Implementation of the MSFD to the

Deep Mediterranean Sea

IDEM

Project Coordinator: Roberto Danovaro

Report 3.3. Report on the indicators and thresholds to identify the GES and the key areas for design monitoring programs in the Mediterranean deep sea

Leader: UB

Participants: CNR, CSIC, DFMR, ENEA, IFREMER, TAU, UM, UNIVPM

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.

www.msfd-idem.eu

How to cite this document:

IDEM Project[1]. (2019d). Deliverable 3.3: IDEM Report 3.3. Report on the indicators and thresholds to identify the GES and the key areas for design monitoring programs in the Mediterranean deep sea. *IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project*. UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM, UNIVPM.

[1] The authors that contributed to the generation of the Deliverable 3.2 are the following: Canals Miquel, Güell-Bujons Queralt, Sànchez-Vidal Anna, de Haan Liam, Soldevila Emma, Amblàs David, Frigola Jaime, Lastras Galderic, Foglini Federica, Castellan Giorgio, Angeletti Lorenzo, Bianchelli Silvia, Brind'Amour Anik, Cantafaro Annalucia, Carugati Laura, Ciuffardi Tiziana, Danovaro Roberto, Evans Julian, Fabri Marie-Claire, Fanelli Emanuela, , Galil Bella, Goren Menachem, Grimalt Joan, Knittweis Leyla, López Jordi F, Pieretti Nadia, Scarcella Giuseppe, Schembri Patrick Joseph, Taviani Marco, and Vaz Sandrine.

TABLE OF CONTENTS

ACRONYMS TABLE

AMBI	AZTI's Marine Biotic Index (Borja et al., 2000)
AT	Anthropogenic threat (Task 3.3 specific abbreviation)
AZTI	Technology Center on Marine and Food Innovation, Basque Country, Spain
B	Biomass
BC	Biotic coefficient (Borja et al., 2000)
BPC	Biopolymeric Carbon
BQI	Benthic quality index (Rosenberg et al., 2004)
C	Carbon
CBD	Convention on Biological Diversity
COP19	The nineteenth session Conference of the Parties
CS	Canyon systems
CWC	Cold water corals
D	Data (Task 3.3 specific abbreviation)
D1-D11	Descriptors 1 to 11
DB	Database
DDT	Dichlorodiphenyltrichloroethane
DGM	Dissolved gaseous mercury
DMeHg	Dimethylmercury
DW	Dry weight
DW	Dense Water formation areas
DWF	Dense Water Formation
E	East/eastern
EBSA	Ecologically or Biologically Significant Areas
EC	European Commission
ECoQ	ECological Quality
EQS	Ecological Quality Status
ELCA	East Levantine Canyons
ER	Ecological relevance (Task 3.3 specific abbreviation)
F	Fishing mortality/Fishing mortality rate
f	Trawling frequency (Rijnsdorp et al., 2016)
FAO	Food and Agriculture Organization
FRA	Fisheries Restricted Area
GFCM	General Fisheries Commission for the Mediterranean
GES	Good Environmental Status
H'	Shannon biodiversity index (Pielou, 1975)
HC	Hydrocarbon
HCB	Hexachlorobenzene
HELCOM	Convention for the Protection of the Marine Environment in the Baltic Sea Area
I	Indicator (Task 3.3 specific abbreviation)
ICES	International Council for the Exploration of the Sea
ICG-COBAM	(OSPAR) Intersessional Correspondence Group on the Coordination of Biodiversity Assessment and Monitoring
IDEM	Implementation of the MSFD to the DEep Mediterranean Sea
ISS	Multi-metric index of size spectra sensitivity (Basset et al., 2012)

IMO	International Maritime Organization
LFI	Large Fish Indicator
M	Methods (Task 3.3 specific abbreviation)
M-AMBI	Multivariate AMBI (Borja et al., 2004)
MED	Mediterranean Sea
MEDOCC	MEDiterranean OCCidental Index (Pinedo and Jordana, 2008).
MedPAN	Mediterranean Protected Areas Network
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MSY	Maximum Sustainable Yield
N	North/northern
NGO	Non-governmental organization
NIS	Non-indigenous species
OR	Other relevant deep-sea systems
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
P	Production
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PSSA	Particularly Sensitive Sea Areas
R	Recovery time (Rijnsdorp et al., 2016)
RAC/SPA	Regional Activity Centre for Special Protection Areas
RSC	Regional Sea Conventions
S	South/southern
SBI	SeaBed Integrity (Eigaard et al., 2017)
SCI	Sites of Community Interest
SM	Seamounts
SPAMI	Specially Protected Areas of Mediterranean Importance
SSB	Spawning Stock Biomass
ST	Straits
ST.DEV	Standard deviation
TG	Technical Group
TOC	Total Organic Carbon
UNEP-MAP	United Nations Environment Programme-Mediterranean Action Plan
VME	Vulnerable Marine Ecosystems
VMS	Vessel Monitoring System
W	West/western
W.W	Wet weight

1. INTRODUCTION

The IDEM project, focusing in the implementation of the MSFD in the deep Mediterranean Sea, consists of 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 and the most feasible criteria/indicators together with its thresholds and description of the most promising deep Mediterranean key areas and (4) dissemination of the outputs.

This deliverable contains the outcomes of (Task 3.3 of IDEM Action 3, focused in the identification of feasible thresholds for the indicators selected together with the description of deep sea key areas for future monitoring programs. As already stated in the title of the task, assignments within Task 3.3 are tightly interrelated with the outputs of Task 3.1 and 3.2. Accordingly, this document contains information and uses terminology already described in previous IDEM deliverables (IDEM Project, 2019a, 2019b). Consequently, previous knowledge from previous tasks might be needed to fully understand the contents of this deliverable. Also, it should be stated the existence of supporting documents developed in order to provide enough details about the obtained results. A detailed description of the approaches formulated and of the additional documents is available in chapter 2.

As already introduced, the main objective of this task and this deliverable is the identification of feasible thresholds for the selected indicators together with the description of deep sea key areas for future monitoring programs. During the performance of this task available information on several MSFD related document was revised (Moffat et al., 2011; European Commission, 2017; TG Noise, 2018). The task also considered the incorporation of approaches and proposals developed by protection and monitoring initiatives of different bodies encompassing RSC, NGOs and other national and internationals institutions (UNEP-MAP-RAC/SPA, 2010; HELCOM, 2012a, 2012b; ICG-COBAM, 2013; DEVOTES Project, 2014; OSPAR, 2017; UNEP-MAP, 2017; FAO, 2018; Convention on Biological Diversity (CBD), n.d; International Maritime Organization (IMO), n.d.).

The outstanding difference with the other deliverables is that the second part of the deliverable, focused in the identification of key areas for monitoring programs, is not organized per descriptors. The reason behind is that the task of identifying key monitoring areas should encompass the outcomes of all the other tasks combining also all descriptors together.

2. THE IDEM APPROACH FOR TASK 3.3

The approach developed for fulfilling Task 3.3 objectives consists of two parts: (i) Part A aiming at the identification of the available thresholds, and (ii) Part B focused in the suggestion and evaluation of key areas for monitoring programs. A summary of the procedure is illustrated in Figure 1.

Part A of Task 3.3 highly depends on the outcomes of the indicators evaluation performed within Task 3.2 (IDEM Project, 2019b, 2019c, 2019d). In order to avoid redundant work, a revision of the available thresholds for the selected indicators was already performed within Task 3.2

spreadsheet document since one of the evaluation parameters was precisely the existence of thresholds and/or reference conditions. In consequence, Deliverable 3.3 will include the outcomes of Task 3.2 revision of thresholds complemented with a description of the missing ones, organized per descriptor. An additional section about general guidelines and possible methodologies for settings and identifying thresholds, reference conditions and related concepts is also incorporated in chapter 3.1 of this Deliverable (Fig. 1A).

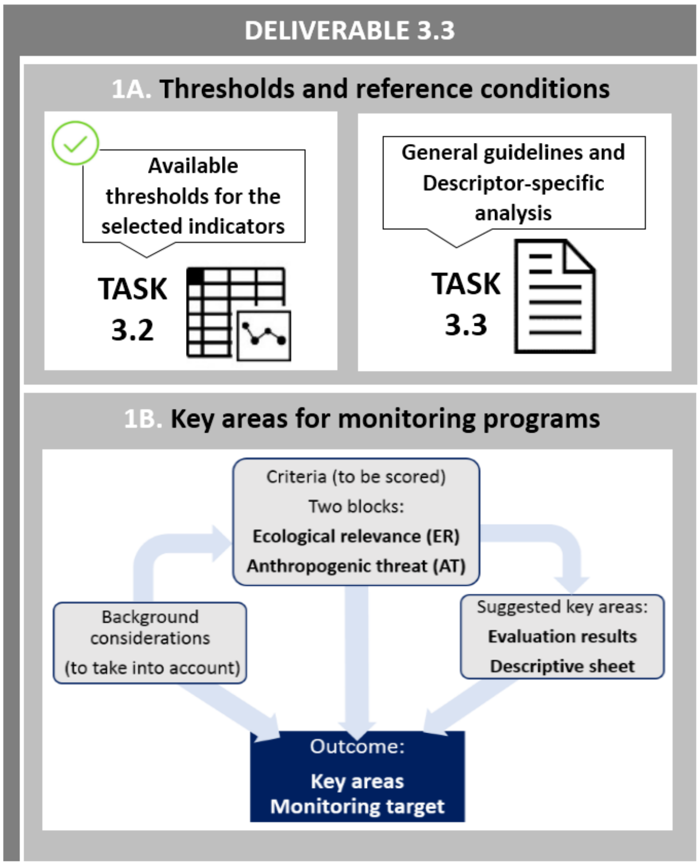


Figure 1. Diagram summarizing the approach develop for Task 3.3 and the contents of Deliverable 3.3. The diagram consists of two sections, one for each part of the approach. **1A:** documents and contents regarding the identification of thresholds and reference conditions. The two symbols illustrate (from left to right) the Task 3.2 Evaluation process spreadsheet documents (see IDEM Project, 2019b) and Deliverable 3.3 compiling Task 3.3 outcomes (this document). **1B.** Chart illustrating the four steps developed for the identification of key areas for monitoring programs.

The performance of Part B of the IDEM approach is outlined in Figure 1B. The approach is based in four steps. The process will encompass the compilation of background considerations, the establishment of two sets of criteria for the evaluation of key areas for monitoring, the resulting selected areas described in individual descriptive sheets and a final compilation of all Part B results with further recommendations, further work proposed and a suggested final monitoring target (aim) for the deep Mediterranean Sea.

In order to guide and complete consistently the steps of Task 3.3 a supporting spreadsheet document has been generated. The document compiles the background considerations and the selected criteria (step 1 and 2 of the approach) in the first tab as introduction to the approach. The main aim of the document is to provide the platform for the evaluation of the suggested key areas, performed in the second tab of spreadsheet. The suggested areas are also briefly defined within the third tab of the spreadsheet. Results are summarized in the last tab. A common format for the descriptive sheets of the finally selected areas has also been designed and distributed to ensure a coherent output of Task 3.3. The descriptive sheets can be consulted in chapter 4.3.3 of this deliverable.

3. PART A: THRESHOLDS TO IDENTIFY THE GES

3.1 General guidelines and possible approaches for setting thresholds

This part of the project requires the description of the indicators thresholds to identify GES. The establishment of suitable, appropriate and widely applicable thresholds is a complex process, especially regarding deep-sea systems, where data and knowledge scarcity is substantial. However, the first difficulty appears already for defining robust thresholds due to the multiple ambiguous nomenclatures used in literature for referring to thresholds and/or reference conditions.

The plain definition of threshold is "the level or point at which you start to experience something, or at which something starts to happen[2]". In environmental sciences the application of this term is quite ambiguous and leads to multiple formulations and approaches to identify and settle thresholds. For instance, the following terms were used for referring to thresholds and reference conditions in the literature consulted (Borja et al., 2012; HELCOM 2012a; Moffat et al., 2013; ICES, 2014): GES boundaries, tipping points, benchmarks, boundary levels, baselines and favorable conservation status.

In this frame, it is important distinguishing between threshold and reference conditions. While the first term should be used for indicating a limit of acceptance of a pressure, state or impact, the second refers to the undisturbed or minimally disturbed conditions used as benchmarks. Accordingly, benchmarks, baselines and favorable conservation status could be understood as reference conditions, and GES boundaries and tipping points as synonyms of thresholds. Ideally, the formulation of a threshold should be performed considering the baseline established for a region, system and/or habitat (HELCOM, 2012a). The most robust baselines are the reference conditions, although their identification is also quite complex. Reference conditions can be ascertained by the study of protected areas, historical conditions or by modeling approaches (Moffat et al., 2013; ICES, 2014). These three procedures are normally combined together with expert judgment (Borja et al., 2012). When reference conditions are not available, other baseline options such as past sate, current state or directional trends are used (Borja et al., 2013; Moffat et al., 2013). Using a baseline as a past state means using a recorded data point or data

[2] Cambridge Dictionary (https://dictionary.cambridge.org/dictionary/english/threshold)

series, ideally the first ones recorded. However, we should consider that deep-sea time series of data are really scarce. Finally, setting a current state as baseline should be the last option and should take into account the pressures that prevail and their effects. This last option at least ensures that no further deterioration happens.

As important as defining the baselines applied, the GES target that we want to achieve and/or maintain should be clearly understood and agreed (Moffat et al., 2013). The GES target should be understood as the objective that we aim for and that represents or ensures a good environmental status (Borja et al., 2012). Once the baselines are settled and the GES target is clear, a threshold can be set as a boundary of good status setting the point where GES starts to be compromised, determining the acceptable deviation range from the baseline (HELCOM, 2012a). Figure 2 illustrates the concepts and processes just described.

Although ideally the previous approach should be the one followed, in practice the use of current baselines may be the only practical option due to the lack of information on reference conditions for most deep-sea systems. This fact will condition the GES targets established and thus the thresholds settled. Another option currently used is to set as baseline a potential state based on knowledge regarding ecological status, past and current state and reference conditions known or inferred (HELCOM, 2012a). Actually, the establishment of thresholds is accomplished by a combination of approaches with a great dose of expert judgment.

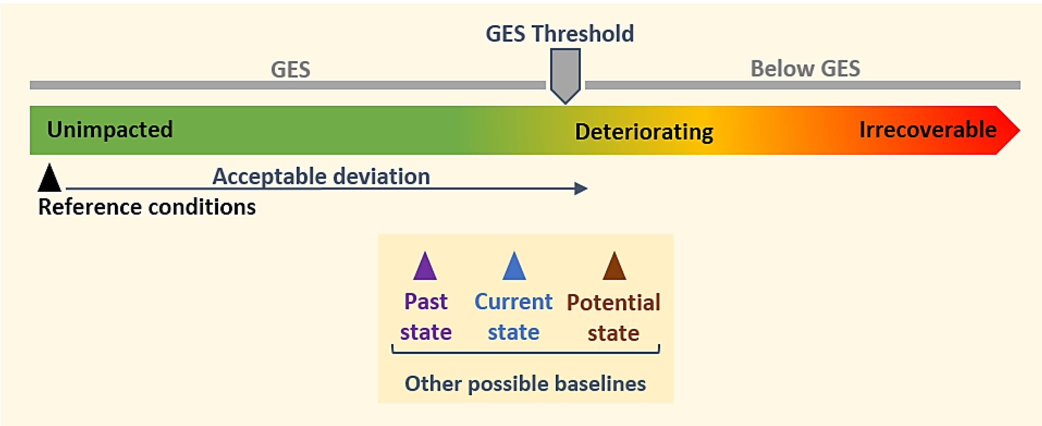


Figure 2. Explanatory diagram summarizing the approaches available for the identification of GES thresholds. The triangles represent different potential baselines that can be used in the approach. Diagram adapted from the combination of Figure 4.4 from HELCOM interim report (2012a) and Figures 3-1 and 3-5 from the report published by Moffat et al. (2013).

One important aspect regarding the establishment of thresholds and baselines is that they should not be in conflict with existent endorsed decisions and directives. Therefore, a revision of the current existing thresholds and reference conditions should be the first step in the process (see chapter 3.2). Subsequently, those available need to be assessed regarding their direct applicability and/or adaptability. It should also be considered that for some cases where thresholds are not set, a defined methodology for identifying and calculating them might exist. Finally, if no method or specific threshold is available, the process of establishing a new one should consider the thresholds existing for similar targets and the methods used in comparable processes.

The set of conclusions compiled by the HELCOM CORSET project (HELCOM, 2012a) when determining the boundaries of GES encompassed the consideration of natural variability and spatial-temporal differences, the understanding of GES as a range, the consideration of existing policies, the requirement of using and aligning GES between indicators and the possibility of adapting GES values to different contexts. The concept of vulnerability should be considered as well, specifically for pressure-focused thresholds (Moffat et al., 2013). To specify the exact level of pressure that a given habitat can tolerate before the occurrence of significant, unacceptable impacts, requires knowing the vulnerability of the. Vulnerability is based on habitat sensitivity and on the pressure exposure level considering the spatial and temporal overlaps between the habitat sensitive components and the pressure.

Other published initiatives dealing with the establishment of thresholds, environmental targets and reference conditions define the same or similar approaches as the ones already described. For example, the ICES report (2014) describes the methodology used for defining GES benchmarks and indicator thresholds. The benchmarks were described by analyzing the data in order to observe tipping points in ecosystem state-function relationships. Experiments and historical data together with modeling techniques can postulate tipping points and thus illustrate the limits and the thresholds for a given system, pressure or impact. Overall, the significant data and knowledge gap regarding deep-sea systems and processes directly influences the possibilities of setting suitable thresholds and/or reference conditions.

3.2 Descriptor-specific available thresholds

A revision of the available thresholds for the selected indicators for each descriptor was already performed within Task 3.2 and presented within the associated spreadsheet (IDEM Project, 2019b). This chapter provides an explanatory overview of the available thresholds, but also of the missing ones, for each descriptor.

The results of the revision performed under Task 3.2 for Evaluation Parameter 10 (see IDEM Project, 2019b) are displayed in Figure 3. The majority of the indicators compiled for the MSFD descriptors are not provided with defined thresholds and/or reference conditions. The number of thresholds identified decreases even more if we consider only those classified as applicable (green-filled bars in Figure 3).

The highest percentage of indicators with thresholds defined and applicable is observed in Descriptor 3. However, the percentages are clearly biased by the limited selection of indicators, only two, regarding D3. Descriptor 1 has no specific indicator with thresholds (as presented in Figure 3 by the light color) since those identified are from indicators adopted from D4 and D6 that were added to the D1 set (IDEM Project, 2019c). Details regarding the adopted indicators and their thresholds are provided within the descriptors where they were described initially (i.e. D4 and D6 in this case). The same explanation applies to Descriptor 7, where the thresholds described correspond to indicators adopted from D6.

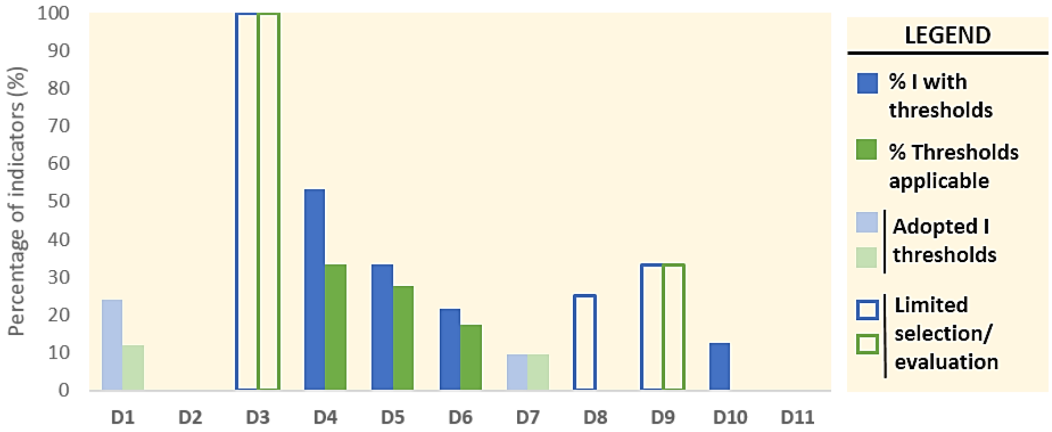


Figure 3. Bar graph representing the results of the revision of available thresholds identified within Task 3.2 for the indicators selected for each descriptor. The graph specifies the percentage of indicators (I) with thresholds (blue bars) and the percentage of thresholds actually applicable (green bars). D3 and D7 bars are presented in lighter blue and green colors since the indicators and thresholds identified have been adopted from other descriptors. D3, D8 and D9 bars are without filing to stand out that results are biased due to a limited selection of indicators for D3, and to a limited number of indicators evaluated for D8 and D9. D2 and D11 sets did not encompass any indicator with thresholds and thus there is no data presented in the graph.

Descriptor 4 encompasses a high percentage of indicators with thresholds. However, the majority are indicators shared with Descriptor 5. Thus, there are not specific thresholds regarding D4. The percentages of indicators with thresholds for D8 and D9 are biased by the limited selection consisting of 4 and 3 indicators, respectively. Actually, only one indicator was evaluated for each descriptor and thus the thresholds identified belong to IDEM_D8_I1 and IDEM_D9_I1 indicators. Although D6 is one of the descriptors with lower percentages of thresholds, most of those identified are applicable to the deep Mediterranean Sea and are consequently recognized as valuable thresholds. Only one indicator of the D10 set (IDEM_D10_I6) was provided with a threshold. However, due to the multiple amendments required it was classified as inapplicable. Applicability of the thresholds is described below. Finally, no threshold was identified for the indicators revised for Descriptor 2 and 11.

Besides revising if thresholds were available, their applicability to the deep sea was assessed as well. Applicability can be assessed in multiple ways. Considering the framework applied in TG Noise workshop (2018), the applicability of a threshold was understood as the suitability of the methodology used. Accordingly, if methods were available and suitable for the deep-sea, the threshold was considered applicable. It should be kept in mind that before actual implementation most of the applicable thresholds still require new data from the deep sea. The descriptor with the highest percentage of applicable thresholds is D4, sharing most of them with D5 due to the high number of shared indicators between D4 and D5 (see chapters 3.2.4 and 3.2.5 for details). As already commented, D6 thresholds are also applicable since the methodologies used would enable the establishment of deep-sea specific threshold when enough data becomes available. The same case applies to the two indicators from the D3 set. Regarding D8 and 10, the thresholds established are not yet applicable to the deep Mediterranean Sea. Unlike D8, the implementation of the thresholds defined for the IDEM_D9_I1 indicator is recommended until results from deep-sea species become available.

The following subsections will present the results obtained for each descriptor. Although the results vary between descriptors, the contents are consistently structured. Each section incorporates a number of tables that describe each of the thresholds identified in the indicators revised in Task 3.2 (IDEM Project, 2019b). The tables are completed with a brief text describing the thresholds and its potential application, specifying what needs to be adapted or reconsidered. The adaptations are summarized within the tables with two symbols illustrating data (D) and methods (M). The first one, (D), refers to the thresholds that can be applied only by changing the data used for the threshold calculation, without any methodology adaptation. The methods with the symbol (M) are present in those thresholds where also the methods and/or formulas used in the calculations require reformulation. The specification of the type of adaptations required identifies the indicators where methodology is already available to set thresholds. The definition of the methodology available and thus the data required is the first step required in the approach defined by the Technical Group on Noise workshop when fundamental gaps hinder the establishment of thresholds (TG Noise, 2018). Finally, a paragraph is incorporated with a summary regarding the amount of missing thresholds, the reasons behind and the potential solutions that could be adopted.

3.2.1 *Descriptor 1*

The thresholds displayed in Figure 3 regarding D1 refer to indicators adopted from D4 and D6. Accordingly, details about these thresholds and their applicability are provided within D4 and D6 chapters (3.2.4 and 3.2.6, respectively). In order to know which are the D4 and D6 indicators used also for monitoring D1, see Deliverable 3.2 (IDEM Project, 2019b, 2019c) where the selection of indicators for each descriptor is explained and accurately disclosed.

The evaluation of the D1-specific indicators (i.e. those relevant to the themes “Species groups of birds, mammals, reptiles, fish and cephalopods” (criteria D1C1 to D1C5) and “Pelagic habitat” (criterion D1C6) indicated that no threshold values exist for any of the selected indicators, and reference conditions in the deep sea are practically unknown. This is due to two main reasons. Firstly, the formulation of the D1-specific indicators is rather broad, referring to parameters that could be monitored “for selected species”, without actually naming particular species. This resulted from the lack of indicators focused on the deep sea or deep-sea species, with most of the indicators originally formulated with reference to shallow-water biota. Secondly, there is lack of data on the selected indicators for the Mediterranean deep sea species in general, given the high costs associated with obtaining such data and the absence of deep-sea monitoring programs that could generate the data. Identifying thresholds or reference conditions is therefore not possible at present.

The next step in terms of implementation of Descriptor 1 in the Mediterranean deep sea is further development of the selected indicators, including determining the species that could be targeted through baseline studies and monitoring programs. Baseline studies should preferably be undertaken in both pristine and potentially impacted deep-sea areas, allowing comparison of indicator values between the two. This would yield information on the extent of change in indicator values linked to specific impacts, and hence facilitate the identification of threshold values. Since several of the D1-sepcific indicators relate to ecological parameters that show temporal variation, regular monitoring at pristine sites (i.e. temporal replication) is needed to establish the range of variation in indicator values that can be considered to represent reference conditions.

3.2.2 *Descriptor 2*

The evaluation of the D2-specific indicators relevant to the themes “Rate of arrival of new NIS, Trends in the abundance of NIS, Trends in the spatial extent of NIS, (D2C1, D2C2, D2C2, D2C3)" is based on recent findings of invasive species (fish and crustaceans) on the upper continental slope of the Levant Sea. The data is fragmentary, resulting from serendipitous finds. Based on the current state of knowledge, no threshold values can be proposed for the selected indicators mentioned above.

In order to formulate threshold values surveys of the benthic and demersal biota of the shelf break/slope interface and upper slope should be undertaken.

3.2.3 *Descriptor 3*

The graphic representation of thresholds availability in Figure 3 exposes D3 as the descriptor with highest percentages of existing and applicable thresholds. This mostly illustrates the low number of D3 indicators and the fact that they are based on already existing and widely agreed methodologies. The thresholds identified are presented in Table 1 and 2. The indicators are generic and may be applied to deep ecosystems as they treat exploited species at stock level (whether or not they inhabit shallow or deep habitats). As a result, no adaptation is required. The major difficulty in their use is the need to obtain for each stock an analytical stock evaluation which require 1) a good understanding of the species life cycle (which may require preliminary studies for some of the least understood deep species), 2) long enough time series (2-3 decades) which are often lacking in official catch and effort data to set appropriate thresholds and 3) fishery scientists to perform the evaluation (the number of which is notoriously insufficient in the Mediterranean relative to the number of exploited stocks). In the absence of long enough time series, methodologies to compute proxies were agreed for fishery mortality. However, no such approximation exists for SSB as of yet and long term monitoring is still required.

