reference conditions, understood as undisturbed or minimally disturbed conditions serving as benchmarks (Moffat et al., 2011; HELCOM, 2012a). The identification of pristine areas is almost impossible nowadays, in the Mediterranean Sea and beyond. The closest approximation is the recognition of almost undisturbed regions, ascertained by the study of highly protected areas, historical conditions or

by modelling approaches (Moffat et al., 2011). Repeatedly, data and knowledge gaps on deep Mediterranean systems hinder the successful implementation of these approaches, of which an accurate revision and a discussion regarding its actual application is provided in Deliverable 3.3 (IDEM Project, 2019d).

4.2 GAPS, HINDRANCES AND GENERAL RECOMMENDATIONS FOR FURTHER WORK

This chapter describes some relevant obstacles and conveys considerations acknowledged during the performance of Task 3.2, together with specific recommendations regarding further work that would be required to make significant progress.

The main difficulty of Task 3.2 was to reduce the magnitude of the work demanded while producing a valuable output. Due to the multiple frameworks and approaches developed and implemented by different RSC working plans, national and international programs, peer-reviewed articles of case-studies and official directives, the amount of scientific publications to be revised was excessive considering the chained cascading character of IDEM actions, task and deliverables and the resulting time left in practice for the production of the last of the deliverables in view of the effort ideally required.. Accordingly, taking into account all practical constraints we developed and approach that accepted shortcuts while delivering consistent results and ensuring the obtaining of equivalent sets of indicators for all descriptors (for details see chapter 2.2, Step 3). Therefore, the reader should be aware that the sets of indicators/criteria presented as output are not exhaustive and a more thorough revision of the European but also international marine conservation initiatives is recommended.

The second consideration is about the consequences of data and knowledge gaps, already explained in multiple IDEM deliverables (IDEM Project, 2018a, 2018b, 2018c and 2019a). Although these gaps exist for each descriptor, subsequently influencing all approaches targeting the deep Mediterranean Sea, specific descriptors are more conditioned than others by this hindrance. Two of the most affected descriptors are D10 and D11, targeting marine litter and noise, respectively. The fundamental knowledge gaps affecting these two descriptors prevent an accurate description of the pressures and their impacts. Thus, the identification and/or formulation of indicators for these descriptors is a complex and difficult task to be accomplished. Extensive studies about these pressures and their potential repercussions are needed before suitable indicators can be implemented.

The identification of major gaps during Task 3.1 introduced another difficulty for descriptors 5 and 7. The formulation of these two descriptors in the current MSFD frame does not enable a suitable application to the deep Mediterranean Sea. D5, focusing in eutrophication, is built up by several criteria that do not apply to the deep-sea such as chlorophyll concentrations, photic limits of the water column or the abundance of opportunistic macroalgae (European Commission, 2017). Additionally, impacts of anthropogenic inputs of nutrients into deep-sea systems and its consequences still need to be proven and characterized. D7 suffers from a similar limitation, since links between alterations of hydrographical conditions and human activities in

the deep remain essentially undescribed (IDEM Project, 2019a). Relevant pressures that might affect hydrological conditions, like physical loss of seabed substrate or changes in morphology are just local and significant direct effects in the deep-sea still require confirmation. Overall, if the formulation and the criteria of a descriptor are not completely suitable to the deep-sea, the selection of convenient indicators is really challenging or even nonsense. The situation just explained evinces alone the need for a critical revision of these two descriptors and their reformulation duly accompanied by a redefinition of the criteria to be assessed or, if there is no foreseeable solution, their partial or total dismissal for the deep sea.

4.3 APPLICATION OF THE INDICATORS'SET

In order to facilitate the application of the indicators' set to all sub-basins, different weightings of indicators can be used. For instance, if a sub-basin is heavily impacted by fishing activities but is almost unaffected by hydrocarbon exploration and production, those indicators reflecting fishing pressures and impacts should have more weight than the ones related to hydrocarbon exploration and production. A model example is provided in Halpern et al. (2012), where environmental goals are assessed with different weights under different value sets reflecting diverse conservation viewpoints. In order to support this approach, a description of the potential weights was added to each indicator data sheet where a differential weight might be applicable. However, this needs to be discussed and agreed for each sub-basin when the application of the indicators is going to be considered for monitoring purposes.

