UNITED
NATIONS

EP

UNEP/MED WG.608/Inf.20

UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

UNEP

28 April 2025
Original: English

Seventeenth Meeting of SPA/BD Focal Points

Istanbul, Türkiye, 20-22 May 2025

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

State of the art regarding the available information on GES and the effects of climate change and other cumulative pressures in its determination in the Mediterranean

UNEP/MAP
SPA/RAC - Tunis, 2025

Specially Protected Areas Regional Activity Centre (SPA/RAC)
Boulevard du Leader Yasser Arafat
B.P. 337 - 1080 Tunis Cedex - Tunisia
E-mail : car-asp@spa-rac.org

Note by the Secretariat

1. As one of the most significant threats to biodiversity in the Mediterranean Sea, climate change requires further clarification within IMAP. Its impact should be integrated into existing indicators and methodologies, particularly in the establishment of baseline and threshold values.

2. To this end, the SPA/RAC, within the ABIOMMED project, has undertaken a review of the elements associated with the assessment of Good Environmental Status (GES), including climate change, in the Mediterranean region.

3. The report "State of the art regarding the available information on GES and the effects of climate change and other cumulative pressures in its determination in the Mediterranean" explores the state of available information on GES and the impacts of climate change, focusing on impediments to GES determination, particularly the effects of climate change on assessment processes within the Integrated Monitoring and Assessment Programme (IMAP) and the Marine Strategy Framework Directive (MSFD).

4. This state-of-the-art study was presented as an information document during the Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Biodiversity and Fisheries, Videoconference, 6-7 June 2024.

5. The present document is submitted to the 17th Meeting of SPA/BD Focal Points for information

United Nations
Environment Programme
Mediterranean Action Plan

Distr.: Limited
09 May 2024

Original: English

Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Biodiversity and Fisheries

Videoconference, 6-7 June 2024

Agenda item 5: Elements for IMAP Revision related to Biodiversity and Non -Indigenous Species (NIS)

State of the art regarding the available information on GES and the effects of climate change and other cumulative pressures in its determination in the Mediterranean

SPA/RAC
Tunis, 2024

Disclaimer:

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Environment Programme/Mediterranean Action Plan concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The Secretariat is also, not responsible for the use that may be made of information provided in the tables and maps of this report. Moreover, the maps serve for information purposes only, and may not and shall not be construed as official maps representing maritime borders in accordance with international law.

The research leading to these results has received funding from the European Commission DG Environment] under grant agreement No 110661/2020/839620/SUB/ENV.C.2– ABIOMMED project (Support coherent and coordinated assessment of biodiversity and measures across Mediterranean for the next 6-year cycle of MSFD implementation).

In charge of the study at SPA/RAC:

Yassine Ramzi SGHAIR, Ecosystem Approach project officer

Samar KILANI, Ecosystem Approach associate project officer

Report prepared by:

Maïa Fourt, SPA/RAC consultant

This deliverable should be referenced as follows:

Fourt,M., Kilani,S. Sghaier,YR., SPA/RAC 2023. State of the art regarding the available information on GES and the effects of climate change and other cumulative pressures in its determination in the Mediterranean, with recommendations and way forward. ABIOMMED Project, Deliverable no 6.2

Executive Summary:

The ABIOMMED deliverable 6, specifically task 6.2, addresses the review of elements associated with Good Environmental Status (GES) assessment, including climate change, within the Mediterranean region. The report explores the state of available information on GES and the impacts of climate change, focusing on impediments to GES determination, particularly the effects of climate change on assessment processes within the Integrated Monitoring and Assessment Programme (IMAP) and the Marine Strategy Framework Directive (MSFD).

The assessment delves into the difficulties encountered in GES evaluation, emphasizing inconsistencies within the IMAP definition, considering the context of climate change. Climate change impacts, such as increased sea temperature, acidification, and extreme weather events, are identified as influencing habitats and species' spatial distribution and condition, particularly under IMAP Ecological Objective 1 (EO1).