IDEM_D3_I1		
Fishing mortality (F) gives an estimate of the pressure that fishing has on a stock. The fishing mortality rate (F) of commercially exploited species is at or below the level of the reference point of the fishing mortality at Maximum Sustainable Yield (MSY) *Minor adaptations required (D)*		
Exploitation level at or below Maximum Sustainable Yield (MSY)	F_{MSY} or $F_{0.1}$	Proxy proposed as threshold. Requires analytical stock evaluations over long time series (D)
MAIN REFERENCE: **Hillborn and Walters (1992)** ADDITIONAL: Gulland and Boerema (1973)		

Table 1. Definition of the thresholds identified for IDEM_D3_I1 indicator including relevant references and comments. (D) Represents the adaptations requiring only new data for its application and (M) the adaptations where a reformulation of the methodology might be needed.

IDEM_D3_I2		
The amount of spawners (Spawning Stock Biomass, SSB) measures the ability of a stock to reproduce. The SSB of commercially exploited species is at or above the level of the reference point of the SSB at Maximum Sustainable Yield (MSY) *Minor adaptations required (D)*		
Population renewal capacity ensuring maximum sustainable yield	B_{MSY}	Proxy proposed as threshold. Requires analytical stock evaluations over long time series (D)
MAIN REFERENCE: **Hillborn and Walters (1992)** ADDITIONAL: Trenken (2006); ICES (2015)		

Table 2. Definition of the thresholds identified for IDEM_D3_I2 indicator including relevant references and comments. (D) Represents the adaptations requiring only new data for its application and (M) the adaptations where a reformulation of the methodology might be needed.

3.2.4 *Descriptor 4*

Out of the 22 indicators identified for D4, ten have a threshold reported in literature. However, these thresholds were essentially designed for coastal systems and, with the exception of IDEM_D4_I21 and I22, all values available have been formulated based on case studies outside the Mediterranean. Thus, with the exceptions indicated, **all are not applicable "as they are" but needed an adaptation for the Mediterranean** and in many cases for the deep sea. For example, the threshold for IDEM_D4_9 "Large fish (by weight) (MSFD 4.2.1)" has been set up for the North Sea (Greenstreet et al., 2011), the Celtic Sea (Shephard et al., 2011). Modica et al. (2014) highlighted that in transferring the Large fish indicator (LFI) for use in a new marine region, it has to be taken into account that fish communities vary from place to place in their composition and structure, reflecting differences in local environmental and habitat conditions (Fisher et al., 2010). Thus, both the exact definition (i.e. the large fish threshold length) of the LFI and the management target deemed most appropriate in one sea area may not be so relevant in another marine region. Further, still related to the example of the LFI, the thresholds were calculated mostly using fish species inhabiting the continental shelf, with very few exceptions (i.e., *Galeus melastomus*, *Merluccius merluccius*, *Phycis blennoides* and *Helicolenus dactylopterus*; see Table 1 in Modica et al., 2014). Still, the value of 35 cm which is considered the most appropriate “large” fish defining threshold length for the fish community in the Bay of Biscay (Modica et al., 2014), seems unrealistic for the Mediterranean (also for shelf-inhabiting species), considering that the comparisons of biomass spectra between Mediterranean and Atlantic assemblages, show clear differences. Where the same species occurs in both the deep Mediterranean and the Atlantic, those in the Mediterranean tend to attain a smaller adult size (Massuti et al., 2004). This indicator, together with IDEM_D4_I7 (suggested for the Central Baltic Sea; Casini et al., 2009), IDEM_D4_I8 (as for LFI, developed for the North Sea, Greenstreet et al., 2011) and IDEM_D4_I11, need major adaptations as they should be tested with new data for the Mediterranean and specific regarding deep-sea communities/species.

Other indicators such as IDEM_D4_I6, IDEM_D4_I7 and IDEM_D4_I20-22 have been developed for coastal environments, but have been already tested, or even developed, in the Mediterranean, so minor adaptations are required in order to set the indicators by using specific data concerning deep-sea ecosystems. However, for indicators IDEM_D4_I20-22, which are shared with D5, thresholds are specifically defined for Descriptor 5. Thus, they are not specific thresholds regarding D4.

IDEM_D4_I6, IDEM_D4_I7 and IDEM_D4_I21					
I6: Abundance/distribution of key trophic groups/species (MSFD 4.3) I7: Abundance trends of functionally important selected groups/species (MSFD 4.3.1). I21: Presence of particularly sensitive and/or tolerant species (MSFD 6.2.1) *Minor adaptations required (D)*					
EQS (Ecological Quality Status)	**AMBI VALUES**	**AMBI EQR**	**BENTIX VALUES**	**BENTIX EQR**	**M-AMBI EQR**
High	0<AMBI ≤ 1.2	0.83	4.5 ≤ BENTIX < 6	0.75	0.83
Good	1.2 <AMBI ≤ 3.3	0.53	3.5 ≤ BENTIX < 4.5	0.58	0.62
Moderate	3.3 <AMBI ≤ 4.3	0.39	2.5 ≤ BENTIX < 3.5	0.42	0.41
Poor	5.5 <AMBI ≤ 6	0.21	2.0 ≤ BENTIX < 2.5	0.33	0.20
Bad	0<AMBI ≤ 6	0	0	0	0
EQS (Ecological Quality Status)	**MEDOCC VALUES**	**MEDOCC EQR**	BENTIX evaluates the cumulative contribution of tolerant and opportunistic species and their combined occurrence in the fauna more stringently than MEDOCC. The M-AMBI index is an integrative multi-metric index better suited than the AMBI to the Mediterranean. However, the combination of diversity measures such as the Shannon diversity index and species richness, which are dependent on habitat type, sample size, seasonal variations and natural dominance of		
High	0< MEDOCC<1.6	0.73			
Good	1.6< MEDOCC< 3.2	0.47			
Moderate	3.2< MEDOCC <4.77	0.20			
Poor	4.77< MEDOCC<5.5	0.08			
Bad	5.5< MEDOCC<6	0			

			characteristic species, sometimes leads to misinterpretations
MAIN REFERENCE: **Simboura and Argyrou (2010)**			
IDEM_D4_I7			
Abundance trends of functionally important selected groups/species (MSFD 4.3.1) *Major adaptations required (D)*			
Planktivore abundance. Ecological threshold separating two alternative ecosystem configurations in which zooplankton dynamics are driven by either hydroclimatic forces or predation pressure and characterized by different system structure, functioning, and stability	$\approx 17 \times 10^{10}$ individuals	Threshold applied within the Baltic sea for the study of sprat abundances that allows identifying one cod-dominated configuration characterized by low sprat abundance and a marked independence between zooplankton and sprat variations, and one sprat-dominated configuration in which cod biomass is low and zooplankton become strongly controlled by sprat predation	
MAIN REFERENCE: **Casini et al. (2009)**			

Table 3. Definition of the thresholds identified for IDEM_D4_I6, IDEM_D4_I7 and IDEM_D4_I21 indicators including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

IDEM_D4_I8 and IDEM_D4_I9	
I8: Proportion of selected species at the top of food webs (MSFD 4.2.) I9: Large fish (by weight) (MSFD 4.2.1) *Major adaptations required (D)*	
Proportion of species larger than 40 cm	Indicator applied in the North Sea
MAIN REFERENCE: **Greenstreet et al. (2011)**	

Table 4. Definition of the thresholds identified for IDEM_D4_I8 and IDEM_D4_I9 indicators including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed

Thresholds for indicators IDEM_D4_I8 and IDEM_D4_I9 could be proposed based on the warning thresholds presented in Table 3. The table was obtained from Link, (2005) where indicators empirically derived from the Georges Bank, Gulf of Maine ecosystem were presented. Further development in the translation of ecosystem indicators into decision criteria is one of the major areas for progress in fisheries science and management.

Ecosystem indicators translated into warning thresholds and limit reference points for EBFM (B: biomass; subscripts $\sum$, TL3, benth, plank: all surveyed species in the system, all species at trophic level 3, all benthivores, all planktivores, respectively; PP: primary production; $B_{\sum Cons}$: the sum of biomass consumed by all species in the ecosystem; S_{min}: minimum number of species; $\overline{L/S}_{max}$: maximum mean number of interactions per species; C_{max}: maximum number of cycles observed; $N_{scav\text{-}med}$: median abundance of scavengers; $V_{jelly\text{-}med}$: median biovolume of gelatinous zooplankton; A_{max}: maximum area of living, hard coral; N/A: not applicable).

Indicator	Description	Warning threshold	Limit reference point
$\bar{l}$	Mean length, all species	30%	50%
β	Slope size spectrum, all species	N/A	10%
$B_{flatfish}$	B of all flatfish species	$B_{flatfish} > 50\% B_{\sum}$	$B_{flatfish} > 75\% B_{\sum}$
$B_{pelagic}$	B of all pelagic species	$B_{pelagic} > 75\% B_{\sum}$ or $B_{pelagic} < 20\% B_{\sum}$	$B_{pelagic} > 85\% B_{\sum}$ or $B_{pelagic} < 10\% B_{\sum}$
B_{TL4+}	B of all species at trophic level 4 and above	$B_{TL4+} > 25\% B_{TL3}$	$B_{TL4+} > 50\% B_{TL3}$
B_{pisc}	B of all piscivores	N/A	$B_{pisc} > B_{benth} + B_{plank}$
$L_{\sum}$	Landings of target species	$L_{\sum} > 5\%$ PP	$L_{\sum} > 10\%$ PP
$\overline{L/S}$	Mean number of interactions per species	10% below $\overline{L/S}_{max}$	N/A
B_{remov}	Fishery removals of all species (landings, bycatch, discards, etc.)	N/A	$B_{remov} > B_{\sum Cons}$
S	Species richness (number of species)	$S < S_{min}$, for 3 years	$S < S_{min}$, for 5 years
C	Number of cycles	30% below C_{max}	N/A
N_{scav}	Abundance of scavengers	100% above $N_{scav\text{-}med}$	200% above $N_{scav\text{-}med}$
V_{jelly}	Volume of gelatinous zooplankton	100% above $V_{jelly\text{-}med}$	200% above $V_{jelly\text{-}med}$
A_{coral}	Area of live, hard coral	30% below A_{max}	50% below A_{max}

Table 5. See original caption below (Link, 2005).

IDEM_D4_I11	
Performance of key predator species using their production per unit biomass (productivity) (MSFD 4.1.1) *Major adaptations required (D)*	
Pelagic fish exceeds 75% or drops 25% below of total fish biomass	Example that need adaptation to the Mediterranean Deep sea Ecosystem
MAIN REFERENCE: **Link (2005)**	

Table 6. Definition of the thresholds identified for IDEM_D4_I11 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

IDEM_D4_I20		
Quantity of the sedimentary organic matter *Minor adaptations required (D)*		
[TOC] < 10 $mg \cdot g^{-1}$	Low risk of decreased species richness	Total organic carbon (TOC) concentrations in sediments in a range of temperate coastal ecosystems were a good indicator for benthic health in terms of benthic species richness
[TOC] > 35 $mg \cdot g^{-1}$	High risk of decreased species richness	
MAIN REFERENCE: **Hyland et al. (2005)** ADDITIONAL: Jessen et al. (2015)		

Table 7. Definition of the thresholds identified for IDEM_D4_I20 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

IDEM_D4_I21			
Biochemical composition of the sedimentary organic matter *Minor adaptations required (D)*			
EQS (Ecological Quality Status)	**Biopolymeric Carbon (BPC)**	**Algal Fraction**	This thresholds are from an output of the cluster analysis discriminating sampling stations on the basis of biopolymeric C concentration in the sediment and the percentage contribution of phytopigments to BPC
Eutrophic	> 3 mgC /gDW	< 12% of BPC	
Mesotrophic	1-3 mgC/ gDW	12-25% of BPC	
Oligotrophic	< 1.0 mgC/gDW	>25% of BPC	
MAIN REFERENCE: **Pusceddu et al., 2011** ADDITIONAL: Bianchelli et al., 2016.			
EQS (Ecological Quality Status)	**Proteins**	**Carbohydrate**	-
Hypertrophic	> 4mg/g	>7 mg/g	
Eutrophic	1.5 - 4 mg/g	5 -7 mg/g	
Meso-oligotrophic	< 1.5 mg/g	<5 mg/g	
MAIN REFERENCE: **Dell'Anno et al. (2002)** ADDITIONAL: Bianchelli et al. (2016)			

Table 8. Definition of the thresholds identified for IDEM_D4_I21 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

IDEM_D4_I22		
Bioavailability of sedimentary organic matter *Minor adaptations required (D)*		
[BPC] > 2.5 mgC·g^{-1}	Bioavailable fraction is less than 10%.	These 2 values, when verified contemporarily in the same area, can, thus, be proposed as threshold levels out of which accumulation of BPC leads to altered organic matter bioavailability to benthic consumers
MAIN REFERENCE: **Pusceddu et al. (2009)**		

Table 9. Definition of the thresholds identified for IDEM_D4_I22 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

3.2.5 *Descriptor 5*

The revision of Descriptor 5 identified only 6 indicators out of 18, for which thresholds or reference conditions were defined. The revision of the thresholds clearly underlined the gap of data regarding the deep sea and pointed out that only few indicators (IDEM_D5_I5, I10 I20-22) present threshold levels validated also for deep-sea systems. Most of the thresholds, especially those related to quantity and quality of sedimentary organic matter were identified in the Mediterranean Basin, at different water depths. Others related to benthic community indexes were validated only in shallow-water ecosystems. Consequently, the actual implementation and validity of the compiled thresholds should be carefully inspected.

Indicators I10 and I28 (IDEM_D5_I10 and IDEM_D5_I28, Table 10), encompass relevant multi-metric indexes assessing benthic assemblages (in terms of community composition and response to disturbances). One main article was identified establishing reference conditions and thresholds for different indexes (Simboura and Argyrou, 2010; Table 10). It should be taken into account that all the indexes were validated in coastal systems. Consequently, although most of them do not require method reformulation, their performance should be tested with deep-sea data.

<table>
<tr><th colspan="6">IDEM_D5_I10 and IDEM_D5_I28</th></tr>
<tr><td colspan="6">I10: Abundance and taxonomic composition of macrofaunal communities of benthic habitats

I28: Presence of particularly sensitive and/or tolerant species (MSFD 6.2.1)

Major/minor adaptations required (M,D) depending on the index</td></tr>
<tr><th>EQS (Ecological Quality Status)</th><th>AMBI VALUES</th><th>AMBI EQR</th><th>BENTIX VALUES</th><th>BENTIX EQR</th><th>M-AMBI EQR</th></tr>
<tr><td>High</td><td>0<AMBI ≤ 1.2</td><td>0.83</td><td>4.5 ≤ BENTIX < 6</td><td>0.75</td><td>0.83</td></tr>
<tr><td>Good</td><td>1.2 <AMBI ≤ 3.3</td><td>0.53</td><td>3.5 ≤ BENTIX < 4.5</td><td>0.58</td><td>0.62</td></tr>
<tr><td>Moderate</td><td>3.3 <AMBI ≤ 4.3</td><td>0.39</td><td>2.5 ≤ BENTIX < 3.5</td><td>0.42</td><td>0.41</td></tr>
<tr><td>Poor</td><td>5.5 <AMBI ≤ 6</td><td>0.21</td><td>2.0 ≤ BENTIX < 2.5</td><td>0.33</td><td>0.20</td></tr>
<tr><td>Bad</td><td>0<AMBI ≤ 6</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><th>EQS (Ecological Quality Status)</th><th>MEDOCC VALUES</th><th>MEDOCC EQR</th><td colspan="3" rowspan="6">BENTIX evaluates the cumulative contribution of tolerant and opportunistic species and their combined occurrence in the fauna more stringently than MEDOCC. The M-AMBI index is an integrative multi-metric index better suited than the AMBI to the Mediterranean</td></tr>
<tr><td>High</td><td>0< MEDOCC<1.6</td><td>0.73</td></tr>
<tr><td>Good</td><td>1.6< MEDOCC< 3.2</td><td>0.47</td></tr>
<tr><td>Moderate</td><td>3.2< MEDOCC <4.77</td><td>0.20</td></tr>
<tr><td>Poor</td><td>4.77< MEDOCC<5.5</td><td>0.08</td></tr>
<tr><td>Bad</td><td>5.5< MEDOCC<6</td><td>0</td></tr>
<tr><td colspan="6">MAIN REFERENCE: Simboura and Argyrou (2010)</td></tr>
</table>

Table 10. Definition of the thresholds identified for IDEM_D5_I10 and IDEM_D5_I28 indicators including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

The following threshold levels reported in Table 11, are related to indicator IDEM_D5_I20. This indicator targets the quantity of sedimentary organic matter and its potential use to indicate the status of marine benthos. The thresholds stated in Table 11 should be understood as minimum and maximum levels of Total organic carbon (TOC) concentrations that imply low and high risks, respectively, of decreased species richness. Values have been validated in coastal systems, also within the Mediterranean Sea (Hyland et al., 2005). The performance of the indicator and consequently the threshold values proposed should be tested and eventually updated with data from deep Mediterranean systems.

IDEM_D5_I20		
Quantity of the sedimentary organic matter *Minor adaptations required (D)*		
[TOC] < 10 mg·g^{-1}	Low risk of decreased species richness	Total organic carbon (TOC) concentrations in sediments in a range of temperate coastal ecosystems were a good indicator for benthic health in terms of benthic species richness
[TOC] > 35 mg·g^{-1}	High risk of decreased species richness	
MAIN REFERENCE: **Hyland et al. (2005)** ADDITIONAL: Jessen et al. (2015)		

Table 11. Definition of the thresholds identified for IDEM_D5_I20 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used.

IDEM_D5_I5 and IDEM_D5_I21 target the quality of sedimentary organic matter, i.e., the percentage of algal fraction and its biochemical composition. Threshold levels reported in tables 12 and 13 (first part) were identified in deep Mediterranean ecosystems, by using cluster analysis (Pusceddu et al., 2011). Levels reported in the second part of Table 13 were identified by a previous study (Dell'Anno et al., 2002), and developed in coastal ecosystems. Thus, the performance of the index and consequently the threshold values proposed regarding ecological quality levels should be tested with new data from deep Mediterranean Sea.

IDEM_D5_I5			
Concentration of Chlorophyll-a in the sediment *Minor adaptations required (D)*			
EQS (Ecological Quality Status)	**Biopolymeric Carbon (BPC)**	**Algal Fraction**	This thresholds are from an output of the cluster analysis discriminating sampling stations on the basis of biopolymeric C concentration in the sediment and the percentage contribution of phytopigments to BPC
Eutrophic	> 3 mgC /gDW	< 12% of BPC	
Mesotrophic	1-3 mgC/ gDW	12-25% of BPC	
Oligotrophic	< 1.0 mgC/gDW	>25% of BPC	
MAIN REFERENCE: **Pusceddu et al. (2011)** ADDITIONAL: Bianchelli et al. (2016)			

Table 12. Definition of the thresholds identified for IDEM_D5_I15 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used.

IDEM_D5_I21			
Biochemical composition of the sedimentary organic matter *Minor adaptations required (D)*			
EQS (Ecological Quality Status)	**Biopolimeric Carbon (BPC)**	**Algal Fraction**	This thresholds are from an output of the cluster analysis discriminating sampling stations on the basis of biopolymeric C concentration in the
Eutrophic	> 3 mgC /gDW	< 12% of BPC	
Mesotrophic	1-3 mgC/ gDW	12-25% of BPC	

Oligotrophic	< 1.0 mgC/gDW	>25% of BPC	sediment and the percentage contribution of phytopigments to BPC (Pusceddu et al., 2011)
MAIN REFERENCE: **Pusceddu et al. (2011)** ADDITIONAL: Bianchelli et al. (2016)			
EQS (Ecological Quality Status)	**Proteins**	**Carbohydrate**	Dell'Anno et al., 2002
Hypertrophic	> 4mg/g	>7 mg/g	
Eutrophic	1.5 - 4 mg/g	5 -7 mg/g	
Meso-oligotrophic	< 1.5 mg/g	<5 mg/g	
MAIN REFERENCE: **Dell'Anno et al. (2002)** ADDITIONAL: Bianchelli et al. (2016)			

Table 13. Definition of the thresholds identified for IDEM_D5_I21 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used.

The following levels are related to indicator IDEM_D5_I22 (Table 14). The two values (BPC concentrations and its bioavailable fraction) can be proposed as threshold levels out of which accumulation of BPC leads to altered organic matter bioavailability to benthic consumers. Such values were identified by Pusceddu et al. (2009) analyzing different oceanic and coastal regions at different water depths, including the Mediterranean Sea. The performance of the indicator and consequently the threshold values proposed should be tested with further data from deep Mediterranean systems.

IDEM_D5_I22		
Bioavailability of sedimentary organic matter *AMinor adaptations required (D)*		
[BPC] > 2.5 mgC·g^{-1}	Bioavailable fraction is less than 10%.	These 2 values, when verified contemporarily in the same area, can, thus, be proposed as threshold levels out of which accumulation of BPC leads to altered organic matter bioavailability to benthic consumers
MAIN REFERENCE: **Pusceddu et al. (2009)**		

Table 14. Definition of the thresholds identified for IDEM_D5_I22 indicator including relevant references and comments. (M) Represents the adaptations where a reformulation of the methodology might be needed.

Thresholds outlined above are related to indicators, describing quantity and quality of sedimentary organic matter, which were proposed also in the frame of Descriptor 4. Thus, those thresholds are not specific for D5, but could be used for both Descriptors.

Within the indicators selected for Descriptor 5, 13 are currently lacking reference conditions and threshold levels. The review of criteria, indicators and thresholds performed under IDEM project highlights that data and knowledge available regarding deep sea are not enough to set appropriate threshold levels. For some indicators, such as IDEM_D5_I1, I2, I8, I11 and I19, data regarding deep-sea ecosystems have been collected, but thresholds have not been identified yet. Further efforts should be done in order to use the collected data to set reference conditions and threshold levels, depending on the pressure, habitats and regions considered. For the rest of indicators, difficulties of sampling the deep sea and the scarcity of data hinders the identification of reference conditions and thresholds. Approaches and methodologies could be adapted from the existing ones to guarantee the actual and successful implementation of the MSFD in the deep sea. TG Noise group in 2018 (TG Noise, 2018) proposed to first identify the methodology available and thus the data required for implementation. In the case of Descriptor 5, there is urgent need of methods revision and data collection before the establishment of missing thresholds.

3.2.6 *Descriptor 6*

The revision of Descriptor 6 indicators identified only 5 indicators out of 23 where thresholds or reference conditions were defined. Accordingly, the paragraphs below, together with five tables, one for each indicator, state and describe the identified thresholds. A revision of the thresholds clearly exposed the data gap regarding the deep-sea, since only one indicator (IDEM_D6_I25) involved some analysis of deep-sea systems. Additionally, half of the thresholds were validated in systems outside the Mediterranean Basin. Consequently, the actual implementation and validity of the compiled thresholds should be carefully inspected.

Indicator I6 (IDEM_D6_I6), defined in Table 15, is related to indicator I25 (IDEM_D6_I25) presented in Table 16, since both target fishing activities and their impacts on the benthic communities. The threshold stated in Table 15 should be understood as the implementation of the formula of maximum trawling frequency defined in the last row of Table 16 ($f = R^{-1}$). This formula establishes a threshold for bottom trawling frequency based on the recovery time of the community. If trawling frequency is below the threshold the populations will be temporarily reduced but will be able to recover. The threshold defined in IDEM_D6_I6 stated a concrete maximum frequency considering the community present in the habitat studied (Eigaard et al., 2017), thus new data is required for establishing this threshold in Mediterranean deep-sea systems. IDEM_D6_I25 compiles other thresholds and reference conditions, all based on the properties of the communities, and thus is habitat-dependent. The methodology behind this thresholds and reference conditions is valuable and applicable but sets of data regarding deep Mediterranean systems are required to set actual numeric thresholds.

<table>
<tr><th colspan="3">IDEM_D6_I6</th></tr>
<tr><td colspan="3">Distribution and aggregation (intensity) of fishing activities. Footprint per unit of landings

Minor adaptations required (D)</td></tr>
<tr><td>Critical trawling intensity</td><td>0.1 $year^{-1}$</td><td>Habitat-specific</td></tr>
<tr><td colspan="3">MAIN REFERENCE: Eigaard et al. (2017)
ADDITIONAL: Collie et al. (2000); Kaiser et al. (2006); van Denderen et al. (2015); Pitcher et al. (2016) and Rijnsdorp et al. (2016)</td></tr>
</table>

Table 15. Definition of the thresholds identified for IDEM_D6_I6 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

<table>
<tr><th colspan="3">IDEM_D6_I25</th></tr>
<tr><td colspan="3">Ecological impact of bottom trawling on the benthic community: seabed integrity, functionality and recoverability

Minor adaptations required (D)</td></tr>
<tr><td colspan="2">SBI= 0 all taxa impacted</td><td rowspan="2">Based on the longevity of the community (habitat-specific)</td></tr>
<tr><td colspan="2">SBI=1 none of the taxa impacted</td></tr>
<tr><td colspan="3">MAIN REFERENCE: Eigaard et al. (2017)
ADDITIONAL: Thrush et al. (2005)</td></tr>
<tr><td>State indicator</td><td>Benthic invertebrate biomass (B) or production (P) is greater than 90% of pristine benthic biomass ($B_{0.9}$) or production ($P_{0.9}$)</td><td rowspan="2">Based on the time to recovery to $B_{0.9}$ and $P_{0.9}$ after trawling estimated using a size-based model of the benthic community</td></tr>
<tr><td>Pressure indicator</td><td>The proportion of the area where trawling frequency is sufficiently high to prevent predicted B or P reaching predicted $B_{0.9}$ or $P_{0.9}$</td></tr>
<tr><td colspan="3">MAIN REFERENCE: Hiddink et al. (2006)
ADDITIONAL: Duplisea et al. (2002)</td></tr>
<tr><td>Trawling pressure indicators</td><td>Traffic light system of data classification (0-1)</td><td rowspan="2">The distribution of subsurface impact was qualitative classified with a traffic light system than can help infer the range levels of the pressure and its impacts. Additional references: Eigaard et al. (2015, 2016)</td></tr>
<tr><td>Index of trawling impact</td><td>Traffic light system of data classification (0-1)</td></tr>
<tr><td>Maximum trawling frequency</td><td>f = R-1
(f=trawling frequency, R= recovery time)</td><td>Trawling frequency threshold based on the recovery time of the benthic community. Additional references: Thrush et al. (2005); Bolam et al. (2014)</td></tr>
<tr><td colspan="3">MAIN REFERENCE: Rijnsdorp et al. (2016)
ADDITIONAL: Thrush et al. (2005); Bolam et al. (2014); Eigaard et al. (2015, 2016)</td></tr>
</table>

Table 16. Definition of the thresholds identified for IDEM_D6_I25 indicator including relevant references and comments. This indicator encompasses multiple measures applied in different articles and thus different kinds of thresholds. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

The following indicator (IDEM_D6_I19) encompasses relevant multi-metric indexes that can assess the community, its properties and its response to disturbances. Regarding thresholds, four different articles establishing reference conditions and thresholds for particular indexes were identified (Borja et al., 2000; Simboura and Zenetos, 2002; Rosenberg et al., 2004 and Labrune et al., 2006), see Table 17. However it should be considered that all the indexes were validated in coastal systems. Consequently, although most of them do not require, apparently, methodological reformulations, their performance should be tested with actual data from Mediterranean deep-sea systems. Accordingly, thresholds also need to be updated with deep-sea data following the approaches defined for each index.