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ANNEX I - GUIDELINES FOR THE EVALUATION PROCESS OF INDICATORS

The IDEM approach to evaluate indicators is based on a structured, standardized system implemented through a common spreadsheet. This annex provides the guidelines for the evaluation process of indicators. It should be taken into account from the beginning that this document was generated for the version 1 of the evaluation process spreadsheet and thus it should not be applied point by point for version 2 (see spreadsheet documents in chapter 3.12 for details). The differences between the two versions are explained in the chapter 2.2 of this Deliverable.

The IDEM system presented below is adapted from the one applied for the selection of GES indicators in the DEVOTES project (Queirós et al., 2016). It has been complemented with inputs from two other pre-existing frameworks (Schroeder, 2010; Otto et al., 2018). The system consists of two blocks, the evaluation parameters (EP) and the evaluation steps (ES), illustrated in Figure AI.1.

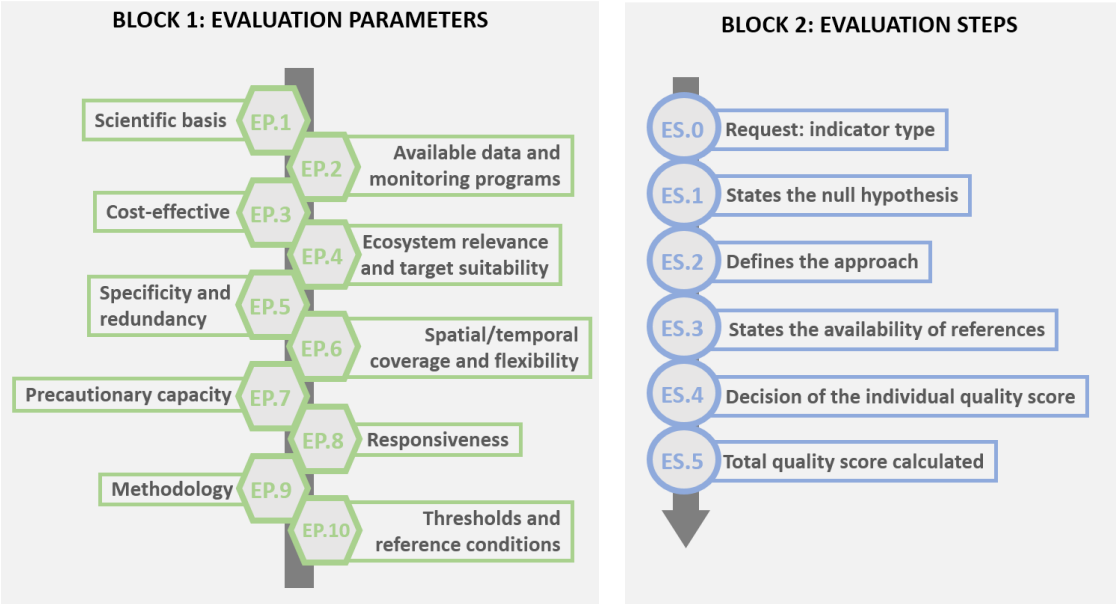

Figure AI.1 Schematic chart summarizing the two main blocks that form the basis of the IDEM evaluation system for selecting deep-sea indicators. The left panel illustrates the 10 evaluation parameters that determine which indicator's characteristics are assessed. The right panel shows the steps defining the common, standardized process to follow for completing the evaluation of the indicators. Definitions, specifications and detailed guidelines for the implementation of the system are available in the following section.

This annex is divided in two sections. In the first section, the initial four steps ES.1 to ES.4 plus ES.0 are described and specified for each EP in order to standardize the evaluation process for all descriptors. The second section describes ES.5 since it must encompass the outcomes of all EPs.

1.1 EVALUATION STEPS (ES.0 → ES.4)

This chapter section defines firstly the common structure of the evaluation process based on the initial ESs ES.0 to ES.5 and, secondly, the specifications for the implementation of the ES for each EP.