The report highlights the need for clarifications in GES definitions, especially for EO1, addressing contradictions and specifying terms like "natural habitats" or "natural range" in the context of climate change impacts. Challenges in defining baseline values and threshold values, especially for benthic habitats under climate change conditions, are discussed, urging a consensus on methodologies.

The assessment extends to other Ecological Objectives, emphasizing the need for harmonization, clearer interrelations, and the development of indicators, methodologies, and threshold values. Climate change impacts on fisheries, non-indigenous species (NIS), and eutrophication are considered, with recommendations for integrating climate change effects into GES assessments.

Noteworthy points include the potential development of parameters related to climate change impacts on vulnerable coastal areas and the suggestion to introduce an Ecological Objective on climate change. The report concludes by emphasizing the ongoing efforts to renew the EcAp Roadmap, providing an opportunity to integrate climate change impacts efficiently into the existing monitoring program without adding new indicators.

In summary, the report calls for a comprehensive consideration of climate change impacts on GES assessments, emphasizing the importance of adapting methodologies, revising definitions, and integrating climate change parameters into the monitoring framework to enhance the understanding of cumulative effects on marine biodiversity in the Mediterranean region.

Table of contents

List of abbreviations and acronyms

AC Assessment criteria
ACCOBAMS Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area
AIS Automatic Identification System
BV Baseline value
C Criterion, MSFD
CBD Convention on Biological Diversity
CCI Candidate Common Indicator, IMAP
CFCs Chlorofluorocarbons
CI Common Indicator, IMAP
CIESM Mediterranean Science Commission
COP Conference of the Parties here relative to Barcelona Convention
CORMON Correspondence Group on Monitoring
CP Contracting Parties here relative to Barcelona Convention
CPUE Catch per unit of effort
D 1-11 Descriptor 1-11
EASAC European Academies' Science Advisory Council
EC European Commission
EcAp Ecosystem Approach
EcAp CG Ecosystem Approach Coordination Group
EEA European Environmental Agency
EEZ Exclusive Economic Zones
EIA Environmental Impact Assessment
EO Ecological Objective, IMAP
EU European Union
FAO Food and Agriculture Organisation of the United Nations
GES Good Environmental Status
GFCM General Fisheries Commission for the Mediterranean
HAB Harmful Algal Bloom
IAS Invasive Alien Species
ICZM Integrated Coastal Zone Management
IMAP Integrated Monitoring and Assessment Programme
INFO/RAC Information and Communication Regional Activity Centre
IPCC Intergovernmental Panel on Climate Change
IUCN International Union for Conservation of Nature
JRC Joint Research Centre
LPUE Landing per unit of effort
MAP Mediterranean Action Plan
MAS Monitoring and Assessment Criteria
MCP Maximum Catch Potential
MED POL Programme for the Assessment and Control of Marine Pollution in the Mediterranean Sea
MED QSR Mediterranean Quality Status Report
MIO-ECSDE Mediterranean Information Office for Environment, Culture and Sustainable Development
MHW Marine Heat Waves
MPA Marine Protected Area
MS Member States, EU
MSFD Marine Strategy Framework Directive
MSP Marine Spatial Planning
MSY Maximum Sustainable Yield
NEAT Nested Environmental status Assessment Tool
NIS Non-indigenous Species
NOAA National Oceanic and Atmospheric Administration

OO Operational Objective
OSPAR Convention for the Protection of the Marine Environment for the North-East Atlantic
PAP/RAC Priority Actions Programme Regional Activity Centre
QSR Quality Status Report
REMPEC Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
ROV Remotely Operated Vehicle
RPAS Remotely Piloted Aircraft Systems
SDG Sustainable Development Goal
SEA Strategic Environmental Assessment
SPA/RAC Regional Activity Centre for Specially Protected Areas
SSB Spawning Stock Biomass
SSBMSY Spawning Stock Biomass of the maximum sustainable yield
TV Threshold value
UNEP/MAP United Nations Environmental Program / Mediterranean Action Plan
VME Vulnerable Marine Ecosystem
WFD Water Framework Directive

1. Introduction

1. The Mediterranean countries assess the marine environmental state with an ecosystem approach based on (ii) the UNEP/MAP Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment criteria (IMAP), and (ii) the European Marine Strategy Framework Directive (MSFD) in European countries.