<table>
<tr><th colspan="4">IDEM_D6_I19</th></tr>
<tr><td colspan="4">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)

Major/minor adaptations required (M,D) depending on the index</td></tr>
<tr><td>Unpolluted</td><td>0.0 < BC < 0.2</td><td>Normal (benthic community)</td><td rowspan="8">AMBI Index. Based on species sensitivity to a stress gradient in coastal systems. The index is based on ecological grouping of the species regarding an organic enrichment disturbance. Thus, major adaptations are required concerning both data and methods (M, D)</td></tr>
<tr><td>Unpolluted</td><td>0.2 < BC < 1.2</td><td>Impoverished</td></tr>
<tr><td>Slightly polluted</td><td>1.2 < BC < 3.3</td><td>Unbalanced</td></tr>
<tr><td>Meanly polluted</td><td>3.3 < BC < 4.3</td><td>Transitional to polluted</td></tr>
<tr><td>Meanly polluted</td><td>4.5 < BC < 5.0</td><td>Polluted</td></tr>
<tr><td>Heavily polluted</td><td>5.0 < BC < 5.5</td><td>Transitional to heavily polluted</td></tr>
<tr><td>Heavily polluted</td><td>5.5 < BC < 6.0</td><td>Heavily polluted</td></tr>
<tr><td>Extremely polluted</td><td>Azoic</td><td>Azoic</td></tr>
<tr><td colspan="4">MAIN REFERENCE: Borja et al. (2000)</td></tr>
<tr><td>Normal/Pristine</td><td>4.5 ≤ BENTIX < 6.0</td><td>High (ECoQ)</td><td rowspan="5">BENTIX Index. Based on the AMBI index described in Borja et al., 2000. Ecological groups are also formulated but the species are classified within only two wider ecological groups, the sensitive and the tolerant. Although validated in coastal systems, fewer adaptations are expected to be required for its application in deep-sea systems (D)</td></tr>
<tr><td>Slightly polluted, transitional</td><td>3.5 ≤ BENTIX < 4.5</td><td>Good (ECoQ)</td></tr>
<tr><td>Moderately polluted</td><td>2.5 ≤ BENTIX < 3.5</td><td>Moderate (ECoQ)</td></tr>
<tr><td>Heavily polluted</td><td>2.0 ≤ BENTIX < 2.5</td><td>Poor (ECoQ)</td></tr>
<tr><td>Azoic</td><td>0</td><td>Bad (ECoQ)</td></tr>
<tr><td colspan="4">MAIN REFERENCE: Simboura and Zenetos (2002)</td></tr>
<tr><td>≥ 16.0</td><td>High (ECoQ)</td><td colspan="2" rowspan="5">BQI Index. Based on a combination of the species tolerance and sensitivity to disturbance together with species abundance values, distribution pattern ant total number of species. The index needs to be adapted considering new data on Mediterranean deep-sea ecosystems (D)</td></tr>
<tr><td>16>12</td><td>Good (ECoQ)</td></tr>
<tr><td>12>8</td><td>Moderate (ECoQ)</td></tr>
<tr><td>8>4</td><td>Poor (ECoQ)</td></tr>
<tr><td>4></td><td>Bad (ECoQ)</td></tr>
<tr><td colspan="4">MAIN REFERENCE: Rosenberg et al. (2004)</td></tr>
<tr><td>AMBI >= 1.2</td><td>H' > 4</td><td>High (ECoQ)</td><td></td></tr>
</table>

1.2 < AMBI <= 3.3	3 < H' ≤ 4	Good (ECoQ)	Comparison of three biotic indexes (AMBI, H' and BQI). H' Shannon biodiversity index accounts for species richness and dominance patterns (Pielou, 1975)
3.3 < AMBI <=4.3	2 < H' ≤ 3	Moderate (ECoQ)	
4.3 < AMBI <= 5.5	1 < H' ≤ 2	Poor (ECoQ)	
AMBI > 5.5	H' ≤ 1	Bad (ECoQ)	
MAIN REFERENCE: **Labrune et al. (2006)**			

Table 17. Definition of the thresholds identified for IDEM_D6_I19 indicator including relevant references and comments. This indicator encompasses multiple indexes and various thresholds and/or reference conditions. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

IDEM_D6_I21 encompasses an index based on size-structure metrics that also takes into account other community properties (Table 18). The index, validated in coastal systems of the Mediterranean Sea, describes the methodology and suggests a formula that could be apparently applied to every system. The performance of the index and consequently the threshold values proposed regarding ecological quality levels should be tested and updated with actual data from Mediterranean deep sea systems.

IDEM_D6_I21		
Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community (MSFD 6.2.4) *Minor adaptations required (D)*		
0 - 1.2	High (ECoQ)	Multi-metric indexes named size spectra sensitivity (ISS). The index combines size structure metrics with metrics about the sensitivity of size classes to anthropogenic disturbance and species richness data. The methodology for obtaining threshold values is described and summarized in a formula
1.2-.2.1	Good (ECoQ)	
2.1 - 2.9	Moderate (ECoQ)	
2.9 - 4	Poor (ECoQ)	
4-6	Bad (ECoQ)	
MAIN REFERENCE: **Basset et al. (2012)** ADDITIONAL: JRC (2005)		

Table 18. Definition of the thresholds identified for IDEM_D6_I21 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

The last thresholds identified relate to indicator IDEM_D6_I24, described in Table 19. The thresholds suggested refer to the impact index value encompassed within this indicator. A classification of the values obtained when calculating this impact value provides thresholds for assessing the level of impact. The approach applied allows the application of this classification scheme to any system. Additionally, a unique threshold for GES is proposed to be applied to all kind of habitats. Since the studies behind these thresholds were performed in the Baltic Sea, it should be discussed if the 15% suggested is also the most convenient GES threshold for Mediterranean deep-sea habitats.

<table>
<tr><th colspan="3">IDEM_D6_I24</th></tr>
<tr><td colspan="3">Cumulative impacts on benthic biotopes
Impact index value (anthropogenic cumulative impact)

Minor adaptations required (D)</td></tr>
<tr><td>0</td><td>Not impacted</td><td rowspan="4">Thresholds based on the values of the cumulative impact index calculated and the statistical analysis performed. The index is calculated based on the formula established by Halpern et al. (2008) that takes into account the pressures and the ecosystem components present considering the weight of each pressure on each component</td></tr>
<tr><td>0 - Mean value</td><td>Low impact</td></tr>
<tr><td>Mean value - Mean value + Stdev</td><td>Medium impact</td></tr>
<tr><td>Mean + Stdev - Maximum value</td><td>High impact</td></tr>
<tr><td colspan="3">MAIN REFERENCE: HELCOM (2012b)
ADDITIONAL: Halpern et al. (2008); Korpinen et al. (2012)</td></tr>
<tr><td>25% of the habitat significantly impacted</td><td>Bad conservation status</td><td rowspan="2">Once the habitats are identified as impacted, a threshold for GES is proposed as 15% of habitat considering that under the EU Habitats Directive a threshold of 25% is being used to classify a habitat type to ‘Bad conservation status’</td></tr>
<tr><td>15% of the habitat significantly impacted</td><td>Threshold for GES</td></tr>
<tr><td colspan="3">MAIN REFERENCE: HELCOM (2012b)
ADDITIONAL: Habitats Directive (92/43/EEC)</td></tr>
</table>

Table 19. Definition of the thresholds identified for IDEM_D6_I24 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

Within the indicators selected for Descriptor 6, 18 are currently lacking a threshold or a reference condition. Most of these indicators reflect pressures or their corresponding impacts where the data and/or knowledge available are not enough to set an appropriate threshold. Additionally, the difficulties of sampling the deep sea and the scarcity of data hinder the identification of reference conditions. Approaches and methodologies to find thresholds could be adapted from the existing ones but again the data gap determines its actual calculation and a successful implementation. Therefore, in order to improve this situation the implementation of the approach from the TG Noise group agreed on 2018 (TG Noise, 2018) is recommended. This approach focuses first in the definition of the methodology available and thus the data required for its implementation. In the case of descriptor 6, most of the thresholds identified used methodologies that could be applied in the Mediterranean systems to set thresholds. However, a revision of the methods required for the rest of indicators without thresholds is still missing. In summary, more data is needed before the establishment of most of the missing thresholds.

3.2.7 *Descriptor 7*

The revision of Descriptor 7 indicators did not identify any specific thresholds or reference conditions. The only existing thresholds for D7 are those displayed in Table 19, which refer to the IDEM_D6_I24 indicator adopted to the set of Descriptor 6, but also applicable to Descriptor 7. Accordingly, details about these thresholds and their applicability are provided within D6 chapter (see 3.2.6). In order to know which are the D6 indicators used also for monitoring D7, Deliverable 3.2 should be consulted (IDEM Project, 2019b, 2019c).

For what concern the other identified indicators, due to the intrinsic nature of this descriptor, to the lack of common agreed methodology and the difficulty to provide a quantitative assessment, it is difficult to define clear baselines (neither thresholds nor trends). This is true for coastal area, but especially for the deep sea.
The reason for the general lack of thresholds for Descriptor 7 is also evident looking at the main gaps described for the permanent alteration of hydrographical conditions in Deliverable 3.1 (IDEM Project, 2019a). Gap **D7C1.G3** underlines the methodological operational difficulty to differentiate the impacts of direct anthropogenic pressures and the global change consequences. As reported in González et al., 2015*:* "Thresholds for GES/non GES are almost non-existent. The strong natural variability masks anthropogenic impact, and thus, it is very difficult to set thresholds. It should be possible to define 'impact' (i.e. when a habitat has been altered by changes in hydrology)". Concerning the level of pressure, the main difficulty in setting thresholds is the separation between changes directly linked to large-scale human activities and natural multi-decadal variability and slow long-term changes like climate changes and/or ocean acidification (as also described in gap **D7C1.G4**).
Furthermore, indicators lack in thresholds as the assessment of permanent changes needs reliable reference dataset (lack of long time-series described in gap **D7C1.G2**). In this sense a 30-year reference period is already suggested by Gonzalez et al. (2015), in order to differentiate if an area is affected or not and if the change is permanent and not a signal of natural variability.
Lack in thresholds is also due to the fact that no common monitoring strategies are implemented for D7 (see gap **D7MT.G1**).

The existence of an adequate monitoring programme together with long time-series dataset would be essential for D7 and for the MSFD in general, allowing the assessment of thresholds and background large-scale changes. Fixed long-term observatories should be accurately selected for the continuous monitoring of hydrological variability in key strategic sites, to be used as "sentinel stations".

3.2.8 *Descriptor 8*

Few publications have been found related to the concentrations of contaminants in the deep Mediterranean Sea. Data is scarce, not continuous in time or space and not significant. Thus, the data available is not enough to assess which areas of the Mediterranean deep sea are exposed to pollution. The following four indicators were proposed in the project:

- **IDEM_D8_I1:** Concentration of the contaminants measured in matrices such as biota, sediment and water
- **IDEM_D8_I2**: Effects of contaminants
- **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
- **IDEM_D8_I4:** 8.2.2 Occurrence, origin, extent of significant acute pollution events and their impact on biota physically affected by this pollution

From the four indicators proposed, only the first has been evaluated with difficulties due to low availability of published data.

Table 20 shows threshold values obtained from the compilation of a database (IDEM DB) from literature data of pollution levels of persistent organic compounds (organochlorinated, PAH and aliphatic hydrocarbons) found in sediments and waters of the deep sea areas of the Mediterranean Basin. The only reference values established by the EU Commission are related to mercury levels in surface waters (Directive 2008/105/EC). As presented in Table 20, the actual levels measured and published clearly exceed the reference values. However, mercury (Hg) is rich in deep ocean waters of the Mediterranean basin due to natural processes. Thus, systematic monitoring of pollution levels of sediments and waters is required in the areas where deep ocean marine species are used for human consumption (Descriptor 9). Once correlation between pollution levels in sediments, water and organisms is stablished in the deep sea, simple and cost-effective procedures can be stablished to monitor contamination and calculate proper thresholds (either monitoring the stable location of sediments, or a more variable water or organism targets). Therefore, although the actual thresholds are neither applicable nor sufficient, the monitoring methodology is available and suitable. Accordingly, only minor adaptations were established as required (Table 20).

IDEM_D8_I1					
Concentration of the contaminants measured in matrices such as biota, sediment and water (MSFD 8.1.1) *Minor adaptations required (D)*					
Pollutant	**Type of Target**	**Minimum**	**Maximum**	**Thresholds** Directive 2008/105/EC	**Comments**
PCBs	sediment (ng/g)	1	4,6	-	IDEM DB
DDTs	sediment (ng/g)	0,1	5	-	IDEM DB
HCB	sediment (ng/g)	0,04	0,8	-	IDEM DB
PAH	sediment (ng/g)	15	1834	-	IDEM DB
Hg	sediment (ng/g)	60	70	-	IDEM DB
Hg	sediment (ng/g)	36	90	-	IDEM DB
Hg Total	water (pg/L)	82	1284	50 (pg/L surface waters)	IDEM DB
Hg DGM	water (pg/L)	22	134	50 (pg/L surface waters)	IDEM DB
DMeHg	water (pg/L)	7	2790	50 (pg/L surface waters)	IDEM DB

Hg Total	Particulate (pg/L)	157	1233	-	IDEM DB
Hg	sediment (µg/g)	0,06	0,07	-	IDEM DB
Pb	sediment (µg/g)	17	26	-	IDEM DB
Cd	sediment (µg/g)	0,1	0,15	-	IDEM DB
Hydrocarbons (C10-C34,Pr,Ph)	sediment (ng/g)	1	1500	-	IDEM DB
Total Aliphatic HC	sediment (ng/g)	735	2767	-	IDEM DB – Gulf of Tunis
MAIN REFERENCE: **IDEM Database and Directive 2008/105/EC**					

Table 20. Definition of the thresholds identified for IDEM_D8_I1 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

3.2.9 *Descriptor 9*

As in the case of Descriptor 8, little data is available from studies regarding chemical contamination of fish from deep Mediterranean Sea. Scarce and punctual data does not enable the establishment of statistically significant threshold values. Considering the potential implications of D9-realted data, the application of European Union Commission reference values established for coastal and inland waters species (Commission Regulation (EC) No. 466/2001) is recommended until enough data is obtained from systematic measurements in deep Mediterranean Sea communities (see values in Table 21). Thus, only one indicator has been evaluated (IDEM_D9_I1: Actual levels of contaminants that have been detected), as the other two proposed (IDEM_D9_I2: Number of contaminants which have exceeded maximum regulatory levels and IDEM_D9_I3: Frequency of regulatory levels being exceeded) need frequent and systematic measurements in the deep sea. Unless the particular conditions of the deep Mediterranean strongly influence the contaminants effects on the organisms and thus the effects caused when ingested by humans, only minor adaptations would be needed in the actual threshold values (Table 21).

IDEM_D9_I1				
Actual levels of contaminants that have been detected (MSFD 9.1.1a) *Minor adaptations required (D)*				
Pollutant	**Type of Target**	**Thresholds** (EC) No. 466/2001		**Comments**
Mercury (Hg)	Fish	0,5	EU Maximum (µg/g w.w.)	Data measured in Koenig et al., (2013) in NW Mediterranean deep-sea organism: 0.3 (minimum) – 4.4 (maximum)
Mercury (Hg)	Fish	1	EU Maximum (µg/g w.w.)	-
Lead (Pb)	Fish	0,2	EU Maximum	-

			(µg/g w.w.)	
Lead (Pb)	Fish	0,4	EU Maximum (µg/g w.w.)	-
Lead (Pb)	Crustacean	0,5	EU Maximum (µg/g w.w.)	-
Lead (Pb)	Bivalves	1,5	EU Maximum (µg/g w.w.)	-
Lead (Pb)	Cephalopods	1	EU Maximum (µg/g w.w.)	-
Cadmium (Cd)	Fish	0,05	EU Maximum (µg/g w.w.)	-
Cadmium (Cd)	Fish	0,1	EU Maximum (µg/g w.w.)	-
Cadmium (Cd)	Swordfish	0,3	EU Maximum (µg/g w.w.)	-
Cadmium (Cd)	Crustacean	0,5	EU Maximum (µg/g w.w.)	-
Cadmium (Cd)	Bivalves	1	EU Maximum (µg/g w.w.)	-
Cadmium (Cd)	Cephalopods	1	EU Maximum (µg/g w.w.)	-
Dioxin	Fish and fishery products	4	EU Maximum pg WHO-PCDD/F-TEQ/g fresh weight	-
Dioxin	Fish oil intended for human consumption	2	EU Maximum pg WHO-PCDD/F-TEQ/g fresh weight	-
PAH	Non-smoked fish	2	EU Maximum (µg/Kg w.w.)	-
PAH	Crustacean	5	EU Maximum (µg/Kg w.w.)	-
PAH	Bivalves	10	EU Maximum (µg/Kg w.w.)	-
MAIN REFERENCE: **European Commission regulation (EC). No. 466/2001**				

Table 21. Definition of the thresholds identified for IDEM_D9_I1 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed.

3.2.10 *Descriptor 10*

The revision of Descriptor 10 indicators identified only 1 indicator out of 8 with suggested baseline conditions and proposed targets, which clearly signals the data gap regarding seafloor litter. Thresholds have not been set for any of the indicators whereas baseline values and targets have been suggested only for Indicator 6 (IDEM_D10_I6), as depicted in Table 22. The 19th Meeting of the Contracting Parties to the Barcelona Convention (COP19, Decision IG.22/10) has set baseline conditions and targets for IDEM_D10_I6 based on information extracted from publications about the Mediterranean Sea. However, such reference values and trends are subject to periodic adjustment based on additional data provided by national and/or sub regional monitoring programs. In addition, the defined baseline values and targets have been set without the discrimination between depth ranges, sub-regions or basins, marine provinces, depositional settings, size of litter and/or particular litter items, which hinders the implementation and monitoring of targets and the overall assessment of litter on the seafloor. Thus, regarding deep-sea systems, thresholds and specific baseline values should be set and discussed. For instance, setting item-specific thresholds (based on top-item lists) for different sub-regions and/or depositional settings (e.g. canyons, slopes, abyssal plains, etc.) or seafloor substrates in the deep Mediterranean Sea, and/or setting thresholds linked to different types of harm may be plausible approaches. Furthermore, data and identification on relevant accumulation areas or hotspots should be gathered in order to correctly appreciate the overall trends of litter on the seafloor. For instance, the percentages of litter reduction (% decrease) set as targets for entire sub-regions may not be enough for areas with high accumulation potential or hotspots where litter can be found in much higher quantities. Likewise, the processes that lead to the development of accumulation areas should be further investigated. Finally, information of micro-litter on the seafloor, and particularly in the deep-sea, should also be prioritized due to the actual data scarcity, which currently hinders the application of baselines and targets, and thus thresholds, together with the assessment of the risk that it may pose to particular habitats and organisms.

The main need for setting thresholds regarding the selected indicators of Descriptor 10 is the compilation of greater quantities of seafloor data and harmonization of sampling methods. The establishment of new protocols for sampling the deep-sea floor and the development of entanglement and ingestion indicators for deep-sea organisms are also needed.

<table>
<tr><th colspan="4">IDEM_D10_I6</th></tr>
<tr><td colspan="4">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

Major adaptations required (M,D)</td></tr>
<tr><td rowspan="4">Sea floor litter (items/km²)</td><td>Min value</td><td>0</td><td rowspan="4">Type of target: % decrease
Minimum: stable values
Maximum: 10% decrease in 5 years
15% decrease in 15 years
Established for all the MED</td></tr>
<tr><td>Max value</td><td>1100</td></tr>
<tr><td>Mean value</td><td>179</td></tr>
<tr><td>Proposed baseline</td><td>130 - 230</td></tr>
<tr><td colspan="4">MAIN REFERENCE: COP19 (Decision IG.22/10). (2016)</td></tr>
</table>

Table 22. Definition of the thresholds identified for IDEM_D10_I6 indicator including relevant references and comments. (D) Represents the adaptations requiring only a change of the data used and (M) the adaptations where a reformulation of the methodology might be needed

3.2.11 Descriptor 11

The two indicators revised regarding Descriptor 11 are not provided with any concrete threshold. The lack of basic knowledge, data and long-term monitoring trends hinder the establishment of thresholds. Studies regarding the spatial-temporal distribution of impulsive sounds and low-frequency sounds throughout the Mediterranean deep-sea basin are required in order to detect (if any) areas in reference conditions. The identification of these areas would enable the description of the desired conditions in order to be used as baseline for setting GES thresholds. The TG Noise workshop performed in Brussels in 2018 addressed the identification of thresholds for underwater noise. The decision of the workshop was to focus first on methodology for obtaining and interpreting data since the fundamental knowledge gaps impeded the establishment of thresholds (TG Noise, 2018). In summary, the approach consists of a first step focused on methodology followed by a revision of the present evidences (current, state, trends and reference conditions) and of the options available for finally concluding on agreed thresholds (TG Noise, 2018). Accordingly, in order to set thresholds for Descriptor 11 indicators, methods need to be previously defined.

4. PART B: IDENTIFICATION OF KEY AREAS FOR MONITORING PROGRAMS OF THE MEDITERRANEAN DEEP SEA

The aim of part B of Task 3.3 is the identification of key areas for monitoring the deep Mediterranean Sea. The approach developed in the IDEM Project for selecting such key areas was already introduced in chapter 4 and outlined in Figure 1B. Each of the four steps that conform the approach is explained in the following sections, encompassing the methodology developed and also the results obtained. An overview of these steps is provided below in order to introduce the next sections.

- **Step 1**. Brings in all background considerations compiled by IDEM partners, which should be taken into account within this task.
- **Step 2.** Establishment of the criteria applied for the selection of the key areas for monitoring. The criteria are divided in two groups: Ecological Relevance (ER) and Anthropogenic Threat (AT), and scored regarding their applicability to each area assessed.
- **Step 3.** Evaluation of the suggested areas using the criteria defined in Section 2 and final classification based on the two averaged scores obtained (one for ER and one for AT). Each selected area should be briefly characterized within a descriptive sheet including at least a location map and other maps if available (e.g. bathymetry, habitats). The outcome of previous Task 2.3 within IDEM should be considered and duly integrated if deemed appropriate
- **Step 4.** Compilation of the results of the previous three steps. The final outcome will include recommendations, suggestions for further work and a suggested final target (aim) regarding the monitoring of areas that are critical to assess the environmental status of the deep Mediterranean Sea and, eventually, the achievement of GES.

This deliverable describes the approach followed and the results obtained.

4.1 Background considerations

This section should contain all relevant considerations from previous IDEM tasks, scientific literature and experts' judgment. For an accurate and coherent proposal of key areas the following considerations need to be taken into account:

- the scarcity of data on many parameters relevant to assess GES of the deep Mediterranean Sea (IDEM Project 2018a, 2018b);
- the existence of pronounced W-E and N-S physical and biological gradients at least for the open sea surface and the pelagic domain in terms of basic parameters and, more generally, data (e.g. VMS and basic data). For detail see the IDEM Task 2.2 and 2.3 results (IDEM Project 2018b, 2018c);
- the peculiar physiographic configuration of the Mediterranean Basin, with different sub-basins communicating across relatively shallow straits, and also with the Atlantic Ocean (exchanges through straits);
- the poor representation of the deep Mediterranean Sea within the current network of MPAs (MedPAN, UNEP/MAP-RAC/SPA, 2016);
- the protection and monitoring initiatives by different bodies encompassing RSC, NGOs, national and internationals institutions, such as (GFCM Vulnerable Marine Ecosystems (VMEs) (FAO, 2018); Ecologically or Biologically Significant Areas (EBSAs) (Convention on Biological Diversity: https://www.cbd.int/ebsa/); Specially Protected Areas of Mediterranean Importance (SPAMIs) (UNEP-MAP-RAC/SPA, 2010); Particularly Sensitive Sea Areas (PSSA) (International Maritime Organization: http://www.imo.org/en/OurWork/Environment/PSSAs/Pages/Default.aspx) and marine areas proposed for SCI by the INDEMARES project (https://www.indemares.es/en/home);
- the heterogeneity of the Mediterranean Sea Basin regarding ecosystems, biogeographic properties and high-energy processes;
- the occurrence of multiple pressures in the marginal Mediterranean Sea where impacts are concentrated inducing a stronger and faster affectation (Schroeder et al., 2017);

The compilation of the previous considerations was used together with scientific literature, experts' judgements and several protection initiatives outputs to formulate a set of criteria for evaluating potential key areas.

4.2 Evaluation criteria and scoring system

The system for identification of key areas should be based in a set of criteria compiling all relevant issues that could help defining a key area for monitoring. Ideally, the identified criteria should be assessed for each area based on scientific knowledge and data. However, the considerable data gap regarding the deep Mediterranean Sea compromises this approach. Thus, taking into account the data and time limitations of the IDEM project, the approach followed was based on the identification of a suitable set of criteria assessed by experts' opinion and the available literature (Habitats Directive (92/43/EEC); Marine Strategy Framework Directive (2008/56/EC); UNEP-MAP-RAC/SPA, 2010; Korpinen et al., 2012; Micheli et al., 2013; Piante and Ody., 2015; Convention on Biological Diversity, n.d; International Maritime Organization, n.d).

This chapter compiles and describes the criteria chosen for the evaluation of the key areas proposed. The set is divided in two blocks: **Ecological Relevance (ER)** criteria that define the characteristics and properties of key ecologically significant areas and habitats, and **Anthropogenic Threat (AT)** criteria representing anthropogenic threats, including drivers of human pressures, disturbances and impacts.

A scoring system was defined for the chosen criteria, thus establishing an objective quantitative framework. The key areas for monitoring have to be selected based on the background considerations of section 4.1 and on the selected ER and AT criteria. Justification of their selection has to be supported by the quantitative assessment based on the scores obtained for each criterion. The scoring system applies ranges from 0 to 3 considering the applicability and/or relevance of each criterion for a given area. The scale is defined as follows:

- 0: not applicable / insufficient data
- 1: low
- 2: medium
- 3: high

It should be noted that areas where there is a major lack of knowledge (insufficient data) would score 0 in ER and/or AT. This reflects the nonsense of proposing key areas for monitoring on which there is no information. To overcome this weakness, the acquisition of at least basic information from such areas should be stimulated and given priority in future research and management efforts. For areas within the Mediterranean Sea where the less information background is missing the reader is referred to deliverables D2.2 and D3.1 (IDEM Project, 2018b, 2019a).