The process starts with ES.0 where the indicator class is defined as state, pressure or impact. ES.1 states the null hypothesis as a negative sentence defining when the EP is not fulfilled. It is used to test if the indicators accomplish the evaluation parameters. ES.2 defines the approach formulated for testing the hypothesis, adapting the requirements to the parameter assessed. Two main approaches can be considered: (i) qualitative, based on a literature review and on expert's judgment, and (ii) quantitative, where different elements are assessed and combined in a final score. ES.3 demands a list of the references examined and used for either choosing the individual score in ES.4 or performing the quantitative assessment. Finally, ES.4 states the individual quality score that the indicator has obtained for each EP.

Following the ICES (2015) approach, the possible individual scores (ES.4) would be 0, 0.5 or 1. The EPs tested by a qualitative approach are directly graded with an individual score following the scores' justification provided in the guidelines. The EPs assessed by quantitative approaches (EP.2, EP.3, EP.6 and EP.8) will give a score to each of the elements encompassed and evaluated within the parameter. The sum of these scores will be interpreted in ES.4 with a scale defining which range of grades obtains each of the three individual quality scores. Two EPs (EP.1 and EP.2) include additional weighting. The one-out-all-out criterion, defined in Queirós et al. (2016), is stated for EP.1, which determines the direct rejection of the indicator if it fails to meet this parameter. EP.2 is defined as basic fulfillment. Thus, if an indicator that is finally selected scores 0 in this parameter, the lack of data should be highlighted within the indicator data sheet since its applicability would be compromised.

EP.1 Scientific basis

Background. EP adopted from Queirós' et al. (2016) Indicator Quality (IQ) criteria 1.

ES.1 Null hypothesis. There is no scientific basis for the indicator.
ES.2 Approach. Involves expert judgment and qualitative approach. The parameter evaluates the existence of publications demonstrating the conceptual basis for applying the indicator. Therefore, a review of relevant literature is set as methodology.
ES.3 References. Peer-reviewed scientific papers and other publications.
ES.4 Individual quality score:

1	Scientific basis verified (multiple publications including peer-reviewed scientific papers, directives, RSC and official European Commission reports)
0.5	Endorsed indicator (few publications, not included in any directive or RSC framework)
0	Not endorsed/no relevant references available

Additional weight: *one-out-all-out parameter.* Since this parameter is considered as an essential indicator feature in the assessment, the indicators scoring 0 should be directly excluded from the final selected pool.

EP.2 Available data and/or monitoring programs

Background. EP based on IQ criteria 8 described in Queirós et al. (2016). This feature was also assessed by the 6th criterion of the framework developed by Otto et al. (2018) for selecting and validating food web indicators.

ES.1 Null hypothesis. There is no data or monitoring program supporting the indicator.
ES.2 Approach. Involves a quantitative approach. It must be assessed if the indicator is already being used (i.e. it is operational in monitoring programs) and if it is supported by enough data (scientific papers, datasets and other publications). Peer-reviewed scientific papers are preferred, but other publications such as governmental or international institutional reports could also deserve consideration. Within the same evaluation framework, spatial and temporal distribution of the data must be assessed.

	Areas where it is operational	Relevant scientific papers	Available datasets (online repositories)	Other publications
Spatial distribution	1-5	1-5	1-5	1-5
Temporal distribution	+1/-1	+1/-1	+1/-1	+1/-1

Legend 1	**5.** Operational for all MED basins
	4. Operational for most MED basins
	3. Operational for half MED basins
	2. Operational for only one MED basin
	1. Operational for other marine regions outside the MED
	-2: Subtract 2 points if its application doesn't cover the deep-sea
Legend 2	**5.** Availability of scientific papers/datasets/other publications for all MED basins
	4. Availability of scientific papers /datasets/other publications for most MED basins
	3. Availability of scientific papers /datasets/other publications for half MED basins
	2. Availability of scientific papers /datasets/other publications for only one MED basin
	1. Availability of scientific papers /datasets/other publications for other marine regions outside the MED
Legend 3	**+1**. Data series available (sustained and/or punctual observations)
	-1. No data series available

ES.3 References. Information about existing monitoring programs, reviewing of scientific papers, online-repositories and other publications containing data.
ES.4 Individual quality score and range of grades:

1	24-16
0.5	15-8
0	7-0

Additional weight: *basic fulfillment*. If an indicator that is finally selected scores **0** in this parameter, the lack of data should be highlighted within the indicator data sheet since its applicability would be compromised.