2. Both these policies are designed to attain and maintain Good Environmental Status (GES) in coastal and marine waters and ecosystems at national, sub-regional and regional scale. Qualitative definitions of GES have been refined through the Ecological Objectives/Descriptors, Operational Objectives/Criteria and Indicators. Nevertheless, quantitative Threshold Values (TV) which delimit the "non GES" from the "GES" state, are needed to determine and obtain comparable assessments of GES at regional or sub-regional scale.

3. Although GES is assessed through an ecosystem approach considering the multiple marine ecosystems and the anthropogenic pressures on them, climate change impacts are not explicitly taken in consideration or assessed through MSFD or IMAP, although both recognise climate change impacts on marine and coastal ecosystems and environment.

4. Climate change is an anthropogenic driven process with global impacts, which can however differ from a region to another and from an ecosystem to another. The Mediterranean is one of the regions that undergoes the most important climate change impacts (MedECC, 2020; Lejeusne et al., 2010; etc.). This is due in particular to the fact that the Mediterranean Sea is a semi-enclosed sea accelerating sea temperature increase.

5. Following a general approach defining Good Environmental Status (GES), the document develops elements for GES definition for each Ecological Objective as well as the impacts that climate change can have on GES definition.

2. Defining Good Environmental Status (GES) for the Mediterranean countries

2.1. The European Marine Strategy Framework Directive (MSFD) and Good Environmental Status (GES)

7. Several Mediterranean countries are European and are required to attain and maintain GES through the implementation of the Marine Strategy Framework Directive (MSFD) that defines Good Environmental Status (GES) as "The environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive". The Directive was adopted in 2008 (consolidated text Directive 2008/56/EC) building on several previous directives and policies such as the Water Framework Directive (WFD), the Birds and Habitat Directive and the Common Fisheries policy. In MSFD, GES is assessed through 11 Descriptors.
8. Further precisions on criteria and methodological standards on GES of marine waters are given in the Commission Decision 2010/477/EU amended by the Commission Directive (EU) 2017/845 in which indicative elements to be taken into account for the preparation of national marine strategies are listed.
9. MSFD is currently being revised to eventually propose changes and additions for the upcoming years. Effort are also developed in European countries to harmonise the assessment of the conservation status of habitats under the Habitat Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora) with the MSFD assessment where appropriate, especially for Descriptor 1 Biodiversity.

2.2. UNEP/MAP-Barcelona Convention policy regarding the Ecosystem approach and Good Environmental Status (GES)

10. The Convention on Biological Diversity (CBD) defines the Ecosystem Approach (EcAp) as "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way […]. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems." EcAp through the Integrated Monitoring and Assessment Programme (IMAP), is the primary framework for action under the Convention on Biological Diversity to attain Good Environmental Status (GES) in the Mediterranean Sea. IMAP was built on some existing regional monitoring programmes such as MED POL Monitoring programme and was developed in coherence with MSFD.
11. Within the UNEP/MAP-Barcelona Convention, the Ecosystem Approach is an overarching principal and process, with a first implementation roadmap (EcAp Roadmap 2008-2021) that was adopted by the Contracting Parties by decision (Decision IG.17/6, COP 15, 2008). The EcAp Roadmap (2008-2021) implementation is currently being evaluated in view of proposing a renewed EcAp policy.
12. The vision of the EcAp Roadmap that corresponds to GES at the global Mediterranean Sea scale is defined in the adopted Decision IG.17/6 as: *"A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations"*.
13. GES should be attained and maintained described by 11 Ecological Objectives (EOs) detailed in Decision IG. 20/4. Seven EOs have been further defined by Operational Objectives (OO), Common Indicators (CI), GES definitions and proposed targets in Decision IG. 21/3 (adopted during COP 18). During COP 19, the Contracting Parties adopted Decision IG.22/7 that defines the Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and

Related Assessment criteria (IMAP) that was developed in coherence with MSFD. 27 Common Indicators (CIs) including 4 Candidate Indicators have been developed belonging to 9 of the 11 Ecological Objectives. Indicators proposed in Decision IG. 20/4. EO 4 *marine food webs* and EO 6 *sea-floor integrity* were considered not enough mature to be included for development of indicators. These are currently being defined.