In order to consolidate all criteria to provide an easily interpretable outcome and final classification an average score was calculated for each group of criteria, thus obtaining two final scores that were represented in a graph. The two scores obtained for each areas were translated in a final classification of the area in Type 1 or Type 2, or none of these two (see Figure 4). **Type 1** key areas are nominated as regions for priority monitoring under AT (vs. GES) since they are characterized by a high ecological relevance but also a high occurrence of anthropogenic threats. Key areas classified as **Type 2** are suggested for priority monitoring (vs. GES) devoid of identified high AT. Identifies areas of priority monitoring (and likely preserving) because of their ecological relevance (high ER values) and natural value, which are lacking or experience a low level of human-induced disturbance or degradation (low AT scores).

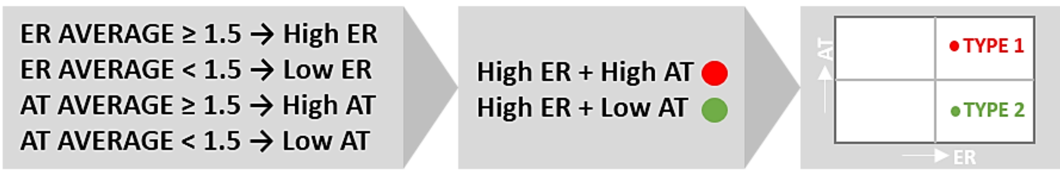


Figure 4. Diagram summarizing the process of classifying the areas suggested based on their scores regarding Ecological Relevance (ER) and Anthropogenic Threats (AT). The red colour represents Type 1 areas and the green refers to Type 2. For details see chapter 4.3.2.

In order to guide and complete consistently the evaluation step of Task 3.3 one supporting spreadsheet document has been generated. The main aim of the document is to provide the platform for the evaluation of the suggested key areas. A general presentation of the evaluation results is available in the subsection 4.3.2 by a graphic representation of the obtained values. The detailed results of the evaluations, specifying all the scores for each criterion for all the areas, are provided in the supporting spreadsheet document attached in section 4.3.2.

4.2.1 Ecological Relevance (ER) criteria

All relevant initiatives proposing criteria for the identification of key areas should be considered and revised. The appropriate criteria should be assessed and duly adapted for the establishment of deep Mediterranean Sea key areas for monitoring. Criteria not present in any previous imitative but considered relevant should be added as well.

The following existing criteria were revised: CBA criteria for defining EBSA (https://www.cbd.int/ebsa/), SPAMI sites selection criteria (UNEP-MAP-RAC/SPA, 2010), criteria for selecting PSSA by the International Maritime Organization (http://www.imo.org/en/OurWork/Environment/PSSAs/Pages/Default.aspx) and the Habitats Directive 92/43/EEC recommendations. After revising and adapting the existing criteria and formulating other ones deemed relevant, a final set of criteria was selected. A short description of each of the criteria is available below:

ER.1 Uniqueness: Areas that contain either (i) unique, rare or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems, and/or (iii) unique or unusual geomorphological or oceanographic features.

ER.2 Dependency: Areas that are relevant for different populations to survive and thrive, encompassing spawning and breeding grounds, nursery areas, migratory routes, presence of bioengineers and/or establishment of colonies.

ER.3 Importance for threatened, endangered or declining species and/or habitats: Areas containing crucial habitats for the survival and recovery of endangered, threatened, declining species, or areas with significant assemblages of such species.

ER.4 Vulnerability, fragility, sensitivity, or slow recovery: Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile and vulnerable (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.

ER.5 Natural representativeness: Areas that are highly representative of ecological or physiographic processes, biodiversity, or community or habitat types, or other natural characteristics.

ER.6 Bio-geographic importance: Areas that either contain rare biogeographic qualities or are representative of a biogeographic "type" or types, or contain unique or unusual biological, chemical, physical, or geological features. This criterion can encompass submarine canyons, seamounts, seafloor seeps, brine pools, mud volcanoes, pockmarks fields and other outstanding systems.

ER.7 Integrity: Areas that are biologically functional units, effective self-sustaining ecological entities and show high degrees of conservation (structure and functions) or high restoration possibilities.

ER.8 High-energy processes relevant for deep sea dynamics: Areas of occurrence of deep water formation, upwelling, downwelling, fronts, Taylor columns, high productivity or other relevant processes that are critical for the ecological functioning of the deep Mediterranean Sea and/or its sub-basins and the habitats they hold. These areas involve significant vertical transfers of matter and energy.

ER.9 Water exchanges: Areas where exchanges between different marine compartments are significantly taking place. They include basin and sub-basin-scale exchanges (i.e. straits). These areas involve significant horizontal transfers of matter and energy.

ER.10 Existing MPAs: Areas that are already part of marine protected areas or other defined site of interest, such as an EBSA, PSSA, SPAMI, FRA, Natura 2000 site or any other designation.

ER.11 Extreme scientific interest: Areas that are worth retaining because of its environmental characteristics, ecosystem relevance and/or value as baseline areas for monitoring studies (i.e. areas that provide suitable baseline conditions).

Obviously, several of the criteria above may overlap in given areas, in the same way that not all the criteria above could be applied to all potential areas to be selected as key areas for monitoring.

4.2.2 *Anthropogenic Threat (AT) criteria*

The anthropogenic threat criteria should be able to express the most relevant pressures described by the pressure-based descriptors in the MSFD frame and their potential impacts. Apart from the Marine Strategy Framework Directive (2008/56/EC), the following peer-reviewed articles and publications have been revised to identify such criteria: Korpinen et al., 2012; Micheli et al., 2013 and Piante and Ody, 2015.

The final set of criteria selected is described below:

AT.1 Introduction of alien species (D2-based): refers to high presence of alien species, partly or totally substituting original ones and/or altering the functioning of the affected habitat. This threat is included as an AT because the driving force behind the invasions by alien species is human action, either indirectly (i.e. through global warming) or directly (i.e. opening of artificial gateways such as the Suez Channel, or direct release of exotic species from ballast waters).

AT.2 Overfishing and stock depletion (D3-based): refers to areas encompassing specific systems were overfishing lead to stock reductions below safe biological limits.

AT.3 High artificial nutrient inputs delivered to the deep-sea (D5-based): refers to places where high concentrations of nutrients delivery and accumulate in the deep-sea, altering benthic communities and processes. Locations with potential high risk of hypoxia or other alterations due to the increase of nutrient concentrations are to be considered in this criterion. Also includes known events of oxygen deficiency, especially in near-bottom waters.

AT.4 Intensive, sustained fishing (D6-based): refers to areas where intensive, sustained fishing results in serious harm to benthic habitats.

AT.5 Large-scale seascape change (D6-based): refers to areas where recurrent trawling has led to major modifications of the natural seascape (e.g. 20’s to 1000’s of km^2, and 10’s to 100’s of m in height). Such seascape change could have other major consequences in terms of sedimentation regimes, biogeochemical exchanges, and the like.

AT.6 Deep-sea exploration and production activities (D6-based): includes hydrocarbon and mineral search and production, bioprospecting, and also the placement of infrastructures on the seabed, such as submarine cables and pipelines.

AT.7 Significant alterations of hydrological processes (D6-D7-based): refers to regions affected by climate-driven persistent changes in temperature, salinity and pH, and also where persistent or episodic anomalous changes in the circulation are documented. Alterations of the natural sediment fluxes and the consequent persistent water turbidity should be assessed within this criterion.

AT.8 Dispersal and accumulation of contaminants including marine litter (D8-D10). Marine system dynamics influenced by multiple drivers and processes (e.g. currents or submarine topographic elements) determines the distribution of the items introduced in the ecosystem, encompassing contaminants and marine litter. For instance, marine litter on the deep-sea accumulates in the so-called “litter hotspots” preferentially located into depressions like submarine canyons. Areas with high potential of accumulating contaminants and litter should be highlighted. Harm to habitats and organisms by marine litter is to be accounted within this criteria.

AT.9 Presence of contaminants in fish and other seafood for human consumption exceeding levels established in relevant standards (D9-based). Refers to areas where it has been already demonstrated, or is highly probable, that fish and other seafood is significantly contaminated.

AT.10 Persistent and intense underwater noise (D11-based): refers to areas where anthropogenic noise is concentrated and thus might be significantly affecting populations and communities.

AT.11 Significant effects of land-sourced, coastal and surface drivers on deep-sea ecosystems (D5-D10-based). This criterion is established to consider deep-sea areas highly impacted by any type of pressure originated in land, along the coast or the sea surface. This criterion is closely related to ER.8 since both criteria consider, among other elements, areas involving significant vertical transfers of matter and energy.

AT.12 Maritime traffic (D2, D8, D10 and D11-based): refers to areas that encompass major traffic routes leading to pressures under the above-mentioned descriptors since vessels are a potential input of alien species, contaminants, litter and noise.

It should take into account that depending on the pressures occurring in a given area several criteria may overlap but other ones might not be applicable.

4.3 The key areas selected for monitoring programs of the deep Mediterranean Sea

The definition of the criteria and the correspondent scores for the evaluation approach allowed an unambiguous implementation including the compilation of multiple experts' opinions. This chapter contains three subsections describing the process and the results of the evaluation of the suggested areas. Firstly, a general overview of the suggested areas is presented specifying the monitoring and preservation initiatives considered. The second subsection presents the results of the evaluation of previously suggested areas providing a graphic representation accompanied by a brief descriptive text. The detailed results of the evaluations specifying all the scores for each criterion for all the areas are provided in the supporting spreadsheet document attached in subsection 4.3.2. The final subsection compiles all descriptive sheets generated for each of the key areas finally selected.

4.3.1 *Suggested regions as potential key areas*

A number of regions have been suggested as potential key areas for monitoring the deep Mediterranean Sea. The selection of areas was performed considering expert's judgement and all relevant monitoring and preservation initiatives in the Mediterranean Basin. The initiatives considered were the following:

- SPAMI sites defined by the UNEP-MAP-RAC/SPA (UNEP-MAP-RAC/SPA, 2010)
- EBSA defined by the CBD (https://www.cbd.int/ebsa/)
- PSSA defined by the IMO (http://www.imo.org/en/OurWork/Environment/PSSAs/Pages/Default.aspx)
- FRAs defined by FAO (FAO, 2018)
- The marine areas proposed for SCI by IDEMARES project (https://www.indemares.es/en/home)

The list of areas, organized in six categories, is available in Table 23. A brief description of each of the areas can be found within the supporting spreadsheet developed for the evaluation process (see document: *Task 3.3 Key areas evaluation* attached in chapter 4.3.2).

CATEGORY	CODE	AREA PROPOSED FOR EVALUATION
STRAITS (AND CHANNELS) (ST)	ST.1	Strait of Gibraltar
	ST.2	Eivissa and Mallorca channels
	ST.3	Strait of Bonifacio
	ST.4	(Deep basins of the) Sicilian Channel
	ST.5	Otranto Strait
	ST.6	Aegean Sea and Cretan northern Ionian Sea straits
DENSE WATER FORMATION AREAS (DW)	DW.1	North-western Mediterranean dense water formation (MEDOC area) and spreading area
	DW.2	Adriatic dense water formation and spreading area
	DW.3	Aegean dense water formation and spreading area
CANYON SYSTEMS (CS)	CS.1	Canyon systems of the western Gulf of Lion and north Catalan margin
	CS.2	Canyon systems of the southern Adriatic sea
	CS.3	Cassidaigne canyon, eastern Gulf of Lion
	CS.4	Levante canyon, Ligurian Sea
	CS.5	East Levantine canyons (ELCA)
CWC PROVINCES / HABITATS (CWC)	CWC.1	CWC habitats of Santa Maria Di Leuca and nearby occurrences
	CWC.2	Western Mediterranean Northern Area
	CWC.3	CWC Habitats of Bari canyon systems
SEAMOUNTS (SM)	SM.1	Seamounts of the Alboran Sea
	SM.2	Eratosthenes Seamount
	SM.3	Other seamounts (e.g. Tyrrhenian Sea)
OTHER RELEVANT DEEP-SEA SYSTEMS (OR)	OR.1	Deep Nile Delta fan
	OR.2	Hellenic trench
	OR.3	Levant Sea
	OR.4	Eastern Corsican slope

Table 23. List of suggested key areas for monitoring the deep Mediterranean Sea. The areas are organized in six categories and provided with a code.

Within the supporting spreadsheet document a group of additional areas was incorporated at the end of the list. These areas were not included in the evaluation because there was not a strong, unanimous agreement on their importance/relevance or because they were suggested tardy and the evaluation could not be performed. The list encompasses the following areas: Jabuka/Pomo pit, Menorca Channel and the deep basins within the Central Aegean Sea. The Stait of Bonifacio, suggested as ST.3, was not included in further analysis since its mostly shallow condition does not encompass any relevant deep-sea properties or pressures.

The spreadsheet document was distributed to all IDEM partners in order to gather as many evaluation scores as possible for each potential area.

4.3.2 The results of the potential key areas evaluation

The evaluation of the potential key areas delivered a substantial set of scores per area. Averaged scores for the Ecological Relevance (ER) and for the Anthropogenic Threat (AT) criteria were calculated for each area. In order to obtain these scores two operations were performed. Firstly, the scores provided by the different partners for each criterion were combined by calculating and average score per criterion. Then, as second operation, an average score was calculated for the ER set and the AT set of criteria (Table 24), considering the average score obtained in the first operation. The obtaining of these two scores allowed the final classification of the potential areas following the process already described in Figure 4. The scores also determined the organization of the areas in the dispersion plot generated to illustrate the results (Figure 5).

The evaluation of each of the areas was performed in the platform provided within the supporting spreadsheet document. Accordingly, detailed results of the evaluations specifying the scores provided by each IDEM partner for each criterion for all the areas can be consulted in this supporting document attached just below:

Task 3.3_Key areas evaluation.xlsx

All the potential areas evaluated were either classified as Type 1 or Type 2 and thus no area was rejected due to the scores obtained. Additionally, all the areas besides one (OR.4) were established as Type 1 because of their high ecological relevance but also a high occurrence of anthropogenic threats (Table 24). The only area classified as Type 2 was the Eastern Corsican slope (OR.4) because of its relative lower level of human-induced disturbances (i.e. AT=1.09/3).

AREA AND CODE	ER (AVERAGE)	ER (ST.DEV)	AT (AVERAGE)	AT (ST.DEV)	CLASSIFICATION
STRAITS (ST)					
ST.1: Strait of Gibraltar	2.61	0.42	2.14	0.52	**Type 1**
ST.2: Eivissa and Mallorca Channels	2.36	0.29	1.72	0.61	**Type 1**
ST.4: Sicilian Channel	2.55	0.29	2.02	0.60	**Type 1**
ST.5: Otranto strait	2.25	0.45	2.12	0.61	**Type 1**
ST.6 : Aegean and Cretan N-Ionian straits	2.21	0.58	1.93	0.61	**Type 1**
DENSE WATER FORMATION AREAS (DW)					
DW.1: NW-MED DWF and spreading area	2.54	0.17	2.16	0.64	**Type 1**
DW.2: Adriatic DWF and spreading area	2.59	0.30	2.15	0.73	**Type 1**
DW.3: Aegean DWF and spreading area	2.44	0.41	1.90	0.61	**Type 1**
CANYON SYSTEMS (CS)					
CS.1: CS W-Gulf of Lion and N-Catalan margin	2.65	0.20	2.03	0.66	**Type 1**

CS.2: CS S-Adriatic Sea	2.83	0.20	2.18	0.60	**Type 1**
CS.3: Cassidaigne Canyon (E-Gulf of Lion)	2.50	0.39	2.22	0.67	**Type 1**
CS.4: Levante Canyon (Ligurian Sea)	2.51	0.46	2.08	0.52	**Type 1**
CS.5: E-Levantine Canyons (ELCA)	2.40	0.45	1.99	0.65	**Type 1**
CWC PROVINCES / HABITATS (CWC)					
CWC.1: CWC Habitats Santa Maria di Leuca	2.64	0.55	1.71	0.49	**Type 1**
CWC.2: W-MED northern area	2.82	0.34	2.32	0.64	**Type 1**
CWC.3: CWC Habitats Bari Canyon systems	2,73	0,47	2,60	0,55	**Type 1**
SEAMOUNTS (SM)					
SM.1: Seamounts of the Alboran Sea	2.59	0.26	2.01	0.51	**Type 1**
SM.2: Eratosthenes Seamount	2.50	0.58	1.99	0.49	**Type 1**
SM.3: Seamounts of the Tyrrhenian sea	2.46	0.40	1.90	0.48	**Type 1**
OTHER RELEVANT DEEP-SEA SYSTEMS (OR)					
OR.1: Deep Nile Delta Fan	2.61	0.37	2.53	0.47	**Type 1**
OR.2: Hellenic Trench	2.47	0.62	1.86	0.56	**Type 1**
OR.3: Levantine slope, bathyal soft bottoms	2.02	0.58	1.94	0.51	**Type 1**
OR.4: Eastern Corsican slope	2.24	0.79	1.09	0.47	**Type 2**

Table 24. Results of the evaluation of the potential key areas listed in Table based on the scoring of the two blocks of criteria: Ecological Relevance (ER) and Anthropogenic Threats (AT). The average and the standard deviation (ST.DEV) were calculated for each block of criteria applying the formulas “AVERAGE” and “STDEV.S” available within the spreadsheet in the Excel version of 2013. The classification stated at the rightest column refers to the two options described within chapter 4.2.

The calculation of the scores complemented by the generation of the dispersion plot enabled the final classification of the potential areas. As can be observed in Figure 5, all besides OR. 4 were located within the upper right part of the graph (red rectangle) confirming its classification as Type 1 areas. Figure 5B displays a zoom into the Type 1 areas in order to see their distribution and clustering.

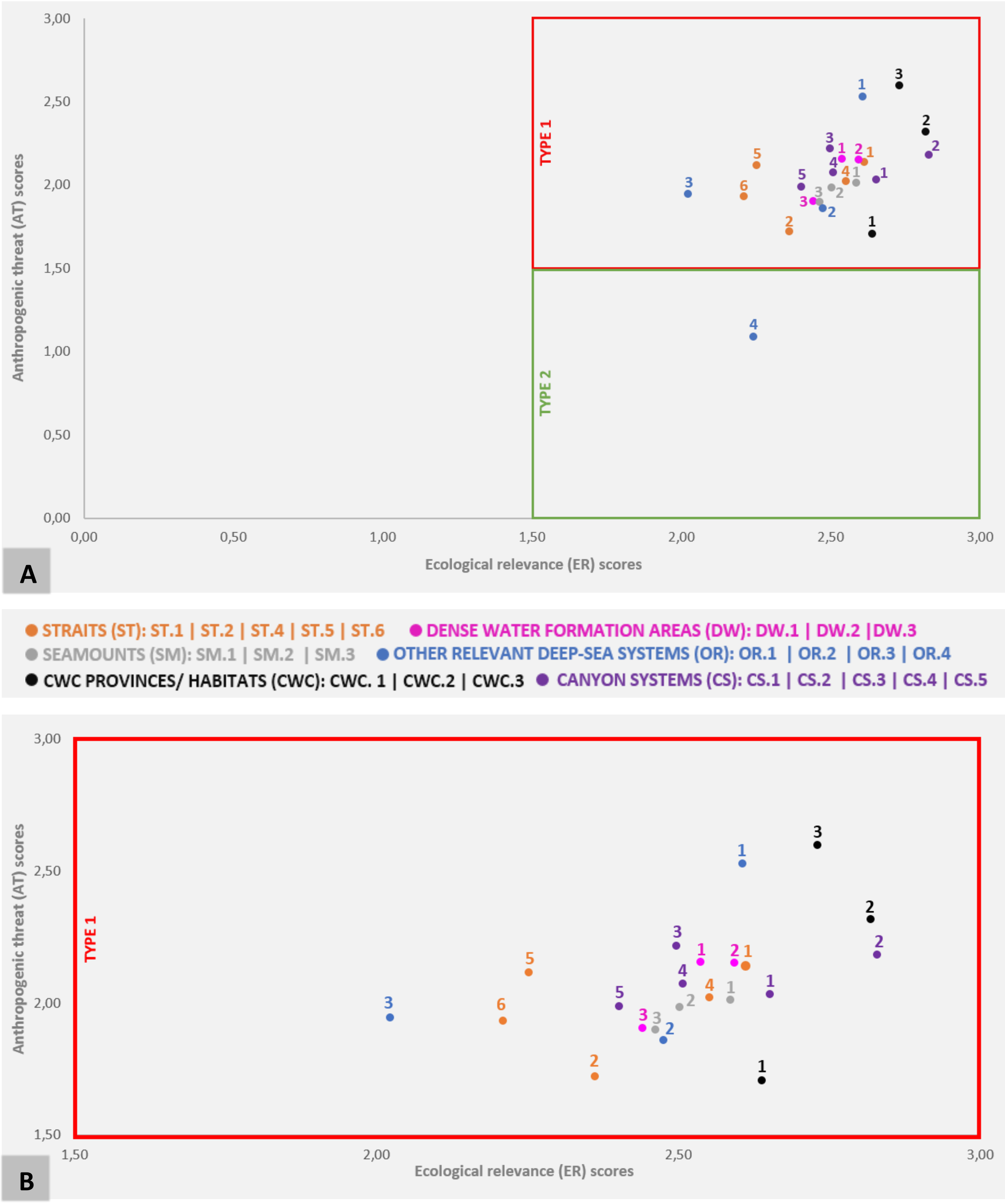


Figure 5. Dispersion plot generated with the two average scores obtained by each area in the evaluation process. The ER average scores are displayed with the X-axis and the AT ones in the Y-axis. **A**. General plot with all the areas, specifying Type 1 (red) and Type 2 (green) classification regions within the graph. **B**. Zoom of Type 1 areas. The areas are illustrated with colors regarding their category and numbered accordingly, as presented in Table 23. Orange: straits; pink: dense water formation areas; grey: seamounts; blue: other relevant deep-sea systems; black: CWC provinces/habitats and purple: canyon systems. The areas and the corresponding codes are detailed in Table Y.

Figure 5B allows the observation of scoring patterns of the evaluated areas. Canyon systems, seamounts and deep-water formation areas are the regions where some level of clustering within their categories could be observed. This clustering could be interpreted by proposing in the sense that areas within the same categories experience similar levels of pressures and/or display comparable ecological relevance properties. For example, all canyon systems might be susceptible of experiencing the same anthropogenic threats such as alteration of hydrological processes, accumulation of contaminants and marine litter and significant effects from land-sourced, coastal and surface divers. Additionally canyon system areas might share similar ecosystemic properties like bio-geographic importance or the holding of high-energy processes relevant for the deep-sea that would thus result in similar ecological relevance levels. However, the interpretation of this dispersion is not fulfilled entirely since the rest of regions do not group together within their category counterparts. Thus, they either experience different levels and/or types of anthropogenic pressures, reflect different ecological relevance properties or both. The dispersion could also be explained based on the geography of the evaluated areas. For instance, if all the areas located in one particular Mediterranean Basin were clustered together we could interpret that the pressures and/or ecosystem relevance is more related to geographic location than to system-specific properties. Still, geographic clustering could not be observed in the dispersion plot.

After the evaluation was performed and the results analyzed, the subsequent step would be the generation of a descriptive sheet for characterizing each of the areas selected. Ideally, all areas classified either as Type 1 or Type 2 should be established as key areas for monitoring purposes and provided with a descriptive sheet. However, the evaluation and the selection were highly conditioned by the number of scores obtained for each area.

In order to account for this bias, a minimum number of scores was set as threshold for selecting an area and generating a specific descriptive sheet. The maximum number of scores that an area could obtain was 209, considering all the criteria and all the IDEM partners participating in the exercise (see *Task 3.3 Key areas evaluation spreadsheet*, attached above within chapter 4.3.2). The threshold was set at 70 scores in order to discard areas encompassing less than a third of the total possible scores. Accordingly, the areas encompassing more than 70 scores were the ones finally selected and provided with a descriptive sheet. Those areas with less than 70 scores are established as potential key areas in need of further revision but no descriptive sheet will be generated. The number of scores for each area determining their final designation is displayed in Table 25.

CODE	AREA PROPOSED FOR EVALUATION	NUMBER OF SCORES OUT OF 209
	STRAITS (AND CHANNELS) (ST)	
ST.1	Strait of Gibraltar	91
ST.2	Eivissa and Mallorca channels	74
ST.4	(Deep basins of the) Sicilian Channel	92
ST.5	Otranto Strait	77
ST.6	Aegean Sea and Cretan northern Ionian Sea straits	52

DENSE WATER FORMATION AREAS (DW)		
DW.1	North-western Mediterranean dense water formation (MEDOC area) and spreading area	85
DW.2	Adriatic dense water formation and spreading area	76
DW.3	Aegean dense water formation and spreading area	58
CANYON SYSTEMS (CS)		
CS.1	Canyon systems of the western Gulf of Lion and north Catalan margin	105
CS.2	Canyon systems of the southern Adriatic sea	81
CS.3	Cassidaigne canyon, eastern Gulf of Lion	93
CS.4	Levante canyon, Ligurian sea	69
CS.5	East Levantine canyons (ELCA)	79
CWC PROVINCES / HABITATS (CWC)		
CWC.1	CWC habitats of Santa Maria Di Leuca and nearby occurrences	86
CWC.2	Western Mediterranean Northern Area	38
CWC.3	CWC Habitats of Bari canyon systems	16
SEAMOUNTS (SM)		
SM.1	Seamounts of the Alboran Sea	68
SM.2	Eratosthenes Seamount	85
SM.3	Other seamounts (e.g. Tyrrhenian Sea)	55
OTHER RELEVANT DEEP-SEA SYSTEMS (OR)		
OR.1	Deep Nile Delta fan	71
OR.2	Hellenic trench	47
OR.3	Levant Sea	78
OR.4	Eastern Corsican slope	62

Table 25. List of the initially suggested key monitoring areas. The right column specifies the number of scores obtained in the evaluation and their corresponding final designation as selected and thus provided with a descriptive sheet (green) or established as potential key area in need of further revision (orange). The areas are organized in six categories and provided with a code. CS.5 East Levantine canyons (ELCA) is presented in light grey since it was not finally selected despite surpassing the threshold established because of the IDEM experts' recommendation regarding this area.

The reasons behind the low number of scores are directly related to number of experts within the IDEM consortium that limits expertise and knowledge availability. The approach applied for the identification of potential key areas considers the entire Mediterranean since monitoring programs should cover all basins. However, the IDEM consortium is limited to nine partners whose expertise cannot cover all criteria for all Mediterranean regions. Accordingly, the areas not selected due to low number of scores should not be discarded and neglected for future monitoring programs since they have a huge potential for being key monitoring areas. Actually, their revision by different expert's groups should be fostered in order to compile more expertise and properly characterized them.

4.3.3 *Descriptive sheets of the key areas selected*

In order to illustrate the location of the key areas a general map was generated and is presented as Figure 6. The map includes the finally selected areas (in green) and also the potential areas in need of further revision (in orange) since these latter ones were still considered relevant besides the low number of scores obtained. A future implementation of all the areas presented in the map (the selected plus the potential ones) would represent a comprehensive set of key areas for monitoring programs of the deep Mediterranean Sea.