EP.3 Cost effective

Background. EP formulated after adapting Schroeder (2010) economic criteria. Otto et al. (2018) and Queirós et al. (2016) also assessed the cost-effectiveness of the indicators by their 5th criterion and IQ criteria 7, respectively.

ES.1 Null hypothesis. The indicator is not cost effective.
ES.2 Approach. Involves a quantitative approach. The analysis consists of the evaluation of two elements: cost and relevance. Cost is approximated by assessing the requirements of applying the indicator. Relevance is evaluated considering the target addressed and the environmental relevance of the indicator. The parameter also considers the uniqueness and novelty of the data that would be provided by future applications of the indicator. The features described for each element are scored in a scale from 0 to 4.

	Sampling (time and equipment)	Processing and analyzing data (time and equipment)	Personnel required
Cost	0-4	0-4	0-4
	Value	Uniqueness, novelty and redundancy	Target addressed (relevance regarding GES)
Relevance	0-4	0-4	0-4

Legend 1	**4.** No cost	
	3. Limited cost	
	2. Moderate cost	
	1. Large cost	
	0. Unaffordable, undeterminable	
Legend 2 and 3	**4.** High value/relevance	4. Novel and unique data
	3. High value/relevance	3. Novel and unique for some basins only
	2. Moderate value/relevance	2. Novel data updating former data
	1. Limited value/relevance	1. Data filing out current datasets
	0. No value/relevance	0. Redundant data

ES.3 References. Expert knowledge; published scientific papers/documents stating costs (preferably in a quantitative manner, though semi-quantitative approaches could be also useful).
ES.4 Individual quality score and range of grades:

1	24-16
0.5	15-8
0	7-0

EP.4 Ecosystem relevance and target suitability

Background. EP formulated after combining Queirós et al. (2016) IQ2 and IQ4 criteria.

ES.1 Null hypothesis. There is no evidence linking the indicator to their target. Relevant, unambiguous targets cannot be defined.

ES.2 Approach. Involves expert judgment and qualitative approach. The parameter assesses the ecosystem relevance of the indicator and the evidences demonstrating the relation between the indicator and its ecosystem target. EP.4 also evaluates the relevance and complexity of the ideal indicator targets. A literature review is the recommended approach. Evidence for the ecosystem relevance of the indicator should have been published in peer-reviewed literature where a direct link needs to be demonstrated between the ecosystem target and the indicator. In order to assess the possibility to set good, relevant targets, the complexity of the issue assessed and its relevance for obtaining GES also need to be considered.
ES.3 References. Scientific, peer-reviewed, literature.
ES.4 Individual quality score

1	Evidence demonstrated (peer-reviewed publications). Unambiguous targets defined
0.5	Evidence suggested (different kinds of publications). Complex targets defined
0	No clear evidence identified. Only ambiguous targets with low relevance could be defined

EP.5 Specificity and redundancy

Background. This parameter was also assessed by criteria 3 and 12 of the indicator selection frameworks from Schroeder (2010) and Otto et al. (2018), respectively.

ES.1 Null hypothesis. The indicator is unspecific and redundant.
ES.2 Approach. Qualitative approach. The EP analyzes if the indicator reflects primarily one ecosystem target or responses to only one pressure. The relation and interconnections with the rest of indicators of the entire pool is also assessed. The approach suggested consists of a review of literature and of the indicators' catalogue. Redundancy is stated when several indicators are focused in the same or really similar targets. Revision should also include the indicators defined for related descriptors.
ES.3 References. Literature sources and the indicator catalogue for each descriptor.
ES.4 Individual quality score.