14. Concerning environmental status classification, important elements are given in the document *Integrated monitoring and assessment Guidance (IMAP)* (see UNEP(DEPI)/MED IG.22/Inf.2, p. 9):

"The Classification of environmental status can be considered to have three possibilities:

a. In GES – for which monitoring is needed to check status does not deteriorate;

b. Not in GES – for which targets and measures are needed which should lead to GES being achieved and maintained, coupled with monitoring to assess progress in status and against the targets and measures;

c. Unknown status (potentially not in GES) - it will not be possible in all cases to identify a status which is clearly within or clearly outside GES. Where, based on the current best available knowledge, interim boundaries or proxies can be determined, the environmental state within this zone should be classed as 'not in GES'. Where interim boundaries or proxies cannot be determined, classification needs to rely on qualitative (normative) description and expert judgement. According to the precautionary principle, uncertainty of classification must not be used for postponing action. Resulting actions will depend on the shortcomings in the individual case. Actions include at least those to address the shortcomings, e.g. through development of improved assessment methods, more monitoring, complementary research, as well as proportionate measures (e.g. "no regret" measures where improving status is considered necessary even though what constitutes 'good status' remains to be fully defined). "

15. Additionally *"…the setting of a GES boundary needs to respect the dynamic nature of ecosystems and their components, which can change in space and time through climatic variation, predator-prey interactions and other factors, and should thus be set in a way which accommodates these dynamics.*"

2.3.Is GES comparable in MSFD and IMAP?

16. Although slightly differing, the 11 Descriptors of MSFD and the 11 Ecological Objectives (EOs) of IMAP characterise the Good Environmental Status (GES) of the Mediterranean Sea in a comparable way. Table 1 presents GES at EO/Descriptor level for IMAP and MSFD.

17. IMAP Ecological Objectives 7 and 8 are a more detailed version of the MSFD Descriptor 7 and IMAP Ecological Objective 9 includes MSFD Descriptor 8 and 9 (see coloured cells of Table 1).

Table 1 Good Environmental Status (GES) as characterised at the level of Ecological Objectives (IMAP) and Descriptors (MSFD)

N°	IMAP GES at the level of Ecological Objectives	MSFD GES at the level of Descriptors
1	Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions.
2	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.
3	Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock.	Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4	Alterations to components of marine food webs caused by resource extraction or human-induced environmental changes do not have long-term adverse effects on food web dynamics and related viability.	All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
5	Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.
6	Sea-floor integrity is maintained, especially in priority benthic habitats.	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
7	Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8	The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved.	Concentrations of contaminants are at levels not giving rise to pollution effects.
9	Contaminants cause no significant impact on coastal and marine ecosystems and human health.	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
10	Marine and coastal litter do not adversely affect coastal and marine environment.	Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
11	Noise from human activities cause no significant impact on marine and coastal ecosystems.	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

18. Further, GES is more finely defined by IMAP Operational Objectives and MSFD Criteria that are assessed by a series of related indicators.