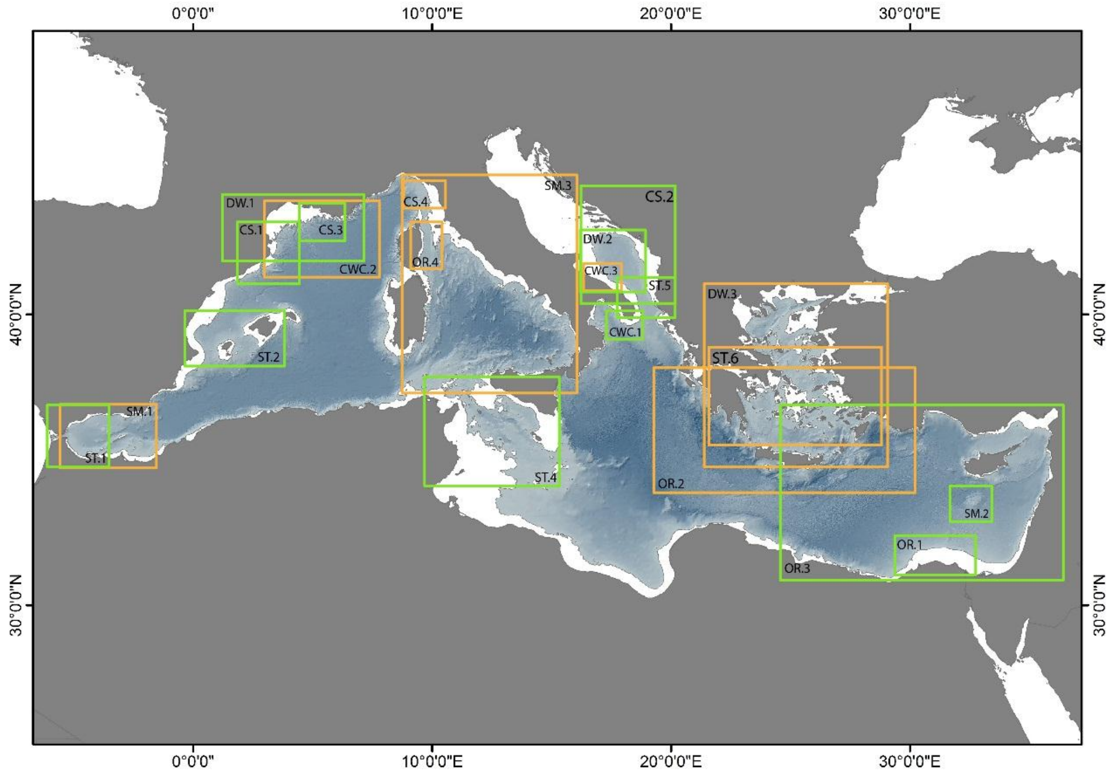


Figure 6. Mediterranean Sea map with all potential key areas highlighted by rectangles and identified by the area's code (see Table 25). The green rectangles identify the areas finally selected and the orange ones the potential key areas not selected due to the need of further revisions. Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.

Subsequently, the chapter displays the individual descriptive sheets generated for the selected key monitoring areas. A common format for all descriptive sheets was designed and implemented for all areas in order to ensure a coherent output of Task 3.3. The sheets provide an easy-reading characterization of the areas constituted by a brief introduction complemented by a specific map, a section summarizing the most relevant ecosystem properties and anthropogenic threats of the area and a final list of useful references. Accordingly, each of the green rectangle areas presented in Figure 6 is individually presented within the descriptive sheets. The potential areas not selected (i.e. orange rectangles areas in Figure 6) were not provided with a descriptive sheet but with a brief description within the supporting spreadsheet document (see attachment in chapter 4.3.2). Individual maps of each potential area were also generated and compiled in Annex I – Geographic location of the potential key areas not selected.

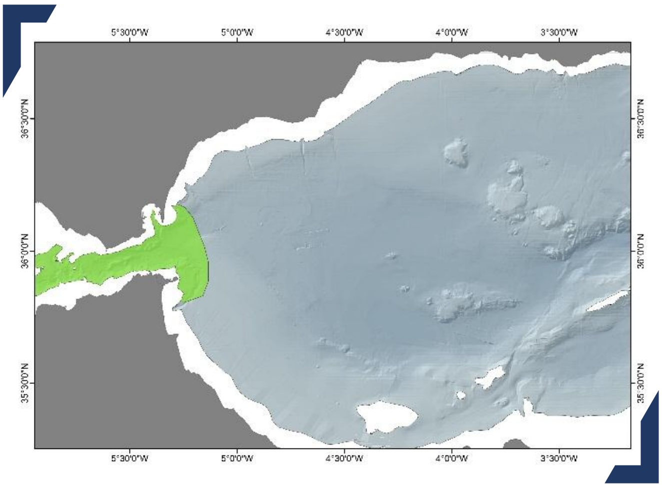
IDEM Key areas descriptive sheet

ST.1 STRAIT OF GIBRALTAR

BASIN: WESTER MEDITERRANEAN

ER SCORE: 2.21/3 **AT SCORE: 1.93/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



Straits likely deserve being monitored by themselves independently if they are included in larger areas. As a transition zone between the Atlantic Ocean and the Mediterranean Sea, the Strait of Gibraltar is the only relevant zone of dynamic water exchange with a large ocean basin. The area is characterized by surface inflow of Atlantic water and a deep outflow of Mediterranean waters that foster the establishment of peculiar conditions determining and influencing the communities present. Thus, apart from the importance as water exchange zone, monitoring of the Gibraltar Strait is also highly relevant regarding the occurrences of deep-water corals communities and as habitat of a large number of cetacean and rare, unique species. Taking into account the importance of maritime traffic in the strait and the high occurrence of cetaceans, the monitoring of this region is highly relevant for Descriptor 11. Additionally, it encompasses other relevant deep-sea systems as pockmarks at water depths between 370 and 1020 m on either side of the Strait. Pockmarks are one of the seabed expressions of active fluid and/or gas flow and thus are highly interesting for the scientific community. Partly overlaps with SPAMI site "Southwestern Alborán" (UNEP-MAP-RAC/SPA, 2010).

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Uniqueness | Dependency | Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | Natural representativeness | Bio-geographic importance | High-energy processes relevant for deep-sea dynamics | Water exchanges | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Introduction of alien species (D2-based) | Persistent and intense underwater noise (D11-based) | Maritime traffic (D2, D8, D10 and D11-based).

— KEY REFERENCES: Candela (1991); Álvarez-Pérez et al. (2005); de Stephanis et al. (2008); UNEP-MAP-RAC/SPA (2010); León et al. (2014).

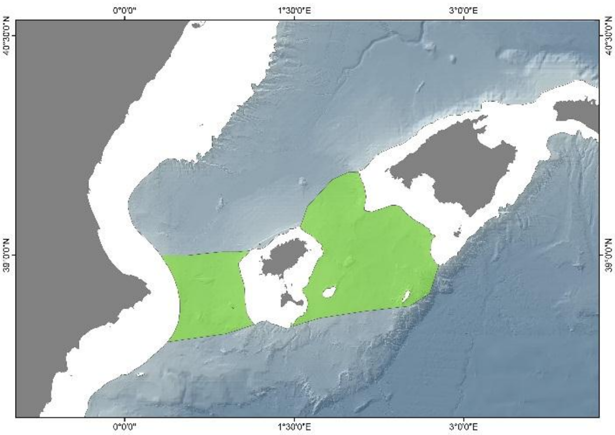
IDEM Key areas descriptive sheet

ST.2 EIVISSA AND MALLORCA CHANNELS

BASIN: WESTER MEDITERRANEAN

ER SCORE: 2.36/3 **AT SCORE: 1.66/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



Straits likely deserve being monitored by themselves independently if they are included in larger areas. These two deep channels are key for the north-south exchanges between the northern Gulf of Lion and the southern Algerian Basin since they are the only significant passages for the circulation of surface and intermediate waters. Apart from the relevance regarding water exchanges, peculiar characteristics of the channels also support the monitoring of these two areas. Both in the Eivissa and Mallorca channels, evidence of pockmarks and fluid escape features are present. Additionally, in the median depression of the Eivissa Channel a prominent 200m high seamount can be found and a volcanic field composed by 118 cone-shaped volcanic intrusions is described in the southeast of the Central Depression of the Mallorca Channel. Additionally, the area hosts large *Isidella elongata* meadows (WGVME, 2018 and WGMPA, 2019). This area is encompassed within the SPAMI site "Southern Balearic" (UNEP-MAP-RAC/SPA, 2010).

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | Existing MPAs | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Overfishing and stock depletion (D3-based) | Intensive, sustained fishing (D6-based).

— KEY REFERENCES: Astraldi et al. (1999); Acosta et al. (2003); Lastras et al. (2004); UNEP-MAP-RAC/SPA (2010); WGVME (2018) and WGMPA (2019).

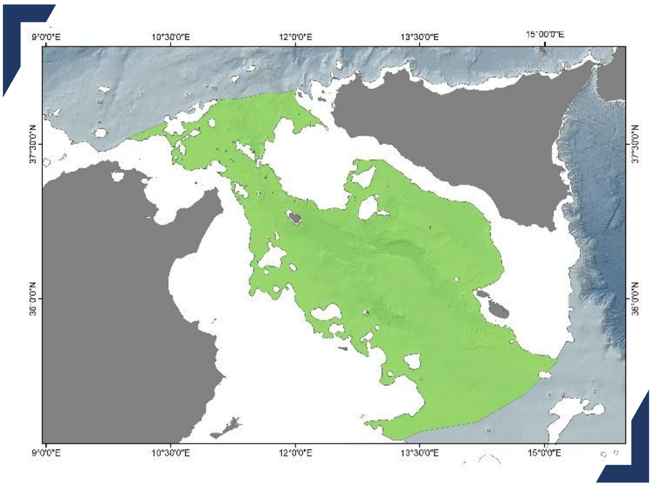
IDEM Key areas descriptive sheet

ST.4 (DEEP BASINS OF THE) SICILIAN CHANNEL

BASIN: CENTRAL-IONIAN MEDITERRANEAN

ER SCORE: 2.55/3 **AT SCORE: 2.02/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



The Sicilian Channel (Sicily Channel, Strait of Sicily) is the natural corridor connecting the East and West basins of the Mediterranean. The Siculo-Tunisian Sill, the narrower sector of the strait between the Tunisian and Sicilian coasts, reaches a maximum depth of 430 m. The complex physiography is predominantly shallow but includes the grabens (troughs) of the Pantelleria Rift System, with water depths greater than 1000 m in the otherwise shallow sea between Tunisia and Sicily, volcanic edifices and banks. Deep-water masses flowing westwards are the Levantine Intermediate Water (LIW) and the upper layer of the Eastern Mediterranean Deep Water (EMDW) passing over the Siculo-Tunisian Sill on their way to the western Mediterranean (combined in the Eastern Overflow Water). The Pantelleria Rift System contains the Malta Trough (1721 m), Linosa Trough (1529 m) and Pantelleria Trough (1317 m) that serve as important conduits for the westward flow of LIW and EMDW. The present distribution of cold-water coral (CWC) frameworks in the Mediterranean is closely linked to the LIW flow, and the Sicilian Channel represents one of the six major CWC provinces in the Mediterranean, bridging the gap between the CWC provinces in the South Adriatic/Santa Maria di Leuca, and south Sardinia. Open slopes dominated by bamboo coral or sea pens, which can serve as essential habitats for some commercially-exploited species, are also known from the Sicilian Channel, while a pockmark field is present West of Gela Basin and hosts chemosynthesis-based communities. The entire area is included within the EBSA "Sicilian Channel" (Convention on Biological Diversity, https://www.cbd.int/ebsa/). Three FRAs for protection of essential fish habitats are established within the Sicilian Channel: the "East of Adventure Bank", "West of Gela Basin" and "East of Malta Bank" FRAs (FAO, 2018). There is partial overlap with the SPAMI sites "Northern Strait of Sicily" and "Tunisian Plateau" (UNEP-MAP-RAC/SPA, 2010). Within Maltese waters, five deep-water areas have been declared as pSCIs to form part of the Natura2000 network (https://era.org.mt/en/Pages/Natura-2000-Datasheets-Maps.aspx).

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Uniqueness | Dependency | Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | natural representativeness | Bio-geographic importance | Water exchanges | Existing MPA | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Overfishing and stock depletion (D3-based) | Intensive, sustained fishing (D6-based) | Deep-sea exploration and production activities (D6-based) | Maritime traffic (D2, D8, D10 and D11-based).

— **KEY REFERENCES:** UNEP-MAP-RAC/SPA (2010); Lauria et al. (2017); FAO (2018); Convention on Biological Diversity (https://www.cbd.int/ebsa/); Natura2000 network (https://era.org.mt/en/Pages/Natura-2000-Datasheets-Maps.aspx).

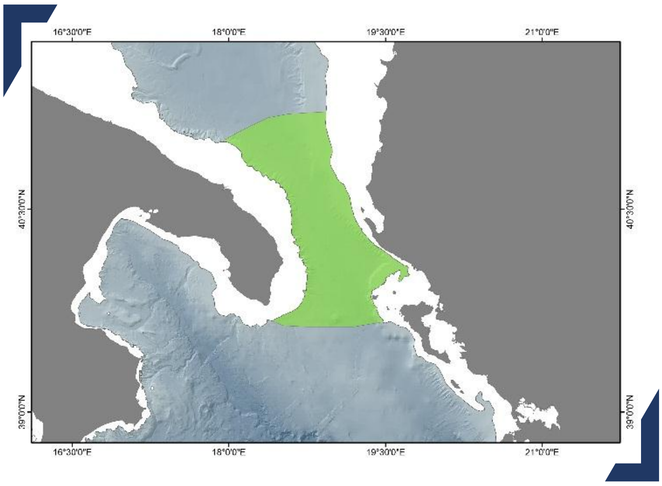
IDEM Key areas descriptive sheet

ST.5 OTRANTO STRAIT

BASIN: CENTRAL-IONIAN MEDITERRANEAN

ER SCORE: 2.55/3 **AT SCORE: 2.12/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



The water masses circulation and exchanges through the Otranto Strait is crucial for the hydrodynamic budget of the Adriatic Sea as well as the deep thermohaline cell of the Eastern Mediterranean (Pollak, 1951, Roether and Schlitzer, 1991). During winter, the strong cooling associated with the northerly winds (Malanotte-Rizzoli, 1991) favors the formation of the Northern Adriatic Dense Water (NAdDW: Vilibic and Orlic, 2002) in the northern part of the basin, and the Adriatic Deep Water (ADW) in the southern part. In the strait, a cyclonic gyre spreads the two deep waters into the Ionian Sea, one adjacent to the western shelf/slope and the other along the strait bottom, influencing the Mediterranean deep convection (Ovchinnikov et al., 1985). The northern Adriatic Sea is also characterized by considerable freshwater run-off by rivers, forming a coastal relatively fresh current, the Adriatic Surface Water (ASW), flowing along the western shelf. To compensate for this outflow of fresher water, two saline water masses, the Ionian Surface Water (ISW) and the Levantine Intermediate Water (LIW), enter the Adriatic Basin through the eastern side of Strait of Otranto. The Otranto channel has been recently proposed as a Fishery Restricted Area to the GFCM (GFCM, 2019) due to the occurrence of large *Isidella elongata* meadows (Lembo, 2015) and *Aristeomorpha foliacea* nurseries. Although more data has been requested to the proponent group and further data are necessary, the area seems to be a hot spot of biodiversity also for other VME indicator species, such as *Anthipathes dichotoma* (Bo et al., 2018).

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Uniqueness | Vulnerability, fragility, sensitivity, or slow recover | Natural representativeness | High-energy processes relevant for deep sea dynamics | Water exchanges.

Highly important anthropogenic threat criteria (>2.5): Intensive, sustained fishing (D6-based) | Deep-sea exploration and production activities (D6-based) | Significant alterations of hydrological processes (D6-D7-based) | Persistent and intense underwater noise (D11-based) | Significant effects of land-sourced, coastal and surface drivers on deep-sea ecosystems (D5-D10-based) | Maritime traffic (D2, D8, D10 and D11-based).

— KEY REFERENCES: Pollak (1951); Ovchinnikov et al. (1985); Malanotte-Rizzoli (1991); Roether and Schlitzer (1991); Vilibic and Orlic (2002); Lembo (2015); Bo et al. (2018); GFCM (2019).

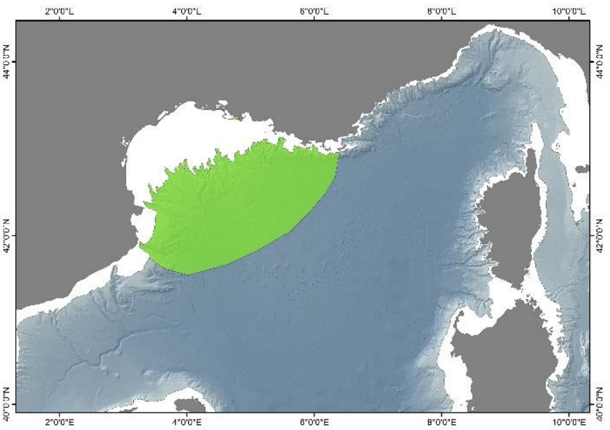
IDEM Key areas descriptive sheet

DW.1 NORTH WESTERN MEDITERRANEAN DENSE WATER FORMATION (MEDOC AREA) AND SPREADING AREA

BASIN: WESTER MEDITERRANEAN

ER SCORE: 2.54/3 **AT SCORE: 2.16/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



Area highly relevant in terms of monitoring as one of the main drivers of the functioning of the deep Mediterranean Sea, and of the Mediterranean Sea as a whole. The area constitutes one of the three main areas of dense water formation (DWF) in the Mediterranean Sea. Mainly two processes drive DWF: near-bottom currents driven by seawater density contrast, known as dense shelf water cascading (DSWC), and open sea convection. The Gulf of Lion located in the NW Mediterranean Sea is a micro-tidal and river-dominated continental margin with an intricate network of submarine canyons. The winter heat losses and evaporation induced by northern and northwesters winds promote cooling and densification of coastal waters that facilitate DSWC. The canyon systems perform as main conduits of the cascading shelf water transporting matter and energy to the deep basin, strongly influencing deep-sea communities. In the open sea, the same cold and dry winds that cause the DSWC also generate the winter convection process in the region known as MEDOC area. The area partly overlaps with the CS.1 (Canyon systems of the western Gulf of Lion and north Catalan margin). It also includes FRAs regions for protecting deep-sea sensitive habitats, including vulnerable marine ecosystems (FAO, 2018) and partly overlaps with SPAMI site "Gulf of Lions Shelf and slope" (UNEP-MAP-RAC/SPA, 2010).

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Vulnerability, fragility, sensitivity, or slow recover | Natural representativeness | Integrity | High-energy processes relevant for deep sea dynamics | Water exchanges | Existing MPAs | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Overfishing and stock depletion (D3-based) | Intensive, sustained fishing (D6-based) | Large-scale seascape change (D6-based) | Dispersal and accumulation of contaminants including marine litter (D8-D10-based) | Presence of contaminants in fish and other seafood for human consumption exceeding levels established in relevant standards (D9-based).

— KEY REFERENCES: Canals et al. (2006, 2009); Puig et al. (2008); Palanques et al. (2009); UNEP-MAP-RAC/SPA (2010); FAO (2018).

IDEM Key areas descriptive sheet

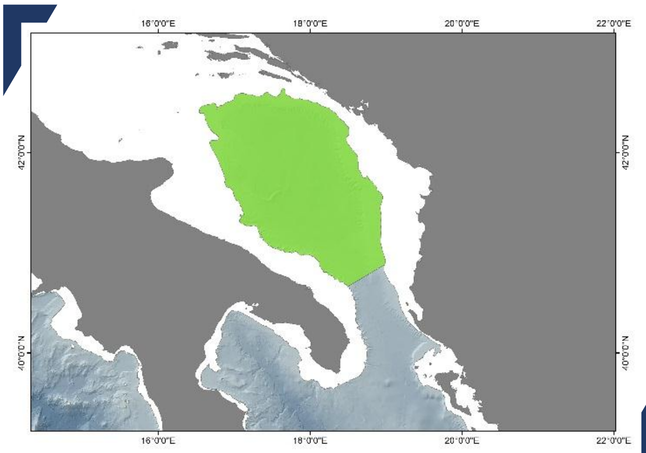
DW.2 ADRIATIC DENSE WATER FORMATION AND SPREADING AREA

BASIN: CENTRAL-IONIAN MEDITERRANEAN

ER SCORE: 2.59/3 **AT SCORE: 2.15/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA

In the Adriatic Sea, during winter, waters are subject to intense cooling, becoming dense enough to sink in the bottom layer and forming the North Adriatic Dense Water (NAdDW: Vilibic and Orlic, 2002), in the northern part of the basin and the Adriatic Deep Water (ADW) in the southern part. These water masses outflow from the Otranto Strait, influencing the Mediterranean deep convection (Ovchinnikov et al., 1985).



— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | Bio-geographic importance |High-energy processes relevant for deep-sea dynamics | Water exchanges | Existing MPAs | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Overfishing and stock depletion (D3-based) | Intensive, sustained fishing (D6-based) | Large-scale seascape change (D6-based) | Significant alterations of hydrological processes (D6-D7-based) | Persistent and intense underwater noise (D11-based) | Significant effects of land-sourced, coastal and surface drivers on deep-sea ecosystems (D5-D10-based).

— KEY REFERENCES: Ovchinnikov et al. (1985) and Vilibic and Orlic (2002).

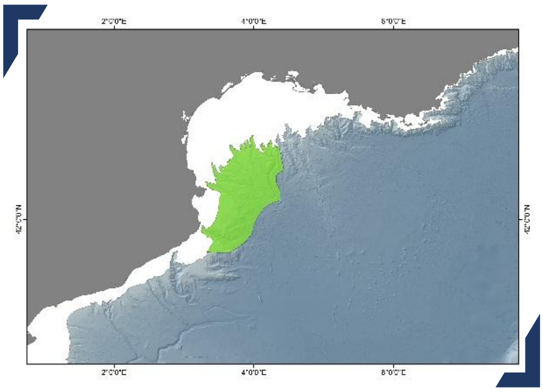
IDEM Key areas descriptive sheet

CS.1 CANYON SYSTEMS OF THE WESTERN GULF OF LION AND NORTH CATALAN MARGIN

BASIN: WESTER MEDITERRANEAN

ER SCORE: 2.65/3 **AT SCORE: 2.03/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



The area includes a set of submarine canyons incised into the continental shelf, which from east to west are Petit-Rhone, Montpellier, Sète (CS), Hérault (Marti), Aude (Bourcart, CB), Pruvost (CP), Lacaze-Duthiers (LCD), Cap de Creus (CC) and La Fonera (LF) canyons. All these canyons but La Fonera form an underwater drainage system opening into Sète Canyon and then into the continental rise. La Fonera is the only isolated canyon in the group. Canyons cross the continental slope and have their distal most reaches at depths in excess of 2000 m. The western canyons of Cap de Creus, and to a lesser extent Lacaze-Duthiers and La Fonera, constitute the main path for dense shelf water cascades (DSWC) carrying large amounts of sediment, organic carbon, chemical pollutants and litter. Some of these canyons host CWC habitats, some others host meadows of VMEs. The main direct anthropogenic threat they are exposed to is bottom trawling on their flanks down to 1000 m depth. However, the effects of trawling (e.g. resuspension, suffocation) extend much deeper, down to the canyons axes and beyond. This area partially overlaps with EBSA "North-western Mediterranean Benthic Ecosystems" (Convention on Biological Diversity, https://www.cbd.int/ebsa/), "South-West Gulf of Lion canyons system" marine area of INDEMARES proposed for SCI (INDEMARES project, https://www.indemares.es/en/home) and SPAMI site "Gulf of Lion Shelf and slope" (UNEP-MAP-RAC/SPA, 2010). Three of these features (CB, CP, CLD) are enclosed in the Gulf of Lion Marine Park (http://www.parc-marin-golfe-lion.fr/images/doc_link/juin_2013/perimetre_fevrier2013.pdf). Two small bottom impacting fishery permanent closures are located on the edge of two of CB and CS canyons (https://www.legifrance.gouv.fr/eli/arrete/2018/4/23/AGRM1733988A/jo/texte/fr). Petit-Rhône canyon also benefits from the relative protection of the Eastern Gulf of Lion Fishery Restricted Area (FAO, 2018).

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Dependency | Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | Natural representativeness | Bio-geographic importance | High-energy processes relevant for deep sea dynamics | Water exchanges | Existing MPAs | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Overfishing and stock depletion (D3-based) | Intensive, sustained fishing (D6-based) | Large-scale seascape change (D6-based) | Dispersal and accumulation of contaminants including marine litter (D8-D10-based).

— KEY REFERENCES: Canals et al. (2006, 2013); Orejas et al. (2009); Fabri et al. (2014); Lastras et al. (2016); FAO (2018); Convention on Biological Diversity, https://www.cbd.int/ebsa/; INDEMARES project, https://www.indemares.es/en/home; https://www.legifrance.gouv.fr/eli/arrete/2018/4/23/AGRM1733988A/jo/texte/fr; http://www.parc-marin-golfe-lion.fr/images/doc_link/juin_2013/perimetre_fevrier2013.pdf.

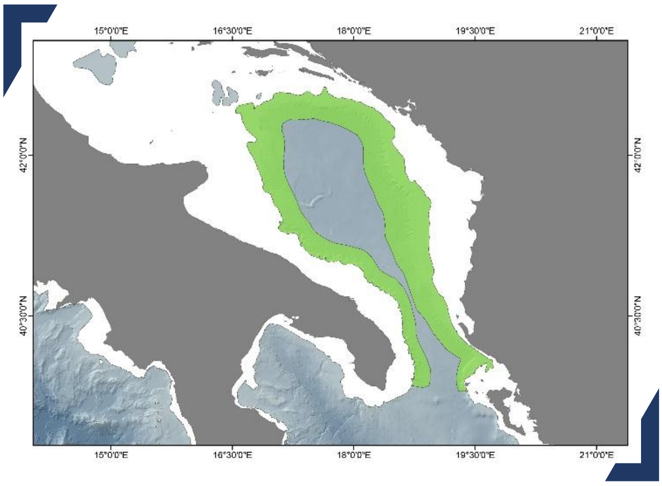
IDEM Key areas descriptive sheet

CS.2 CANYON SYSTEMS OF THE SOUTHER ADRIATIC SEA

BASIN: CENTRAL-IONIAN MEDITERRANEAN

ER SCORE: 2.83/3 **AT SCORE: 2.18/3** **FINAL CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



The southern Adriatic Sea is characterized by an articulated and heterogeneous geomorphology along the margin, encompassing the Bari Canyon System (BCS) in the western part. The BCS is an erosional-depositional structure consisting of two almost parallel E-W oriented main branches, with sub-vertical flanks in its southern part and less abrupt flanks northward (Trincardi et al., 2007). The Bari Canyon represents an efficient channel transporting sediments and nutrients from the continental shelf down to the bathyal zone (Turchetto et al., 2007), being a-periodical impacted by dense water flow (North Adriatic Dense Water, NAdDW) developing from the northern Adriatic Sea and by the Levantine Intermediate Water (LIW) that generates in the Aegean Sea and flows through the entire Mediterranean Sea. The hydrodynamic of the canyon contribute to the sustention of deep-water ecosystems such as cold-water corals (Freiwald et al., 2009; Angeletti et al., 2014; Taviani et al., 2016; Foglini et al., 2019). The Canyon is also characterized by a-periodical dense water cascading, responsible, of erosional-sediment features (e.g., slope incision and dune field) in the area nearby of the Bari Canyon System (Foglini et al., 2016).