1	The indicator is specific and unique (no major overlap is observed)
0.5	The indicator reflects diverse but complementary ecosystem targets Few overlapping indicators are identified in other descriptors of the pool (minor redundancy)
0	The indicator is influenced by multiple properties and pressures Major overlapping is identified between indicators of the same descriptor (major redundancy)

EP.6 Spatial/temporal coverage and flexibility

Background. This parameters was used in Schroeder (2010) and Otto et al. (2018) criteria 4 and 15-16, respectively, for evaluating and selecting indicators.

ES.1 Null hypothesis. The indicator has a really restricted spatial and temporal applicability without the possibility of adapting it to other settings or systems.
ES.2 Approach. Involves a quantitative approach. EP.6 focuses in the spatial and temporal coverage of the indicator. It also considers if it is applicable in heterogeneous systems and across different management approaches. Spatial, temporal and flexible applicability will be assessed in a scale from 0 to 4.

Spatial coverage	Temporal coverage	Flexibility (for heterogeneous systems)	Flexibility (for different management frameworks)
0-4	0-4	0-1	0-1

Legend 1	**4.** All MED basins	**Legend 3**
	3. Most MED basins	**1**. Applicable in heterogeneous systems / across different management frameworks
	2. Only one MED basin	
	1. Other marine ecosystems (habitats) outside the MED	
	0. Not defined	
	-2: Subtract 2 points if its application doesn't cover the deep-sea	**0.** Not applicable in heterogeneous systems / across different management frameworks
Legend 2	**4.** All temporal scales	
	3. For a defined temporal period (sustained monitoring)	
	2. For short periods (punctual monitoring)	
	1. One-time application	
	0. Not defined	

ES.3 References. Case studies, literature (examples of its application), indicators' catalogues, and expert knowledge.
ES.4 Individual quality score and range of grades:

1	10-8
0.5	7-4
0	3-0

EP.7 Precautionary capacity

Background. EP adopted from Queirós' et al. (2016) IQ criteria 5. Also assessed by criterion 14 in Otto's et al. (2018) framework.

ES.1 Null hypothesis. There is no immediate and measurable change in the indicator associated with a change in the target that anticipates ecosystem-level change in the system.
ES.2 Approach. Involves a qualitative approach. The parameter considers the precautionary capacity of the indicator by analyzing the relation and lag time between a change in the ecosystem target and the consequent response of the indicator. Lag time is understood as the time that happens before the indicator reaction to the ecosystem change is detected. A small, measurable lag time would enable the early detection of pressures and impacts, anticipating and preventing further damage by the implementation of precautionary measures and mitigation actions.
ES.3 References. Information and knowledge regarding the lag time between the target and the indicator reaction by revising previous applications, case-studies and scientific papers.
ES.4 Individual quality score

1	Lag time is detectable, small and easily measurable, suitable to enable mitigation actions
0.5	Lag time is detectable, substantial and complex to measure, only partial mitigation could be accomplished

0	Lag time can be neither detected nor measured **OR** the indicator assessed monitors an impact. Therefore, actions to prevent deterioration are not possible.

EP.8 Responsiveness

Background. This parameter was formulated after criteria 1 and 2 from Schroeder (2010), IQ criteria 3 from Queirós et al. (2016), and criteria 9, 10 and 11 from Otto et al. (2018).

ES.1 Null hypothesis. The indicator is not sensitive neither robust, and displays low accuracy and major error rates.

ES.2 Approach. Involves a quantitative approach. This parameter must describe the performance of the indicator regarding sensitivity, robustness and accuracy, combined in a final score. Sensitivity measures the ability to respond to a change in the ecosystem target, also taking into account the relation with the pressure causing the alteration. Robustness refers to the response itself, i.e. if it can be predicted and if it develops as expected. Finally, accuracy reports if the indicator is able to monitor the target against background noise and natural variability. The methodology recommended depends highly on the indicator evaluated. Statistics such as correlation and regression analyses can be applied for sensitivity and robustness assessment, respectively, would the data available be enough and the indicator formulation be adequate (Otto et al., 2018). For the rest of the cases, literature and revision of case studies is recommended for the three parameters.