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Uniqueness | Dependency | Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | Natural representativeness | Bio-geographic importance | Integrity | High-energy processes relevant for deep-sea dynamics | Water exchanges | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Overfishing and stock depletion (D3-based) | Deep-sea exploration and production activities (D6-based) | Persistent and intense underwater noise (D11-based) | Significant effects of land-sourced, coastal and surface drivers on deep-sea ecosystems (D5-D10-based).

— KEY REFERENCES: Trincardi et al. (2007); Turchetto et al. (2007); Freiwald et al. (2009); Angeletti et al. (2014); Foglini et al. (2016); Taviani et al. (2016).

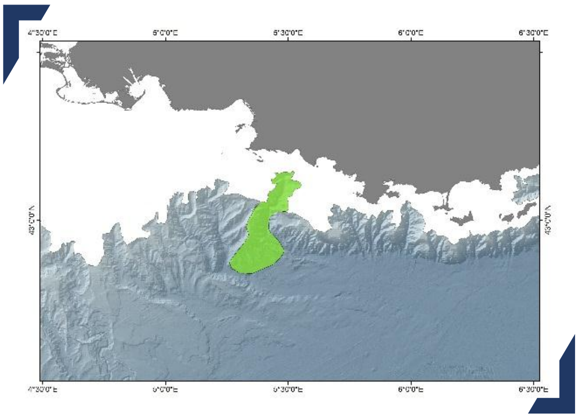
IDEM Key areas descriptive sheet

CS.3 CASSIDAIGNE CANYON and EASTERN GULF OF LION

BASIN: WESTER MEDITERRANEAN

ER SCORE: 2.50/3 **AT SCORE: 2.22/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



This area includes a set of submarine canyons incised into the continental shelf, which from east to west are the Cassidaigne, Planier, Marseille and Grand Rhône. The most intense upwelling of the Gulf of Lion is centred within the Cassidaigne canyon. During the upwelling events, deep- and thus colder-water is channelled along the canyon axis up onto the shelf. However, during downwelling events (mostly in winter), this process is reversed and bottom currents can carry huge amounts of sediment and organic matter to the deep ocean as they scour the shelf and slope seafloor. Cold-water corals have settled in the Cassidaigne canyon and formed large colonies, providing a structural habitat for other species. Nevertheless, the communities are physically impacted by discharges of bauxite residue discharges from an aluminium industry. Red bauxite has been discharged into the canyon since 1967 and red mud extends into the abyssal plain more than 50 km away from the pipe. The quantity of solid particles in the effluent has been progressively reduced, and the outflow was stopped at the end of 2015. Nevertheless, the industrial company concerned requested and was granted a six-year authorization starting in January 2016 for a different effluent containing only chemicals and no suspended matter. The Cassidaigne canyon is included in the Marine Protected Area (MPA) of the "Parc National des Calanques" since 2012 (www.calanques-parcnational.fr – Decree 2012-507). A small bottom impacting fishery permanent closure is located on the edge of the Grand Rhône canyon (https://www.legifrance.gouv.fr/eli/arrete/2018/4/23/AGRM1733988A/jo/texte/fr). Marseille and Grand-Rhône canyons also benefit from the relative protection of the Eastern Gulf of Lion Fishery Restricted Area (http://www.fao.org/gfcm/data/maps/fras/fr/).

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Dependency | Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | High-energy processes relevant for deep-sea dynamics | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Overfishing and stock depletion (D3-based) | Intensive, sustained fishing (D6-based) | Large-scale seascape change (D6-based) | Significant alterations of hydrological processes (D6-D7-based) | Dispersal and accumulation of contaminants including marine litter (D8-D10) | Presence of contaminants in fish and other seafood for human consumption exceeding levels established in relevant standards (D9-based) | Significant effects of land-sourced, coastal and surface drivers on deep-sea ecosystems (D5-D10-based).

— KEY REFERENCES: Millot (1990); Alberola and Millot (2003); Dauvin (2010); Stora et al. (2011); Fontanier et al. (2012, 2015); Fabri et al. (2014, 2017) and Fabri et al. (submitted). www.calanques-parcnational.fr, https://www.legifrance.gouv.fr/eli/arrete/2018/4/23/AGRM1733988A/jo/texte/fr. http://www.fao.org/gfcm/data/maps/fras/fr/,

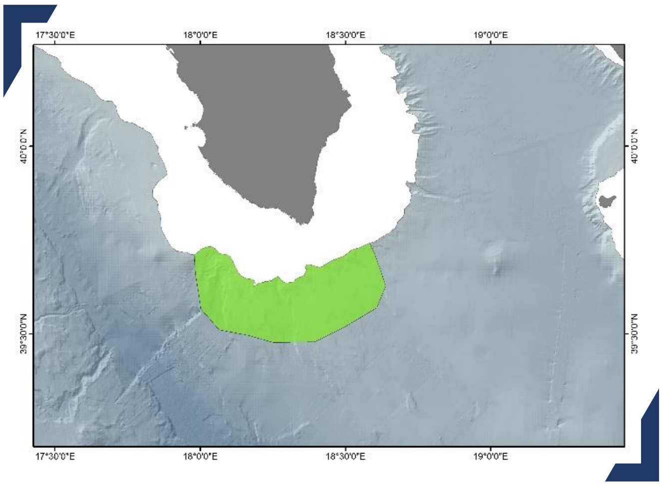
IDEM Key areas descriptive sheet

CWC.1 CWC HABITATS OF SANTA MARIA DI LEUCA AND NEARBY OCCURRENCES

BASIN: CENTRAL-IONIAN MEDITERRANEAN

ER SCORE: 2.64/3 **AT SCORE: 1.71/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



The area is characterized by high density of *Madrepora oculata* and *Lophelia pertusa* bioconstructions, occurring both as isolated colonies and mounds (10–20 m high) (Taviani et al., 2005a, b; Freiwald et al., 2009; Vertino et al., 2010). The province is located between 300 and 1100 m depth off Apulia on a gently sloping plateau with complex seabed topography (Tursi et al., 2004; Taviani et al., 2005a; Malinverno et al., 2010; Savini and Corselli, 2010; Savini et al., 2014). The area host a high-biodiversity megafaunal community, characterized by the presence of stony corals as *Desmophyllum dianthus*, *Stenocyathus vermiformis* and the yellow coral *Dendrophyllia cornigera*, antipatharians (*Leiopathes glaberrima*) and gorgonians (*Callogorgia verticillata*), often in association with sponges, such as *Pachastrella monilifera* and *Poecillastra compressa* (Freiwald et al., 2009; Taviani et al., 2011; D'Onghia et al., 2012, 2017). Here, in 2006, the GFCM established a Fishery Restricted Area (FRA) banning the use of towed gears due to the presence of priority commercial species (e.g. *Aristaeomorpha foliacea, Aristeus antennatus, Merluccius merluccius, Nephrops norvegicus, Pagellus bogaraveo*). In addition, the area represent an important migratory corridor for megafauna like the short-beaked common dolphin (*Delphinus delphis*) and marine turtles (Oceana, 2014).

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Uniqueness | Dependency | Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | Natural representativeness | Bio-geographic importance | Integrity | Existing MPAs | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Intensive, sustained fishing (D6-based).

— KEY REFERENCES: Tursi et al. (2004); Taviani et al. (2005a, b); Freiwald et al. (2009); Malinverno et al. (2010); Savini and Corselli (2010); Vertino et al. (2010); Taviani et al. (2011); D'Onghia et al. (2012, 2017); Oceana (2014); Savini et al. (2014); Bargain et al. (2017).

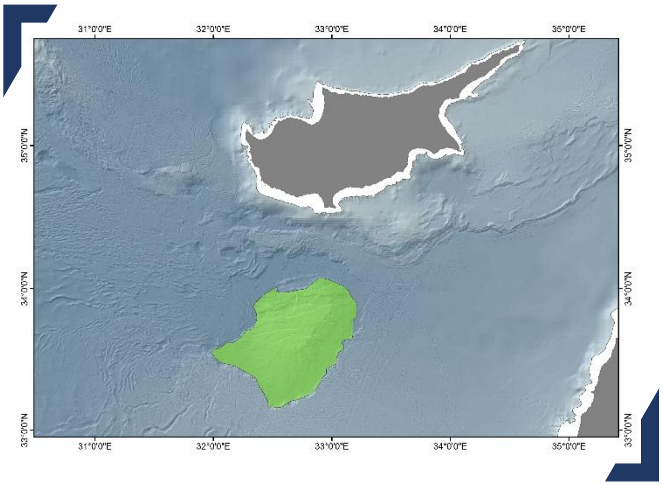
IDEM Key areas descriptive sheet

SM.2 ERATOSTHENES SEAMOUNT

BASIN: AEGEAN – LEVANTINE MEDITERRANEAN

ER SCORE: 2.50/3 **AT SCORE: 1.99/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



The Eratosthenes Seamount (ca. 120 by 80 km) is located in the Eastern Mediterranean about 100 km south of western Cyprus, rising 2000 m above the surrounding abyssal plain. A single faunal investigation took place in 1994 and consisted of an hour haul of a 2 m wide beam-trawl across the seamount top, and 9 box core samples. Yet, these samples yielded a rich and diverse fauna. This notably comprises two species of scleractinian coral (*Caryophyllia calveri, Desmophyllum cristagalli*), which were the first live records from the Levant Basin and significantly extended the species' depth ranges. During the Quarternary the eastern Mediterranean underwent a series of synchronous basin-wide anoxic episodes, the last in the early Holocene. If the anoxia left the seamount as an isolated refuge, and the anoxic episodes were of sufficient duration, its fauna would include taxa not found on the adjacent slope. These may include "relict" taxa that were once widespread but that are now restricted to the seamount, or endemic taxa that evolved in isolation on the seamount. The Eratosthenes Seamount would thus be a UNIQUE HABITAT worthy of detailed investigation and conservation. The 1994 benthic samples provide a glimpse of a deep Levant seamount fauna, in an area and depth commonly expected to be poor in faunal wealth. The surprising faunal diversity and density, and the unexpected presence of live scleractinians, suggests that investigation and conservation of Eratosthenes Seamount should be undertaken.

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Uniqueness | Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | Natural representativeness | Bio-geographic importance | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Overfishing and stock depletion (D3-based) | Intensive, sustained fishing (D6-based).

— KEY REFERENCES: Galil and Zibrowius (1998); Rubin-Blum et al. (2014).

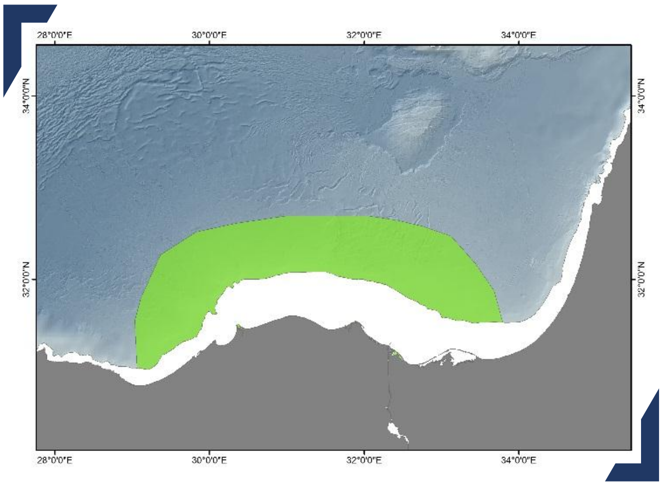
IDEM Key areas descriptive sheet

OR.1 DEEP NILE DELTA FAN

BASIN: AEGEAN – LEVANTINE MEDITERRANEAN

ER SCORE: 2.61/3 **AT SCORE: 2.53/3** **CLASSIFICATION: TYPE 1**

— INTRODUCTION TO THE AREA



The Nile Deep Sea Fan (NDSF) hosts numerous active fluid escape structures including several large gas emitting mud volcanoes characterized by emissions of thermogenic methane and higher hydrocarbons. The NDSF comprises 4 morpho-structural provinces. The faunal assemblages associated with the structures dominated by variable emissions of methane and heavier hydrocarbons and associated with a major thermal contribution are little known. Videographic surveying and sampling revealed patchy mats of sulphide-oxidizing bacteria and association of symbiont-bearing chemosynthetic bivalves and tubeworms (vestimentiferams and lammelibrachia). The environmental high heterogeneity is reflected in significant differences at different spatial scales: (1) the fauna of reduced habitats differed substantially in activity, diversity and biomass from the non-seep environment at similar water depth, (2) cold seep microhabitats showed differences in community structure and composition related to substratum type as well as to the intensity and location of fluid emissions. In view of the prospecting, bidding and extraction of extensive offshore gas and oil fields in the NDSF, and the vulnerability and low resilience of the biotic assemblages, a robust commitment for a coordinated, integrative research and conservation at national and regional levels, is required to achieve protection for the NDSF biota. The region still lacks comprehensive ecological characterization, including scientifically-sound habitat mapping, which is the principal requisite for informing policy makers.

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Uniqueness | Dependency | Importance for threatened, endangered or declining species and/or habitats | Vulnerability, fragility, sensitivity, or slow recover | Natural representativeness | Bio-geographic importance | Integrity | High-energy processes relevant for deep sea dynamics.

Highly important anthropogenic threat criteria (>2.5): Introduction of alien species (D2-based) | Overfishing and stock depletion (D3-based) | High artificial nutrient inputs delivered to the deep-sea (D5-based) | Intensive, sustained fishing (D6-based) | Deep-sea exploration and production activities (D6-based) | Persistent and intense underwater noise (D11-based) | Significant effects of land-sourced, coastal and surface drivers on deep-sea ecosystems (D5-D10-based).

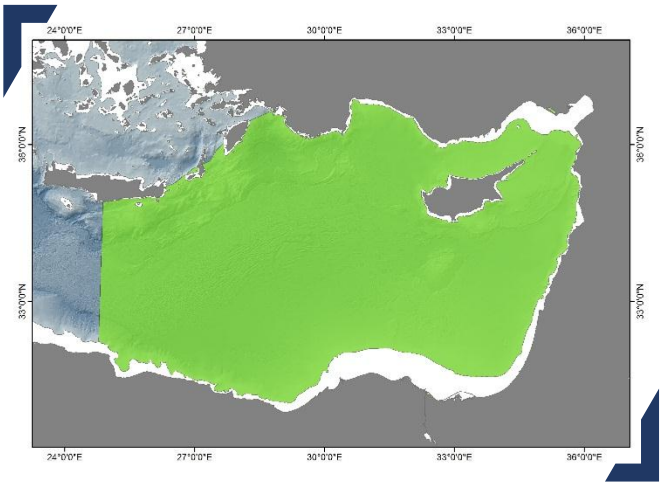
— KEY REFERENCES: Dupre et al. (2007); Bayon et al. (2009); Huguen et al. (2009); Brissac et al. (2011); Ritt et al. (2011, 2012); Felden et al. (2013).

IDEM Key areas descriptive sheet

OR.3 LEVANT SEA (LEVANTINE SLOPE, BATHYAL SOFT BOTTOMS)

BASIN: AEGEAN – LEVANTINE MEDITERRANEAN

ER SCORE: 2.02/3 **AT SCORE: 1.94/3E** **CLASSIFICATION: TYPE 1**



— INTRODUCTION TO THE AREA

The results of a recent IDEM-funded survey suggest that the megafauna of the soft bottom upper slope in the southern Levant Sea comprise distinct and unique assemblages, complementing more extensive studies of the bathyal biota, and differing in the composition and relative abundance of their taxa form slope habitats elsewhere in the Mediterranean Sea. Moreover, these assemblages comprise aggregations of regionally rare erect sponges, hydrozoans, anthozoans and brachiopod fields, which play a significant structural role in soft bottom ecosystems by furnishing the biota with spatially complex habitats. These ecosystem engineer/habitat former taxa are highly susceptible to human disturbance, thus their conservation is crucial for biodiversity preservation. In the Mediterranean Sea such habitats are associated with commercially important fishery grounds, and in consequence, have greatly declined over the past century. Yet, as the local bottom-trawling fishery has been mostly confined to the shelf and shelf edge, these vulnerable assemblages have survived. In view of the prospecting, bidding and extraction of extensive offshore gas and oil fields in the Levant Sea, and the vulnerability and low resilience of the soft bottom assemblages, a robust commitment for a coordinated, integrative research and conservation at national and regional levels, is required to achieve protection for the deep Levantine biota. The region still lacks comprehensive ecological characterization, including scientifically sound habitat mapping, which is the principal requisite for informing policy makers. Additionally, the presence of NIS, including invasive NIS, beyond the shelf edge and deeper has been documented (thus far) from the Levant, plus an intriguing record off the Spanish Mediterranean coast. This is clearly an EMERGING issue and likely to increase with global change. We suggest that it is important AND PRUDENT to include the Levant in the suggestions for "sensitive areas" for NIS monitoring. It bears remembering that many of the marine NIS now established along the Mediterranean coast of Member States, had been recorded earlier in the Levant. It is likely, actually - it is certain, that a similar pattern will be forthcoming for upper slope NIS

— ECOLOGICAL RELEVANCE AND ANTHROPOGENIC THREATS OF THE AREA

Highly relevant ecological relevance criteria (>2.5): Vulnerability, fragility, sensitivity, or slow recover | Bio-geographic importance | Extreme scientific interest.

Highly important anthropogenic threat criteria (>2.5): Deep-sea exploration and production activities (D6-based) | Maritime traffic (D2, D8, D10 and D11-based).

— KEY REFERENCES: Galil (2004); Goren and Galil (2005); Goren et al. (2008); Danovaro et al. (2010); Guarnieri et al. (2017).

4.4 Final monitoring target and further recommended work

This section builds on the previous three sections and is intended to provide the final outcomes of Task 3.3 in a synthetic form together with recommendations and suggestions for future work.

One of the final outcomes of IDEM Action 3 and also Action 4 is the proposal of a final monitoring target. Fixing a target for the protection of pelagic and benthic domains of the deep Mediterranean Sea (e.g. at least 25% of the area protected by 2030 in every sub-basin), coupled with continuous monitoring to assess GES achievement, would establish an objective and foster the performance of factual conservation actions. The IDEM consortium considers that if strict protection measures are not applied it will impossible to assess a number of natural processes under no direct human interference conditions, which are critical to value GES.

The first recommendation concerns the approach implemented for the selection of key monitoring areas, as explained in the previous chapter. As already introduced in subsection 4.3.2, the approach is considerably limited and conditioned by the number of scores gathered by area. The number of scores obtained for a given region reflects the available knowledge and expertise within the IDEM consortium for that area. Although the results are really valuable, the expertise and knowledge of the nine IDEM partners cannot cover all Mediterranean regions or aspects deserving attention. Consequently, some areas encompassed low numbers of scores that prevented a thorough statement as key monitoring areas. Accordingly, areas requiring further revision by more experts were established as potential key areas. Therefore, the final outcomes presented in chapter 4.3 should not be read as the final result or the final selection of key areas for the deep Mediterranean Sea. It is strongly recommended to understand these approach as a possibility of how can this task be fulfilled and which might be the possible results. Hence, the approach could be promoted as a method for compiling more expert opinions that could be translated at the end in the establishment of a Mediterranean set of deep-sea key areas for monitoring and potential conservation purposes.

Further work can encompass an immense list of actions that would be beneficial for the conservation of the deep Mediterranean Sea. Due to the impossibility of describing all of these actions with the required specifications, this chapter focuses on two specific to do actions or proposals.

The first to do action is carrying out **an inventory of existing monitoring stations**, supported by a variety of administrations, research institutions and individual research groups across the Mediterranean Basin. This inventory should include the stations operational status together with an assessment of the data collected so far in terms of quality flagging, duration (time series), representativeness and usefulness for the purpose of monitoring the environmental status of the deep Mediterranean Sea with the aim of achieving a GES. A revision of the actual monitoring potential is essential for tackling the recurrent data scarcity problem. Knowledge about the available monitoring stations will expose the locations where the obtaining of data is more feasible by simultaneously disclosing the most neglected ones. Apart from highlighting the areas monitored, the inventory should include a revision of the parameters targeted to detect overlooked ecosystem components and/or anthropogenic pressures. The performance of such an accurate and exhaustive inventory is the first step for overcoming the pronounced knowledge and data gradients currently existing in the Mediterranean Sea (IDEM Project. 2018b and 2018c).

The second action to undertake refers to the **meta-analysis** thoroughly explained within the framework of IDEM Deliverable 4.3 to identify areas for priority conservation (IDEM Project, 2019e). This approach is tightly linked with the evaluation of key monitoring areas, described within this deliverable. The two actions where developed taking into account the other one, also keeping in mind that Action 3 approach was focused in monitoring whereas the meta-analysis in Action 4 focuses in conservation. The two approaches could complement each other by partially overcoming some of the corresponding limitations. Therefore, the meta-analysis would corroborate with data the key monitoring areas identified based on expert's judgement (Action 3). In a related way, the approach developed for the detection of key monitoring areas is able to highlight relevant areas where the lack of data hinders its identification in the meta-analysis.

5. REFERENCES

Acosta, J., Canals, M., López-Martínez, J., Muñoz, A., Herranz,P., Urgeles, R. et al. (2003). The Balearic Promontory geomorphology (western Mediterranean): morphostructure and active processes. *Geomorphology*, 49 (3-4), 177-204. https://doi.org/10.1016/S0169-555X(02)00168-X.

Alberola, C. and Millot, C. (2003). Circulation in the French Mediterranean coastal zone near Marseilles: the influence of wind and the Northern Current. *Continental Shelf Research* 23, 6, 587-610. https://doi.org/10.1016/s0278-4343(03)00002-5.

Álvarez-Pérez, G., Busquets, P., De Mol, B., Sandoval, N.G., Canals, M., Casamor, J.L (2005) Deep-water coral occurrences in the Strait of Gibraltar. In: Freiwald A., Roberts J.M. (eds) Cold-Water Corals and Ecosystems. Erlangen Earth Conference Series. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-27673-4_10.

Angeletti, L., Taviani, M., Canese, S., Foglini, F., Mastrototaro, F., Argnani, A. et al. (2014). New deep-water cnidarian sites in the southern Adriatic Sea. *Mediterranean Marine Science*, (2), 263-273. https://doi.org/10.12681/mms.558.

Astraldi, M., Balopoulos, S., Candela, J., Font, J., Gacic, M., Gasparini, G.P. et al. (1999). The role of straits and channels in understanding the characteristics of Mediterranean circulation. *Progress in Oceanography*, 44(1-3), 65-108. https://doi.org/10.1016/S0079-6611(99)00021-X.

Bargain, A., Marchese, F., Savini, A., Taviani, M., Fabri, M.C. (2017). Santa Maria di Leuca Province (Mediterranean Sea): Identification of Suitable Mounds for Cold-Water Coral Settlement Using Geomorphometric Proxies and Maxent Methods. *Frontiers in Marine Science* 4, 338. https://doi.org/10.3389/fmars.2017.00338

Basset, A., Barbone, E., Borja, A., Brucet, S., Pinna, M., Quintana, X.D. et al. (2012). A benthic macroinvertebrate size spectra index for implementing the Water Framework Directive in coastal lagoons in Mediterranean and Black Sea ecoregions. *Ecological Indicators*, 12(1), 72–83. https://doi.org/10.1016/j.ecolind.2011.06.012.

Bayon, G., Loncke, L., Dupre, S., Caprais, J.C., Ducassou, E., Duperron, S. et al. (2009). Multi-disciplinary investigation of fluid seepage on an unstable margin: The case of the Central Nile deep sea fan. *Marine Geology* 261, 1-4, 92-104. https://doi.org/10.1016/j.margeo.2008.10.008.

Bianchelli, S., Pusceddu, A., Buschi, E., Danovaro, R. (2016). Trophic status and meiofauna biodiversity in the Northern Adriatic Sea: insights for the assessment of good environmental status. *Marine environmental research*, 113, 18-30. https://doi.org/10.1016/j.marenvres.2015.10.010.

Bo, M., Barucca, M., Biscotti, M.A., Brugler, M.R., Canapa, A., Canese, S. et al. (2018). Phylogenetic relationships of Mediterranean black corals (Cnidaria: Anthozoa: Hexacorallia) and implications for classification within the order Antipatharia. Invertebrate systematics, 32(5), 1102-1110. https://doi.org/10.1071/IS17043.

Bolam, S.G., Coggan, R.C., Eggleton, J., Diesing, M., Stephens, D. (2014). Sensitivity of macrobenthic secondary production to trawling in the English sector of the Greater North Sea: A biological trait approach. *Journal of Sea Research, 85*, 162–177. https://doi.org/10.1016/j.seares.2013.05.003.

Borja, A., Franco, F., Valencia, V., Bald, J., Muxica, I., Belzunce, M.J., Solaun, O. (2004). Implementation of the European water framework directive from the Basque country (northern Spain): a methodological approach. *Marine Pollution Bulletin,* 48 (3–4), 209-218. https://doi.org/10.1016/j.marpolbul.2003.12.001.

Borja, A., Franco, J., Pérez, V. (2000). A Marine Biotic Index to Establish the Ecological Quality of Soft-Bottom Benthos Within European Estuarine and Coastal Environments. *Marine Pollution Bulletin*, 40(12), 1100–1114. https://doi.org/10.1016/S0025-326X(00)00061-8.

Borja. Á. and Grémare, A. (2012). The importance of setting targets and reference conditions in assessing marine ecosystem quality. *Ecological Indicators.* 12(1). 1–7. https://doi.org/10.1016/J.ECOLIND.2011.06.018.

Brissac, T., Rodrigues, C.F., Gros, O., Duperron, S. (2011). Characterization of bacterial symbioses in Myrtea sp. (Bivalvia: Lucinidae) and Thyasira sp. (Bivalvia: Thyasiridae) from a cold seep in the Eastern Mediterranean. *Marine Ecology-an Evolutionary Perspective* 32, 2, 198-210. https://doi.org/10.1111/j.1439-0485.2010.00413.x.

Canals, M., Company, J.B., Martín, D., Sànchez-Vidal, A., Ramirez-Llodra, E. (2013). Integrated study of Mediterranean deep canyons: novel results and future challenges. *Progress in Oceanography,* 118, 1-27. https://doi.org/10.1016/j.pocean.2013.09.004.

Canals, M., Danovaro, R., Heussner, S., Lykousis, V., Puig, P., Trincardi, F. et al. (2009). Cascades in Mediterranean submarine grand canyons. *Oceanography*, 22(1), 26-43. Retrieved from http://www.jstor.org/stable/24860920.

Canals, M., Puig, P., de Madron, X.D., Heussner, S., Palanques, A., Fabres, J. (2006). Flushing submarine canyons. *Nature*, 444(7117), 354. https://doi.org/10.1038/nature05271.