RESPONSIVENESS		
Sensitivity (correlation analysis)	Robustness (regression analysis)	Accuracy
0-3	0-3	0-3

Legend 1	**Legend 2**	**Legend 3**
3. Significant and high correlation ($p<0.05$ and $R>50\%$). Responds clearly to the target change and to the pressure causing it	**3.** Linear regression between the indicator and its target. Responds consistently and as predicted	**3.** Perfect accuracy, with no relevant errors detected
2. Significant and low correlation ($p<0.05$ and $R<50\%$). Responds clearly to the target. The relation with the pressure is more ambiguous	**2.** The relation between the target and the indicators is non-linear in regression analysis. Responds consistently in most cases. Low degree of variability	**2.** Acceptable accuracy, minor errors
1. Significant but poor correlation ($p<0.05$ and $R<20\%$). Unambiguous responses to the target alteration and to the pressure	**1.** The relation between the target and the indicator might vary between different applications. Insufficient information based only on few specific cases. Low consistency	**1.** Poor accuracy, major errors
0. Not significant. No response to changes of the target or the pressure	**0.** The relation between the target and the indicator varies in each application. No consistency	**0.** No accuracy, inability to distinguish errors from trustable results

ES.3 References. Datasets, scientific papers and case studies with quantitative data in order to perform statistical analysis. Also literature describing previous applications of the indicator.

ES.4 Individual quality score and range of grades:

1	9-7
0.5	6-4
0	3-0

EP.9 Methodology

Background. This EP applied in the three reference frameworks. Thus, its formulation combines Schroeder's (2010) criterion 4, Queirós' et al. (2016) IQ 6, and criteria 3 and 4 from Otto et al. (2018).

ES.1 Null hypothesis. The indicator is not measurable and requires a complex interpretation.
ES.2 Approach. Involves a qualitative approach. The parameter will analyze how the indicator is interpreted and which methods are proposed for its application. Two main elements must be taken into account. The first element, measurability, analyzes if the methods proposed are already available, tested and standardized. Spatial applicability also needs to be considered in order to enable monitoring programs across all MED basins. The second element examines if the indicator is understood and interpreted equally for different cases where it is applied, thus promoting consistency and enabling comparable assessments.
ES.3 References. Scientific papers and reports providing examples and case studies describing the interpretation, application and measurement of the indicator.
ES.4 Individual quality score

1	The indicator is measurable with the current methodology Methods are standardized and ready to use across all MED basins Easily to understand and consistent interpretations
0.5	The indicator is measurable but the methodology needs minor adaptations Methods cannot be applied to all MED basins Some degree of complexity, different interpretations though with minor differences
0	Complex to measure Methodology not available nor standardized Inconsistent interpretations

EP.10 Thresholds and reference conditions

Background. EP based in Otto et al. (2018) criterion 13.

ES.1 Null hypothesis. No threshold or reference conditions have been reported for this parameter.
ES.2 Approach. Involves a qualitative approach. The evaluation is based in the revision of available literature in order to identify existing thresholds. If thresholds are available, they should be revised to confirm that they are appropriate, feasible and widely applicable. If there are not, identification of thresholds for related indicators and/or for areas outside the Mediterranean Sea should be considered.
ES.3 References. Literature, case studies and reports from other areas.

ES.4 Individual quality score

1	Thresholds are available, appropriate and applicable to all Mediterranean basins
0.5	Thresholds are available and appropriate for some MED basins only **OR** they are not available but can be obtained by adapting existing ones from other areas or indicators
0	Not existing, even in other areas or related topics

1.2 CALCULATION OF THE TOTAL QUALITY SCORE (ES.5)

For a given candidate indicator, the sequence of ESs needs to be followed for each of the ten EPs (as illustrated in Figure AI.2). The evaluation of each parameter finishes with an individual score (ES.4). If the process is successfully completed, the indicator will get a total quality score in ES.5, which corresponds to the sum of all individual scores. Accordingly, each indicator will be provided with a total score that will determine its final categorization (see Chapter 2).

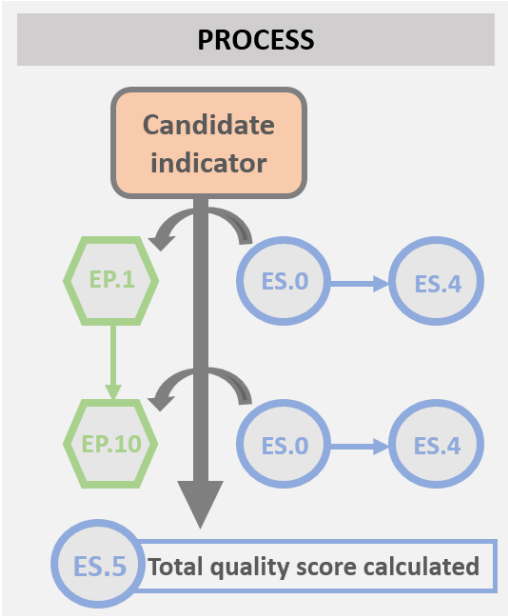

Figure AI.2 Schematic representation of the process followed for each candidate indicator from the initial pool in order to obtain a total quality score in ES.5. Evaluation parameters (EPs) are represented by the green hexagons on the left and the evaluation steps (ESs) by the blue circles on the right.

ANNEX I REFERENCES

ICES. (2015). Report of the Working Group on Biodiversity Science (WGBIODIV), 9-13 February 2015. ICES Headquarters, Copenhaguen, Denmark. ICES CM 2015/SSGEPD:04. 308pp.

Otto, S. A., Kadin, M., Casini, M., Torres, M. A., & Blenckner, T. (2018). A quantitative framework for selecting and validating food web indicators. *Ecological Indicators*, *84*(May 2017), 619–631. https://doi.org/10.1016/j.ecolind.2017.05.045.

Queirós, A. M., Strong, J. A., Mazik, K., Carstensen, J., Bruun, J., Somerfield, P. J., … Krause-Jensen, D. (2016). An Objective Framework to Test the Quality of Candidate Indicators of Good Environmental Status. *Frontiers in Marine Science*, *3*(May). https://doi.org/10.3389/fmars.2016.00073.

Schroeder, D. D. C. (2010). Healthy & Biologically Diverse Seas Evidence Group Technical Report Series: Evaluation and gap analysis of current and potential indicators for Microbes. JNCC (Joint Nature Conservation Committee), Peterborough.

ANNEX II - QUESTIONNAIRE ABOUT THE SUITABILITY OF THE ESTABLISHED INDICATORS FOR DESCRIPTOR 11

The aim of the current questionnaire is to test if the current criteria/indicators established in the MSFD are suitable for the monitoring of D11 in the deep Mediterranean Sea. The questionnaire consists of ten questions that should be answered for each indicator. In order to obtain consistent results between all descriptors, the same parameters defined for the IDEM evaluation process will be questioned (see Figure AII.1).

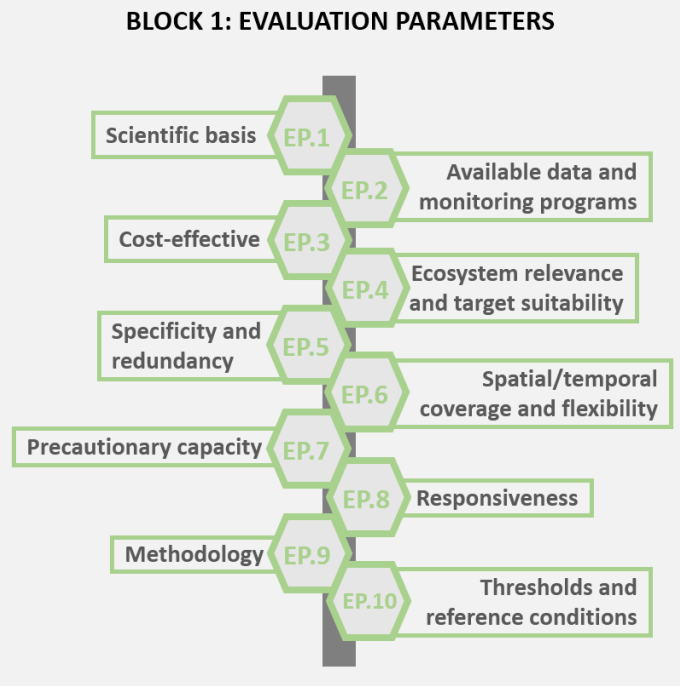

Figure AII.1 Illustrative summary of the evaluation parameters defined for assessing the indicators proposed for monitoring the deep Mediterranean Sea. Adapted from Queirós et al. (2016).