Candela, J. (1991). The Gibraltar Strait and its role in the dynamics of the Mediterranean Sea. *Dynamic Atmosphere Oceans*, 15 (3-5), 7313-7335. https://doi.org/10.1016/0377-0265(91)90023-9.

Casini, M., Hjelm, J., Molinero, J.C., Lövgren, J., Cardinale, M., Bartolino, V. et al. (2009). Trophic cascades promote threshold-like shifts in pelagic marine ecosystems. *Proceedings of the National Academy of Sciences*. 106(1). 197-202. https://doi.org/10.1073/pnas.0806649105.

Collie, J.S., Hall, S.J., Kaiser, M.J., Poiner, I.R. (2000). A quantitative analysis of fishing impacts on shelf-sea benthos. *Journal of Animal Ecology*, 69, 785-798. https://doi.org/10.1046/j.1365-2656.2000.00434.x

COP19 and UNEP/MAP-SPA/RAC. (2016). Decision IG.22/10. Implementing the Marine Litter Regional Plan in the Mediterranean (Fishing for Litter Guidelines, Assessment Report, Baselines Values, and Reduction Targets). 32pp.

D'Onghia, G., Maiorano, P., Carlucci, R., Capezzuto, F., Carluccio, A., Tursi, A., Sion, L. (2012). Comparing deep-sea fish fauna between coral and non-coral "megahabitats" in the Santa Maria di Leuca cold-water coral province (Mediterranean Sea). *PLoS One*, 7(9), e44509. https://doi.org/10.1371/journal.pone.0044509.

D'Onghia, G., Calculli, C., Capezzuto, F., Carlucci, R., Carluccio, A., Grehan, A. et al. (2017). Anthropogenic impact in the Santa Maria di Leuca cold-water coral province (Mediterranean Sea): observations and conservation straits. *Deep Sea Research Part II: Topical Studies in Oceanography*, 145, 87-101. https://doi.org/10.1016/j.dsr2.2016.02.012.

Danovaro, R., Company, JB., Corinaldesi, C., D'Onghia, G., Galil, B., Gambi, C. et al. (2010) Deep-Sea Biodiversity in the Mediterranean Sea: The Known, the Unknown, and the Unknowable. *PLOS ONE* 5(8): e11832. https://doi.org/10.1371/journal.pone.0011832

Dauvin, J.C. (2010). Towards an impact assessment of bauxite red mud waste on the knowledge of the structure and functions of bathyal ecosystems: The example of the Cassidaigne canyon (north-western Mediterranean Sea). *Marine Pollution Bulletin* 60, 2, 197-206. https://doi.org/10.1016/j.marpolbul.2009.09.026.

De Stephanis, R., Cornulier, T., Verborgh, P., Sierra, J.S., Gimeno, N.P., Guinet, C. (2008). Summer spatial distribution of cetaceans in the Strait of Gibraltar in relation to the oceanographic context. *Marine Ecology Progress Series*, 353, 275-288. https://doi.org/10.3354/meps07164.

Dell'Anno, A., Mei, M.L., Pusceddu, A., Danovaro, R. (2002). Assessing the trophic state and eutrophication of coastal marine systems: a new approach based on the biochemical composition of sediment organic matter. *Marine Pollution Bulletin* 44, 7, 611-622. https://doi.org/10.1016/S0025-326X(01)00302-2.

DEVOTES Project. (2014). DEVOTES. The WP3 indicator catalogue software. Introduction to the usage of DEVOTool 0.64. Obtained from: www.devotes-project.eu

Directive 2008/105/EC (2008). Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council. *Official Journal of the European Union.*

Duplisea, D.E., Jennings, S., Warr, K.J., Dinmore, T.A. (2002). A size-based model of the impacts of bottom trawling on benthic community structure. *Canadian Journal of Fisheries and Aquatic Sciences*, 59:1785-1795. https://doi.org/10.1139/f02-148.

Dupre, S., Woodside, J., Foucher, J.P., de Lange, G., Mascle, J., Boetius, A. et al. (2007). Seafloor geological studies above active gas chimneys off Egypt (Central nile deep sea fan). *Deep-Sea Research Part I-Oceanographic Research Papers* 54, 7, 1146-1172. https://doi.org/10.1016/j.dsr.2007.03.007.

Eigaard, O.R., Bastardie, F., Hintzen, N.T., Buhl-Mortensen, L., Buhl-Mortensen, P., Catarino, R., Dinesen, G.E. et al. (2015). Benthic impact of fisheries in European waters: the distribution and intensity of bottom trawling. BENTHIS Deliverable 2.3. 30 pp.

Eigaard, O.R., Bastardie, F., Hintzen, N.T., Buhl-Mortensen, L., Buhl-Mortensen, P., Catarino, R. et al. (2016). The footprint of bottom trawling in European waters: distribution, intensity, and seabed integrity. *ICES Journal of Marine Science*: Journal Du Conseil, 74(3), fsw194. https://doi.org/10.1093/icesjms/fsw194

Eigaard, O.R., Bastardie, F., Hintzen, N.T., Buhl-Mortensen, L., Buhl-Mortensen, P., Catarino, R. et al. (2017). The footprint of bottom trawling in European waters: Distribution, intensity, and seabed integrity. *ICES Journal of Marine Science*, 74(3), 847–865. https://doi.org/10.1093/icesjms/fsw194.

European Commission (2001). Commission regulation (EC) No 466/2001 of 8 March 2001 setting maximum levels for certain contaminants in foodstuffs. *Official Journal of the European Communities.*

European Commission (2017). Commission Decision (EU) 2017/848 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment and repealing Decision 2010/477/EU. *Official Journal of the European Union.*

Fabri, M.C., Pedel, L., Beuck, L., Galgani, F., Hebbeln, D., Freiwald, A. (2014). Megafauna of vulnerable marine ecosystems in French Mediterranean submarine canyons: Spatial distribution and anthropogenic impacts. *Deep-Sea Research Part Ii-Topical Studies in Oceanography* 104, 184-207. https://doi.org/10.1016/j.dsr2.2013.06.016.

Fabri, M.C., Bargain, A., Pairaud, I., Pedel, L., Taupier-Letage, I. (2017). Cold-water coral ecosystems in Cassidaigne Canyon: An assessment of their environmental living conditions. *Deep Sea Research Part II: Topical Studies in Oceanography 137*, 436-453. https://dx.doi.org/10.1016/j.dsr2.2016.06.006.

Fabri, M.C., Vinha, B., Allais, A.G., Bouhier, M.E., Dugornay, O., Gaillot, A., Arnaubec, A., submitted. Photogrammetry: a tool for evaluating cold-water coral ecological status, an example in the Cassidaigne canyon, northwestern Mediterranean Sea, *Progress in Oceanography*.

FAO. Food and Agriculture Organization of the United Nations (2018). The State of Mediterranean and Black Sea Fisheries. General Fisheries Commission for the Mediterranean. Rome. 172 pp.

Felden, J., Lichtschlag, A., Wenzhofer, F., de Beer, D., Feseker, T., Ristova, P.P. et al. (2013). Limitations of microbial hydrocarbon degradation at the Amon mud volcano (Nile deep-sea fan). *Biogeosciences* 10, 5, 3269-3283. https://doi.org/10.5194/bg-10-3269-2013.

Foglini, F., Campiani, E., Trincardi, F. (2016). The reshaping of the South West Adriatic Margin by cascading of dense shelf waters. *Marine Geology*, 375, 64-81. https://doi.org/10.1016/j.margeo.2015.08.011.

Foglini, F., Grande, V., Marchese, F., Bracchi, V.A., Prampolini, M., Angeletti, L. et al. (2019). Application of Hyperspectral Imaging to Underwater Habitat Mapping, Southern Adriatic Sea. *Sensors* 19: 2261. https://doi.org/10.3390/s19102261.

Fontanier, C., Biscara, L., Mamo, B., Delord, E. (2015). Deep-sea benthic foraminifera in an area around the Cassidaigne Canyon (NW Mediterranean) affected by bauxite discharges. *Marine Biodiversity* 44, 4, https://doi.org/10.1007/s12526-014-0281-9.

Fontanier, C., Fabri, M.C., Buscail, R., Biscara, L., Koho, K., Reichart, G.J. et al. (2012). Deep-sea foraminifera from the Cassidaigne Canyon (NW Mediterranean): Assessing the environmental impact of bauxite red mud disposal. *Marine Pollution Bulletin 64*, 9, 1895-1910. https://doi.org/10.1016/j.marpolbul.2012.06.016.

Freiwald, A., Beuck, L., Rüggeberg, A., Taviani, M., Hebbeln, D., R/V Meteor Cruise M70-1 Participants. (2009). The white coral community in the central Mediterranean Sea revealed by ROV surveys. *Oceanography,* 22(1), 58-74. https://doi.org/10.5670/oceanog.2009.06.

Galil, B. and Zibrowius, H. (1998). First benthos samples from Eratosthenes Seamount, eastern Mediterranean. *Marine Biodiversity* 28, 4-6, 111-122. https://doi.org/10.1007/BF03043142.

Galil, B. (2004). The limit of the sea: the bathyal fauna of the Levantine Sea. *Scientia Marina,* 68: 63-72. https://doi.org/10.3989/scimar.2004.68s363.

GFCM, 2019. Report of the third meeting of the Working Group on Marine Protected Areas (WGMPA), FAO HQ, Italy, 18–21 February 2019.

Gonzalez, D., Coughan, C., Stips, A., Stolk, A., Gonzalez Pola, C., Moreno Aranda, I.M. et al. (2015). Review of the Commission Decision 2010/477/EU concerning MSFD criteria for assessing Good Environmental Status. Descriptor 7. EUR 27544 EN. https://doi.org/10.2788/435059. http://mcc.jrc.ec.europa.eu/documents/201603310431.pdf.

Goren, M. and Galil, B. (2005). A review of changes in the fish assemblages of Levantine inland and marine ecosystems following the introduction of non-native fishes. *Journal of Applied Ichthyology*, 21(4), 364-370. https://doi.org/10.1111/j.1439-0426.2005.00674.x.

Goren, M., Mienis, H., Galil, B. (2008). Not so poor—more deep-sea records from the Levant Sea, eastern Mediterranean. Marine Biodiversity Records, 1, E43. https://doi.org/10.1017/S1755267206005203.

Greenstreet, S.P.R., Rogers, S.I., Rice, J.C., Piet, G.J., Guirey, E.J., Fraser, H.M and Fryer, R.J. (2011). Development of the EcoQO for the North Sea fish community. *ICES Journal of Marine Science* 68(1). 1-11. https://doi.org/10.1093/icesjms/fsq156.

Guarnieri, G., Fraschetti, S., Bogi, C., Galil, B. (2017). A hazardous place to live: spatial and temporal patterns of species introduction in a hot spot of biological invasions. *Biological Invasions* 19(8):2277–2290. https://doi.org/10.1007/s10530-017-1441-1.

Gulland, A. J. and Boerema, K. L. (1973). Scientific advice on catch levels. *Fish. Bull.* 71. NO.2 325-335.

Habitats Directive (92/43/EEC) (1992). Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. *Official Journal of the European Communities*.

Halpern, B., Walbridge, S., Selkoe, K., Kappel, C., Micheli, F., D'Agrosa, C. et al. (2008). A global map of human impact on marine ecosystems. *Science* 319(5865), 948–952. https://doi.org/10.1126/science.1149345

HELCOM (2012a). Helsinki Commission. Development of a set of core indicators: Interim report of the HELCOM CORESET project. PART A: Descriptions of the selection process. *Baltic Sea Environment Proceedings No. 129A.*

HELCOM (2012b). Helsinki Commission. Development of a set of core indicators: Interim report of the HELCOM CORESET project. PART B: Descriptions of the indicators. *Baltic Sea Environment Proceedings No. 129B.*

Hiddink, J.G., Jennings, S., Kaiser, M.J. (2006). Indicators of the Ecological Impact of Bottom-Trawl Disturbance on Seabed Communities. *Ecosystems,* 9(7), 1190–1199. https://doi.org/10.1007/s10021-005-0164-9.

Hilborn, R. and Walters, C.J. (1992). Quantitative fisheries stock assessment: Choice, dynamics and uncertainty. Chapman and Hall. New York. 570pp.

Huguen, C., Foucher, J.P., Mascle, J., Ondreas, H., Thouement, M., Gontharet, S. et al. (2009). Menes caldera, a highly active site of brine seepage in the Eastern Mediterranean sea: "In situ" observations from the NAUTINIL expedition (2003). *Marine Geology* 261, 1-4, 138-152. https://doi.org/10.1016/j.margeo.2009.02.005.

Hyland, J., Balthis, L., Karakassis, I., Magni, P., Petrov, A., Shine, J. et al. (2005). Organic carbon content of sediments as an indicator of stress in the marine benthos. *Mar. Ecol. Prog. Ser*. 295:91–103. https://doi.org/10.3354/meps295091.

ICES WKGMSFDD3-II (2015b). Report of the workshop on guidance for the review of MSFD decision descriptor 3 - commercial fish and shellfish II (WKGMSFDD3-II). ICES Headquarters. Denmark. ICES

ICES WKGMSFDD6 (2014). ICES ACOM COMMITTEE. Report of the Workshop to review the 2010 Commission Decision on criteria and methodological standards on good environmental status (GES) of marine waters; Descriptor 6. ICES Headquarters. Denmark.

ICG-COBAM (2013). OSPAR Intersessional Correspondence Group on the Coordination of Biodiversity Assessment and Monitoring (ICG-COBAM) for the OSPAR Biodiversity Committee. Development of a OSPAR common set biodiversity indicators.

Jessen, C., Bednarz, V.N., Rix, L., Teichberg, M., Wild, C. (2015). Marine eutrophication. In Environmental indicators (pp. 177-203). Publisher: Springer. Editors: R.H. Armon, O. Hänninen. https://doi.org/10.1007/978-94-017-9499-2_11.

Kaiser, M.J., Clarke, K.R., Hinz, H., Austen, M.C.V., Somerfield, P.J., Karakassis, I. (2006). Global analysis of response and recovery of benthic biota to fishing. *Marine Ecology Progress Series*, 311:1-14. https://doi.org/10.3354/meps311001.

Korpinen, S., Meski, L., Andersen, J.H., Laamanen, M. (2012). Human pressures and their potential impact on the Baltic Sea ecosystem. *Ecological Indicators*. 15(1). 105–114. https://doi.org/10.1016/j.ecolind.2011.09.023.

Labrune, C., Amouroux, J. M., Sarda, R., Dutrieux, E., Thorin, S., Rosenberg, R., Grémare, A. (2006). Characterization of the ecological quality of the coastal Gulf of Lions (NW Mediterranean). A comparative approach based on three biotic indices. *Marine Pollution Bulletin*, 52(1), 34–47. https://doi.org/10.1016/j.marpolbul.2005.08.005.

Lastras, G., Canals, M., Ballesteros, E., Gili, J.M., Sanchez-Vidal, A. (2016). Cold-Water corals and anthropogenic impacts in La Fonera submarine canyon head, Northwestern Mediterranean Sea. *PloS one*, 11(5), e0155729. https://doi.org/10.1371/journal.pone.0155729.

Lastras, G., Canals, M., Urgeles, R., Hughes-Clarke, J. E., Acosta, J. (2004). Shallow slides and pockmark swarms in the Eivissa Channel, western Mediterranean Sea. *Sedimentology*, 51(4), 837-850. https://doi.org/10.1111/j.1365-3091.2004.00654.x.

Lauria, V., Garofalo, G., Fiorentino, F., Massi, D., Milisenda, G., Piraino, S. et al. (2017). Species distribution models of two critically endangered deep-sea octocorals reveal fishing impacts on vulnerable marine ecosystems in central Mediterranean Sea. *Scientific reports*, 7(1), 8049. https://doi.org/10.1038/s41598-017-08386-z.

Lembo, G. (2015). Programma nazionale Italiano per la raccolta di dati alieutici 2015 Campagne di ricerca in mare Sezione G. Relazione finale GSA18. COISPA, Itay: pp. 52.

León, R., Somoza, L., Medialdea, T., González, F.J., Gimenez-Moreno, C.J., Pérez-López, R. (2014). Pockmarks on either side of the Strait of Gibraltar: formation from overpressured shallow contourite gas reservoirs and internal wave action during the last glacial sea-level lowstand*? Geo-Marine Letters* (2014) 34: 131. https://doi.org/10.1007/s00367-014-0358-2.

Link, J.S. (2005). Translating ecosystem indicators into decision criteria. *ICES Journal of Marine Science.* 62: 569-576. https://doi.org/doi:10.1016/j.icesjms.2004.12.015.

Malanotte-Rizzoli, P. and Bergamasco, A. (1991). The wind and thermally driven circulation of the eastern Mediterranean Sea. Part II: The baroclinic case. *Dynamics of Atmospheres and Oceans*, 15(3-5), 355-419. https://doi.org/10.1016/0377-0265(91)90026-C.

Malinverno, E., Taviani, M., Rosso, A., Violanti, D., Villa, I., Savini, A. et al. (2010). Stratigraphic framework of the Apulian deep-water coral province, Ionian Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, 57(5-6), 345-359. https://doi.org/10.1016/j.dsr2.2009.08.025.

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

Massutí, E., Gordon, J.D.M., Moranta, J., Swan, S.C., Stefanescu, C., Merrett, N.R. (2004). Mediterranean and Atlantic deep-sea fish assemblages: Differences in biomass composition and size-related structure. *Scientia Marina.* 68. 101-115.

MedPAN UNEP/MAP RAC/SPA. (2016). The 2016 status of Marine Protected Areas in the Mediterranean. Main Findings.

Micheli, F., Halpern, B.S., Walbridge, S., Ciriaco, S., Ferretti, F., Fraschetti, S. et al. (2013). Cumulative human impacts on Mediterranean and Black Sea marine ecosystems: Assessing current pressures and opportunities. *PLoS ONE*. 8(12). https://doi.org/10.1371/journal.pone.0079889.

Millot, C., 1990. The Gulf of Lions' hydrodynamics. *Continental Shelf Research* 10, 9-11, 885-894, https://doi.org/10.1016/0278-4343(90)90065-T.

Modica, L., Velasco, F., Preciado, I., Soto, M., Greenstreet, S.P.R. (2014). Development of the large fish indicator and associated target for a Northeast Atlantic fish community, *ICES Journal of Marine Science*, 71(9), 2403–2415. https://doi.org/10.1093/icesjms/fsu101.

Moffat, C., Aish, A., Hawkridge, J.M., Miles, H., Mitchell, P.I., McQuatters-Gollop. A. et al. (2011). Advice on United Kingdom biodiversity indicators and targets for the Marine Strategy Framework

Directive. Healthy and biologically diverse seas evidence group report to the Department for Environment. Food and Rural Affairs. 210pp.

Nöges, P., Toth, L.G., van de Bund, W., Cardoso, A.C., Haastrup, P., Wuertz, J. et al. (2005). The Water Framework Directive final intercalibration register for lakes, rivers, coastal and transitional waters: overview and analysis of metadata. Institute for Environment and Sustainability, Inland and Marine Waters Unit, Joint Research Centre, European Commission, Ispra (VA), Italy. 137pp.

Oceana (2014). Scientific Information to Describe Areas Meeting Scientific Criteria for Mediterranean EBSAs. Malaga Spain, 7-11.04.2014.

Orejas, C., Gori, A., Iacono, C. L., Puig, P., Gili, J. M., Dale, M.R. (2009). Cold-water corals in the Cap de Creus canyon, northwestern Mediterranean: spatial distribution, density and anthropogenic impact. *Marine Ecology Progress Series*, 397, 37-51. https://doi.org/10.3354/meps08314.

Ovchinnikov, I.M., Zats, V.I., Krivosheya, V.G., Udodov, A.I. (1985). Formation of deep Eastern Mediterranean waters in the Adriatic Sea. *Oceanology*, 25(6), 704-707.

Palanques, A., Puig, P., Latasa, M., Scharek, R. (2009). Deep sediment transport induced by storms and dense shelf-water cascading in the northwestern Mediterranean basin. *Deep Sea Research Part I: Oceanographic Research Papers*, 56(3), 425-434. https://doi.org/10.1016/j.dsr.2008.11.002.

Piante, C. and Ody, D. (2015). Blue Growth in the Mediterranean Sea: the Challenge of Good Environmental Status. MedTrends Project. WWF-France. 192 p.

Pielou, E.C. (1975). *Ecological diversity* (No. 574.524018 P5).

Pinedo, S. and Jordana, E. (2008). Spain (Catalonia and Balearic Islands). Water Framework Directive Intercalibration Technical Report. Part, 3, 62-70.

Pitcher, R.C., Ellis, N., Jennings, S., Hiddink, J.G., Mazor, T., Kaiser, M.J. et al. (2017). Estimating the sustainability of towed fishing-gear impacts on seabed habitats: a simple quantitative risk assessment method applicable to data-limited fisheries. *Methods in Ecology and Evolution* 2017,8, 472-480. https://doi.org/10.1111/2041-210X.12705.

Pollak, M.J. (1951). The sources of the deep water of the eastern Mediterranean Sea. *Journal of Marine Research,* 10(1), 128-152.

Puig, P., Font, J., Palanques, A., Sardà, F. (2008). Monitoring dense shelf water cascades: an assessment tool for understanding deep-sea ecosystems functioning. *CIESM Workshop Monographs* 34: 81-86. http://www.ciesm.org/online/monographs/LaSpezia.html.

Pusceddu, A., Bianchelli, S., Gambi, C., Danovaro, R. (2011). Assessment of benthic trophic status of marine coastal ecosystems: Significance of meiofaunal rare taxa. *Estuarine. Coastal and Shelf Science*. 93(4). 420-430. https://doi.org/10.1016/j.ecss.2011.05.012.

Pusceddu, A., Dell'Anno, A., Fabiano, M., Danovaro, R. (2009). Quantity and bioavailability of sediment organic matter as signatures of benthic trophic status. *Marine Ecology Progress Series.* 375. 41-52. https://doi.org/10.3354/meps07735.

Rijnsdorp, A.D., Bastardie, F., Bolam, S.G., Buhl-Mortensen, L., Eigaard, O.R., Hamon, K.G. et al. (2016). Towards a framework for the quantitative assessment of trawling impact on the seabed and benthic ecosystem. *ICES Journal of Marine Science*: Journal Du Conseil, 73(suppl 1), i127–i138. https://doi.org/10.1093/icesjms/fsv207.

Ritt, B., Desbruyeres, D., Caprais, J.C., Gauthier, O., Ruffine, L., Buscail, R. et al. (2012). Seep communities from two mud volcanoes in the deep eastern Mediterranean Sea: faunal composition, spatial patterns and environmental control. *Marine Ecology Progress Series* 466, 93-+. https://doi.org/10.3354/meps09896.

Ritt, B., Pierre, C., Gauthier, O., Wenzhöfer, F., Boetius, A., and Sarrazin, J. (2011). Diversity and distribution of cold-seep fauna associated with different geological and environmental settings at mud volcanoes and pockmarks of the Nile Deep-Sea Fan. *Marine Biology*, 158(6), 1187-1210. https://doi.org/10.1007/s00227-011-1679-6.

Ritt, B., Pierre, C., Gauthier, O., Wenzhofer, F., Boetius, A., Sarrazin, J. (2011). Diversity and distribution of cold-seep fauna associated with different geological and environmental settings at mud volcanoes and pockmarks of the Nile Deep-Sea Fan. *Marine Biology* 158, 6, 1187-1210. https://doi.org/10.1007/s00227-011-1679-6.

Roether, W. and Schlitzer, R. (1991). Eastern Mediterranean deep water renewal on the basis of chlorofluoromethane and tritium data. *Dynamics of Atmospheres and Oceans*, 15(3-5), 333-354. https://doi.org/10.1016/0377-0265(91)90025-B.

Rosenberg, R., Blomqvist, M., Nilsson, C., Cederwall, H., Dimming, A. (2004). Marine quality assessment by use of benthic species-abundance distributions: a proposed new protocol within the European Union Water Framework Directive. *Marine Pollution Bulletin*, 49(9–10), 728–739. https://doi.org/10.1016/j.marpolbul.2004.05.013.

Rubin-Blum, M., Tsadok, R., Shemesh, E., Goodman-Tchernov, B.N., Austin, J.A., Coleman, D.F. et al. (2014). Distribution of the *Lamellibrachia* spp. (Siboglinidae, Annelida) and their trophosome endosymbiont phylotypes in the Mediterranean Sea. *Marine Biology* 161, 6, 1229-1239, https://doi.org/10.1007/s00227-014-2413-y.

Savini, A. and Corselli, C. (2010). High-resolution bathymetry and acoustic geophysical data from Santa Maria di Leuca Cold Water Coral province (Northern Ionian Sea—Apulian continental slope). *Deep Sea Research Part II: Topical Studies in Oceanography*, 57(5-6), 326-344. https://doi.org/10.1016/j.dsr2.2009.08.014.

Savini, A., Vertino, A., Marchese, F., Beuck, L., Freiwald, A. (2014). Mapping cold-water coral habitats at different scales within the Northern Ionian Sea (Central Mediterranean): an assessment of coral coverage and associated vulnerability. *PLoS One*, 9(1), e87108. https://doi.org/10.1371/journal.pone.0087108.

Schroeder, K., Chiggiato, J., Josey, S.A., Borghini, M., Aracri, S., Sparnocchia, S. (2017). Rapid response to climate change in a marginal sea. *Scientific Reports.* 7(1). 4065. https://doi.org/10.1038/s41598-017-04455-5.

Shephard S., Reid D.G., Greenstreet, S. (2011). Interpreting the large fish indicator for the Celtic Sea. *ICES Journal of Marine Science,* 68: 1963-1972. https://doi.org/10.1093/icesjms/fsr114.

Simboura, N. and Zenetos, A. (2002). Benthic indicators to use in Ecological Quality classification of Mediterranean soft bottom marine ecosystems, including a new Biotic Index. *Mediterranean Marine Science*, 3(2), 77. https://doi.org/10.12681/mms.249.

Simboura, N. and Argyrou, M. (2010). An insight into the performance of benthic classification indices tested in Eastern Mediterranean coastal waters. *Marine Pollution Bulletin.* 60(5). 701-709. https://doi.org/10.1016/j.marpolbul.2009.12.005

Stora, G., Arnoux, A., Duport, E., Re, C., Gerino, M., Desrosiers, G., Gilbert, F. (2011). Impact of Red Mud Deposits in the Canyon of Cassidaigne on the Macrobenthos of the Mediterranean Continental Slope.[Ceccaldi, H.J., Dekeyser, I., Girault, M., Stora, G. (Eds.)] Global Change: Mankind-Marine Environment Interactions, pp. 397-400. https://doi.org/10.1007/978-90-481-8630-3_72.

Taviani, M., Remia, A., Corselli, C., Freiwald, A., Malinverno, E., Mastrototaro, F. et al. (2005a). First geo-marine survey of living cold-water Lophelia reefs in the Ionian Sea (Mediterranean basin). *Facies*, 50(3-4), 409-417. https://doi.org/10.1007/s10347-004-0039-0.

Taviani, M., Freiwald, A., and Zibrowius, H. (2005b). Deep coral growth in the Mediterranean Sea: an overview. In Cold-water corals and ecosystems (pp. 137-156). Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-27673-4_7.