Each question should be answered with a score. The possible scores proposed are 0, 0.5 and 1, adopted from the ICES (2015) approach. The decision for a given score should be based on expert judgement following the simple guidelines described in Table AII.1.

Table AII.1 Description of the three possible scores proposed for the assessment of each evaluation parameter. Adapted from ICES (2015) and Queirós et al. (2016).

1	The criteria/indicator fulfills completely the parameter tested.
0.5	The criteria/indicator fulfills only partially the parameter tested.
0	The criteria/indicator does not fulfill the parameter tested.

MSFD CRITERIA AND INDICATORS TO BE TESTED

CRITERION D11C1 — Primary: The spatial distribution, temporal extent, and levels of anthropogenic impulsive sound sources do not exceed levels that adversely affect populations of marine animals.

Indicator 11.1.1 Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1µPa2.s) or as peak sound pressure level (in dB re 1µPapeak) at one meter, measured over the frequency band 10 Hz to 10 kHz.

CRITERION D11C2 — Primary: The spatial distribution, temporal extent and levels of anthropogenic continuous low-frequency sound do not exceed levels that adversely affect populations of marine animals.

Indicator 11.2.1 Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (center frequency) (re 1µPa RMS: average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate.0

If additional indicators from other projects, directives or RSC (Regional Sea Convention) approaches are identified and considered relevant, they can be included in the last rows of the tables.

QUESTIONNAIRE

EP.1 Is the indicator supported by enough scientific basis?

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

EP.2 Do data and/or monitoring programs exist nowadays related to the indicator?

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

EP.3 Is the indicator cost-effective? (Taking into account the cost of the methods and/or technologies required and the relevance of the data provided)

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

EP.4 Are evidences of the indicator's ecosystem relevance published in literature? Are the indicator's targets (monitoring objectives) described in literature? Are they suitable for assessing the deep Mediterranean Sea?

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

EP.5 Does the indicator reflect primarily one ecosystem property/pressure/impact? Is the indicator redundant due to major overlaps with other indicators and their targets?

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

EP.6 Is the indicator applicable to different spatial and temporal ranges? Does its formulation enable possible adaptations for targeting heterogeneous systems and covering different management frameworks?

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

EP.7 Does the indicator have precautionary capacity? Understood as the capacity of the indicator to reflect and ecosystem change within a detectable, short response time. Precautionary capacity would enable the early detection of pressures and impacts, anticipating and preventing further damages.

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

EP.8 Is the indicator's performance sensitive, robust and accurate?

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

EP.9 Is the methodology required for monitoring the indicator available and standardized across all Mediterranean basins?

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

EP.10 Do thresholds and/or reference conditions exist for this indicator?

CRITERIA/INDICATOR	SCORE (0 / 0.5 / 1)
CRITERION D11C1. Indicator 11.1.1	
CRITERION D11C2. Indicator 11.2.1	
<Other indicators>	

BRIEF DESCRIPTION OF THE QUESTIONNAIRE OUTCOMES

CRITERION D11C1. Indicator 11.1.1

<Add a brief description of the suitability of the indicator considering the outcomes of the questionnaire>

CRITERION D11C2. Indicator 11.2.1

<Add a brief description of the suitability of the indicator considering the outcomes of the questionnaire>

<Other indicators>

ANNEX II REFERENCES

ICES. (2015). Report of the Working Group on Biodiversity Science (WGBIODIV), 9-13 February 2015. ICES Headquarters, Copenhaguen, Denmark. ICES CM 2015/SSGEPD:04. 308pp.

Queirós, A.M., Strong, J.A., Mazik, K., Carstensen, J., Bruun, J., Somerfield, P.J. et al. (2016). An Objective Framework to Test the Quality of Candidate Indicators of Good Environmental Status. *Frontiers in Marine Science*, *3*. https://doi.org/10.3389/fmars.2016.00073.

<Add references consulted and/or references recommended for the obtaining of further information>