Taviani, M., Vertino, A., Correa, M. L., Savini, A., De Mol, B., Remia, A. et al. (2011). Pleistocene to Recent scleractinian deep-water corals and coral facies in the Eastern Mediterranean. *Facies*, 57(4), 579-603. https://doi.org/10.1007/s10347-010-0247-8.

Taviani, M., Angeletti, L., Beuck, L., Campiani, E., Canese, S., Foglini, F. et al. (2016). Reprint of: On and off the beaten track: Megafaunal sessile life and Adriatic cascading processes'. *Marine Geology*, 375, 146-160. https://doi.org/10.1016/j.margeo.2015.10.003.

TG Noise (2018). MSFD Common Implementation Strategy - Technical Group on Underwater Noise (TG-NOISE). Thematic workshop: Towards thresholds for underwater noise Common approaches for interpretation of data obtained in (Joint) Monitoring Programmes – Part 2. Brussels. 7-8.11.2018.

Thrush, S. F., Lundquist, C. J., Hewitt, J.E. (2005). Spatial and temporal scales of disturbance to the seafloor: a generalized framework for active habitat management. *American Fisheries Society Symposium*, 41: 639–649.

Trenkel, V. (2006). Méthodes d'évaluation des ressources marines vivantes pour une exploitation durable. HDR. http://archimer.ifremer.fr/doc/00000/1545/.

Turchetto, M., Boldrin, A., Langone, L., Miserocchi, S., Tesi, T., Foglini, F. (2007). Particle transport in the Bari canyon (southern Adriatic Sea). *Marine Geology*, 246(2-4), 231-247. https://doi.org/10.1016/j.margeo.2007.02.007.

Tursi, A., Mastrototaro, F., Matarrese, A., Maiorano, P., D'Onghia, G. (2004). Biodiversity of the white coral reefs in the Ionian Sea (Central Mediterranean). *Chemistry and Ecology*, 20(sup1), 107-116. https://doi.org/10.1080/02757540310001629170.

UNEP-MAP-RAC/SPA (2010). Overview of scientific findings and criteria relevant to identifying SPAMIs in the Mediterranean open seas, including the deep sea. By Notarbartolo di Sciara. G. and Agardy. T. Ed. RAC/SPA. Tunis: 71pp

Van Denderen, P.D., Bolam, S.G., Hiddink, J.G., Jennings, S., Kenny, A., Rijnsdorp, A., van Kooten, T. (2015). Similar effects of bottom trawling and natural disturbance on composition and function of benthic communities across habitats. *Marine Ecology Progress Series,* 541:31-43. https://doi.org/10.3354/meps11550

Vertino, A., Savini, A., Rosso, A., Di Geronimo, I., Mastrototaro, F., Sanfilippo, R. et al. (2010). Benthic habitat characterization and distribution from two representative sites of the deep-water SML Coral Province (Mediterranean). *Deep Sea Research Part II: Topical Studies in Oceanography*, 57(5-6), 380-396. https://doi.org/10.1016/j.dsr2.2009.08.023.

Vilibić, I. and Orlić, M. (2002). Adriatic water masses, their rates of formation and transport through the Otranto Strait. *Deep Sea Research Part I: Oceanographic Research Papers*, 49(8), 1321-1340. https://doi.org/10.1016/S0967-0637(02)00028-6.

WGMPA, Working Group on Marine Protected Areas (2019). Report of the Working Group on Marine Protected Areas (WGMPA), including a session on essential fish habitats (EFH). Scientific Advisory Committee on Fisheries (SAC). Food and Agriculture Organization of the United Nations. General Fisheries Commission of the Mediterranean. FAO headquarters, Rome, Italy, 18 –21 February 2019.

WGVME, Working Group on Vulnerable Marine Ecosystems (2018). Report of the second meeting of the Working Group on Vulnerable Marine Ecosystems (WGVME). Scientific Advisory Committee on Fisheries (SAC). Food and Agriculture Organization of the United Nations. General Fisheries Commission of the Mediterranean. FAO headquarters, Rome, Italy, 26 –28 February 2018.

WEBPAGES

Natura2000 network. https://era.org.mt/en/Pages/Natura-2000-Datasheets-Maps.aspx). Last access on: 16/05/2019.

OSPAR. Intermediate Assessment 2017. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/. Accessed on: 08/01/2019

UNEP-MAP. 2017. Mediterranean 2017 Quality Status Report. https://www.medqsr.org/. Accessed on: 08/01/2019

Convention on Biological Diversity. Ecologically or Biologically Significant Areas (EBSAs). https://www.cbd.int/ebsa/). Accessed on: 26/03/2019

International Maritime Organization. Particularly Sensitive Sea Areas (PSSA) http://www.imo.org/en/OurWork/Environment/PSSAs/Pages/Default.aspx). Accessed on: 26/03/2019

IDEMARES project. Marine areas proposed for SCI. (https://www.indemares.es/en/home). Accessed on: 26/03/2019.

https://www.legifrance.gouv.fr/eli/arrete/2018/4/23/AGRM1733988A/jo/texte/fr. Last access on: 16/05/2019.

http://www.parc-marin-golfe-lion.fr/images/doc_link/juin_2013/perimetre_fevrier2013.pdf. Last access on: 16/05/2019.

RELEVANT IDEM DOCUMENTS

IDEM Project (2018a). Deliverable 2.1: IDEM Report 2.1. Review and collection of the available datasets on indicators and human pressures/impacts on Mediterranean deep sea ecosystems. *IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project.* UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM, UNIVPM.

IDEM Project (2018b). Deliverable2.2: IDEM Report 2.2 on the first assessment of the deep Mediterranean environmental status. *IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project.* UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM, UNIVPM.

IDEM Project (2018c). Deliverable 2.3: IDEM Report 2.3 on habitat/ecosystems/pressure mapping in GIS. *IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project.* UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM, UNIVPM.

IDEM Project (2019a). Deliverable 3.1: IDEM Report 3.1. Report on gaps in data related to indicators, sub-basins, deep-sea ecosystems and human pressures/impacts. *IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project*. UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM, UNIVPM.

IDEM Project (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.

IDEM Project (2019c). Supporting document of the Report 3.2: Task 3.2 Database of the IDEM criteria and indicators. *IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project.* UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM, UNIVPM. Supplementary document.

IDEM Project (2019d). Deliverable 3.3: IDEM Report 3.3. Report on the indicators and thresholds to identify the GES and the key areas for design monitoring programs in the Mediterranean deep sea. *IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project*. UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM, UNIVPM. (Present document).

IDEM Project (2019e). Deliverable 4.3: IDEM Report 4.3. Report 4.3. Report on guidelines to define deep-sea protected areas. *IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project*. UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM, UNIVPM.

ANNEX I - GEOGRAPHIC LOCATION OF THE POTENTIAL KEY AREAS NOT SELECTED

The approach developed for selecting key areas based the method on the collection of expert's judgments in form of evaluation scores provided to each area. Accordingly, the approach was considerably limited and conditioned by the number of evaluation scores gathered for each area.

In order to account for this bias, a minimum number of scores was set as threshold for selecting an area and generating a specific descriptive sheet. This threshold established than the areas obtaining less than the third of the 209 total possible scores (i.e. <70 scores) should not selected. The areas rejected due to the low score number were described as potential key areas in need of further revision since they still have a huge potential for being key monitoring areas when more information and more expertise is available.

Although these areas were not selected and thus not provided with a descriptive sheet, a brief description is available within the supporting spreadsheet document (see attachment in chapter 4.3.2). Additionally, individual maps for each of these areas not selected were also generated and they are presented in this chapter.

ST.6 - AEGEAN SEA AND CRETAN NORTHERN IONIAN SEA STRAITS

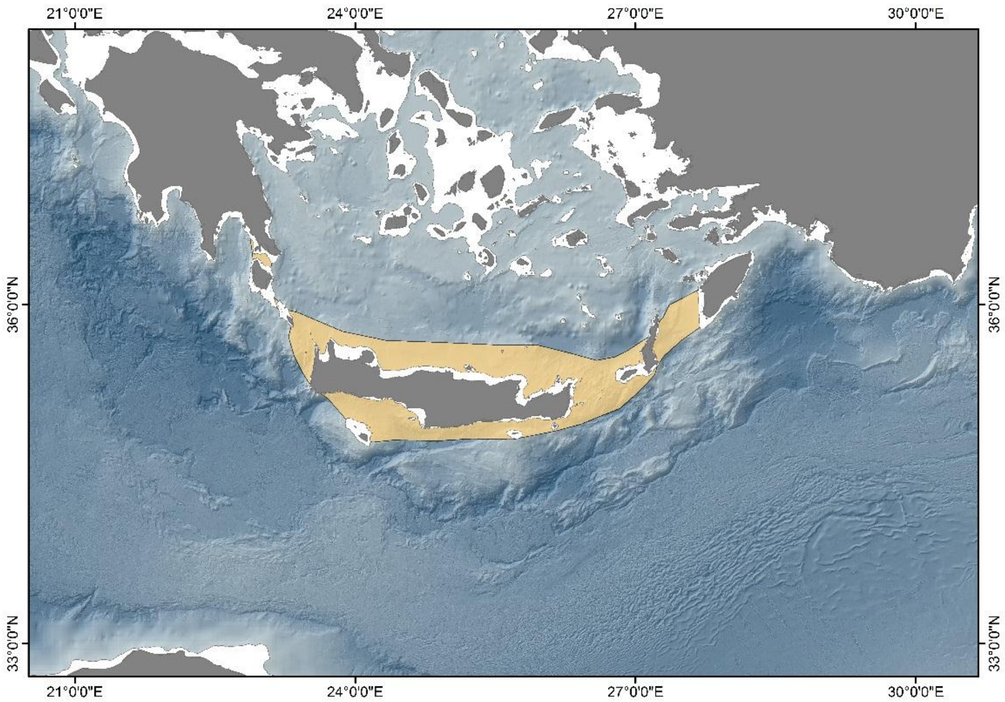


Figure AI.1 Individual map representing in orange the ST.6 area. Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.

DW.3 - AEGEAN DENSE WATER FORMATION AND SPREADING AREA

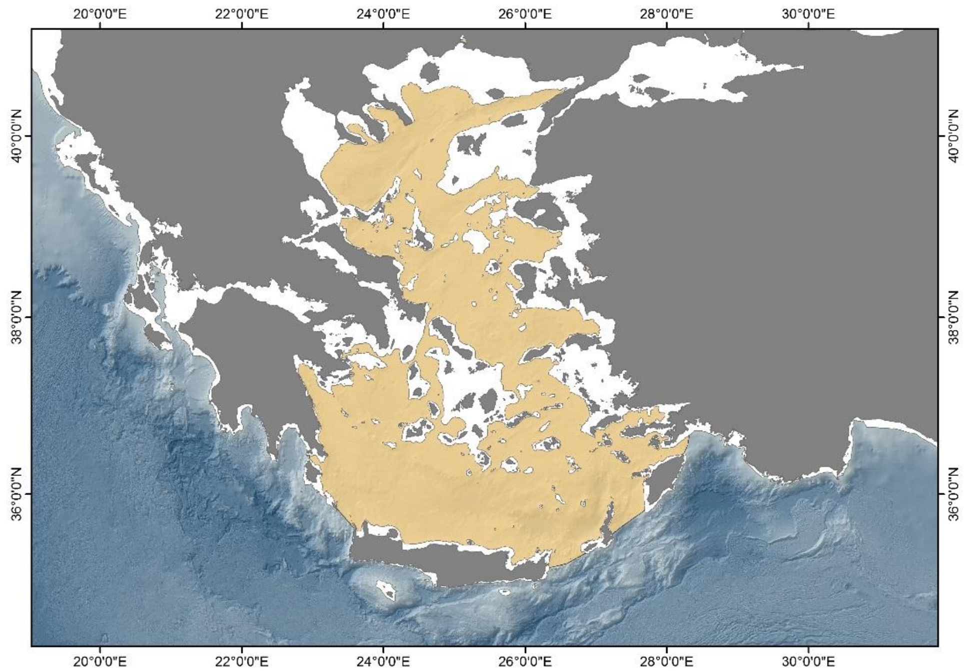


Figure AI.2 Individual map representing in orange the DW.3 area. Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.

CS.4 - LEVANTE CANYON, LIGURIAN SEA

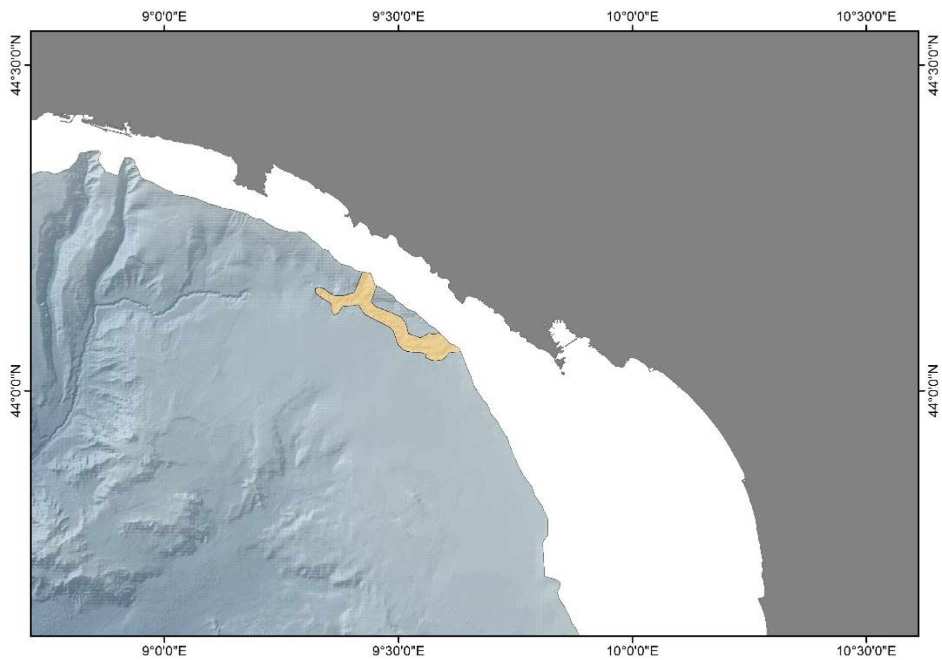


Figure AI.3 Individual map representing in orange the CS.4 area. Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.

CWC.2 - WESTERN MEDITERRANEAN NORTHERN AREA

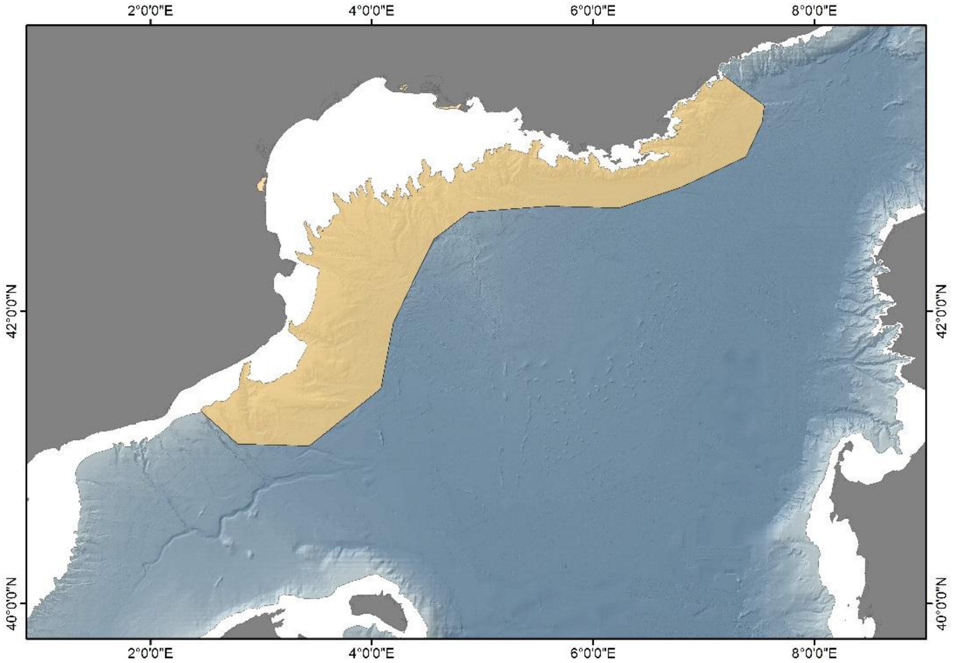


Figure AI.4 Individual map representing in orange the CWC.2 area Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.

CWC.3 - CWC HABITATS OF BARI CANYON SYSTEMS

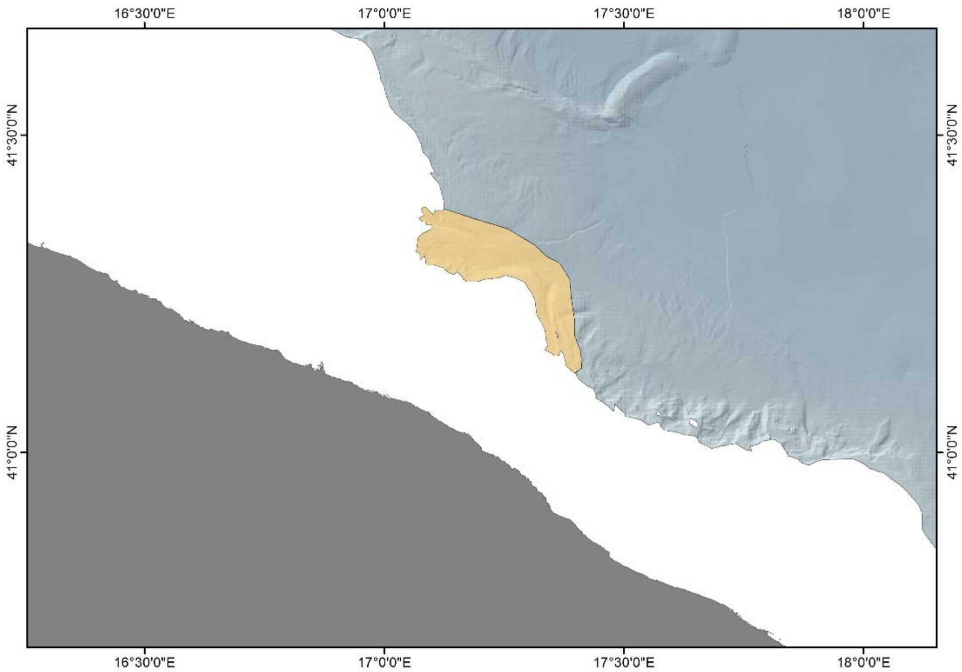


Figure AI.5 Individual map representing in orange the CWC.3 area. Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.

SM.1 - SEAMOUNTS OF THE ALBORAN SEA

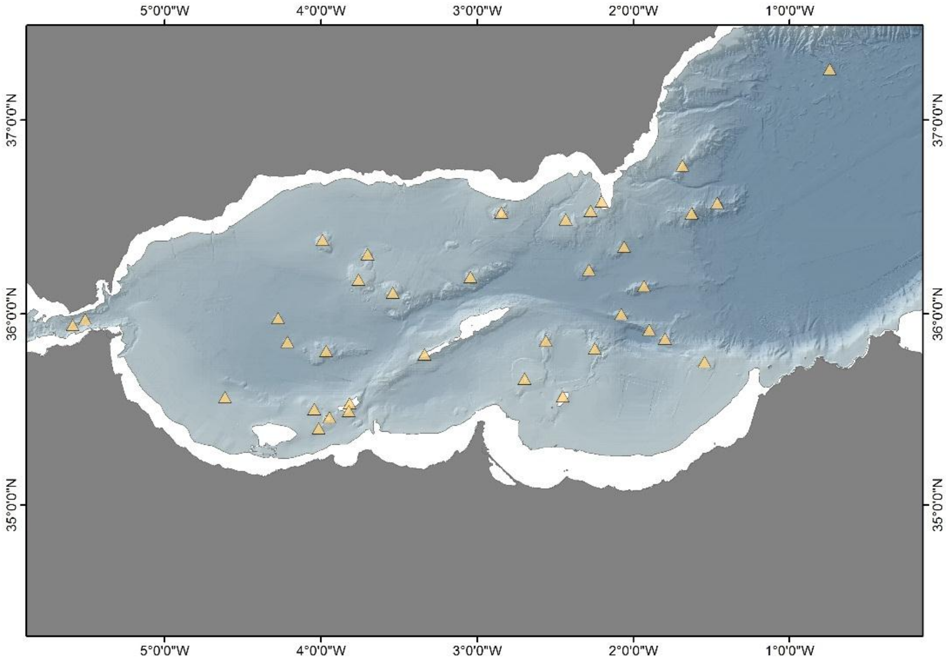


Figure AI.6 Individual map representing in orange the SM.1 area. Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.

SM.3 - OTHER SEAMOUNTS (TYRRHENIAN SEA)

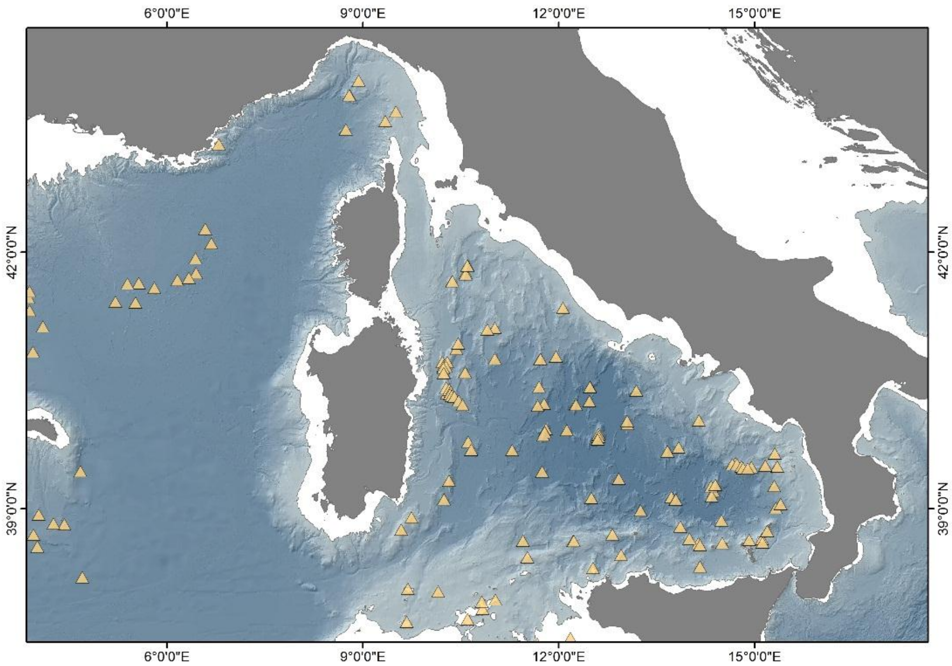


Figure AI.7 Individual map representing in orange the SM.3 area. Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.

OR.2 - HELLENIC TRENCH

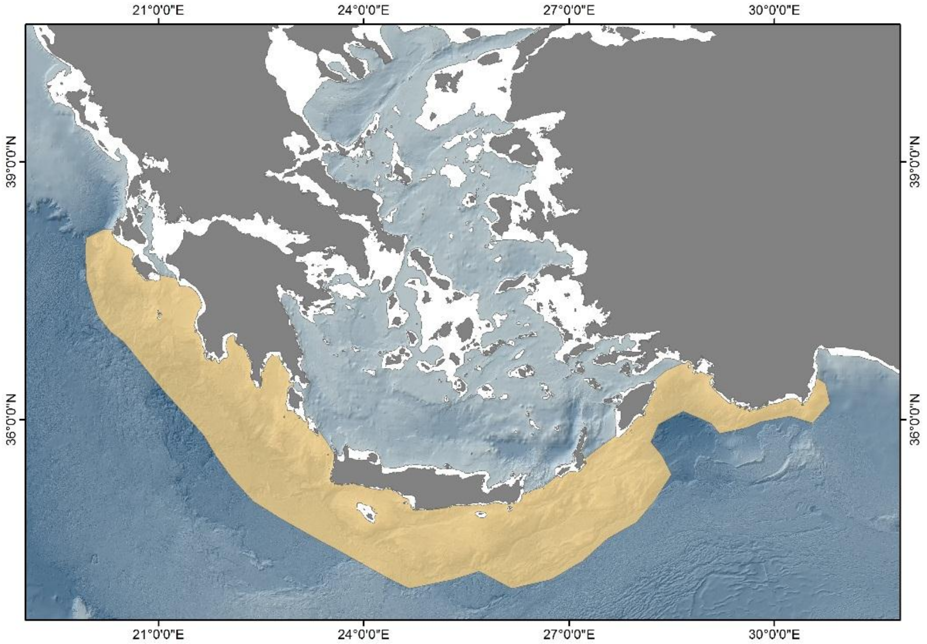


Figure AI.8 Individual map representing in orange the OR.2 area. Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.

OR.4 - EASTERN CORSICAN SLOPE

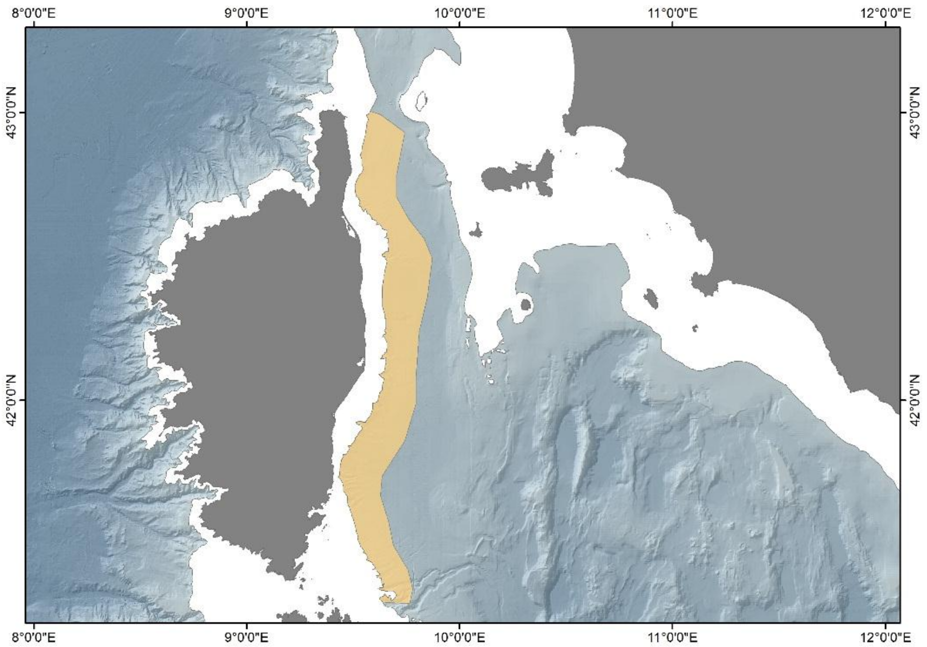


Figure AI.9 Individual map representing in orange the OR.4 area. Shallow zones above 200 m depth are depicted in white since they were not considered within Task 3.3.