19. Methods and recommendations have been described to support the EU Member States (MS) (e.g., Palialexis et al., 2019 for assessments relative to species; Werner et al., 2020 for marine litter) and UNEP/MAP Contracting Parties (e.g., Galanidi and Zenetos, 2022 for Non Indigenous Species; document UNEP/MED WG.482/23 on beach litter) in defining threshold values (TV) and geographical scales for GES assessment.
20. However, difficulties persist in the delimitation of the boundaries between the states of "non GES" and "GES", including the appropriate geographical assessment scale to use, the aggregation rules and the assessment plans to use.
21. In the Mediterranean, GES can be precisely defined in a qualitative way and is comparable within MSFD and IMAP. Yet, threshold values and methods to determine them are still in process of being defined or remain unclear for several indicators either at regional or sub-regional scale. These threshold values are essential for CPs to determine the efforts needed to attain or maintain GES in a comparable way throughout the Mediterranean Sea.

2.4. Pressures considered in GES assessment

22. Several indicators in both policies are state indicators designed to assess the state of marine and coastal ecosystems and the ecological qualities. It is notably the case of indicators related to biodiversity (EO1/D1), food webs (D4) and seafloor (D6).
23. The majority of the other indicators aim to assess anthropogenic pressures and impacts on marine and coastal ecosystems such as pollution (eutrophication, contaminants, energy/noise pollution, and litter) but also fishing pressure, NIS and coastal hydrographic changes and disturbances. At national level, these indicators should inform on which pressure to act on, in order to attain GES.
24. Climate change impacts on marine and coastal ecosystems have not yet been explicitly taken in consideration in both MSFD and IMAP.

2.5. Climate change impacts

a) *Physico-chemical changes*

25. Climate change is a human induced phenomena due to the anthropogenic emissions of greenhouse gases, (mainly carbon dioxide, methane, nitrous oxide, CFCs and others) which trap the heat and result in an increase in temperatures. Climate is changing in the Mediterranean basin faster than at the global scale (MedECC, 2020).
26. The impacts of climate change on the Mediterranean Sea are important and numerous: (i) sea surface and deep waters warming, (ii) seawater acidification due to rising of carbon dioxide, (iii) rise in the sea level due to melting polar ices, (iv) increase in number and intensity of heatwaves on land and in the sea, and (v) more frequent and extreme climatic events such as floods and storms (MedECC, 2020). Summer rainfalls are likely to reduce, limiting fresh water inputs that could affect coastal ecosystems.
27. The Mediterranean Sea and its ecosystems incur already these direct climate change impacts and all future scenarios indicate that these changes will have exacerbated trends.

b) *Direct, indirect and compound impacts of climate change on Mediterranean marine ecosystems*

28. In the Mediterranean Sea, increasing water temperature impacts marine ecosystems in various ways. Increasing sea temperature trends can directly impact ecosystems by:

- → provoking mass mortality events by the time length of heatwaves (local or sub regional impacts generally)
- → inducing changes in the distribution range of mobile species: the species with warm-water affinities expanding North and species that are more psychrophilic and stenotherm will most probably decrease
- → changing life cycles of species including recruitment and reproduction periods
- → creating changes in biodiversity by weakening species sensitive to increased temperatures, in particular sessile species, and favouring thermophilic species
- → contributing to the installation of tropical thermophilic NIS Non Indigenous Species) and IAS (Invasive Alien Species)
- → enhancing the development and virulence of pathogens (e.g. Zgouridou et al., 2023)
- → disturbing primary production
- → increasing jellyfish outbreaks
- → provoking mass mortality events either by favouring the development of pathogens responsible of mortalities at a Mediterranean scale or increasing population vulnerability.

29. **Acidification** of the sea:
    - → may restructure plankton community and therefor impact marine food webs (Spisla et al., 2021)
    - → may disturb and reduce calcification rates of bivalve shells especially at juvenile stages
30. **Sea level rise**:
    - → The sea level rise in the Mediterranean impacts the terrestrial coastal ecosystems by eroding and flooding the terrestrial-marine fringe and increased infiltration of salt (Etienne et al., 2017; Tarchouna, 2019). It will impact also marine species that depend on these ecosystems such as marine turtles which use these areas for nesting.
31. **Compound impacts**:
    - → Acidification contributes with higher temperatures to lower growth rates of certain bivalves (Gazeau et al., 2014). They are large variations though in the sensitivity of bivalves to climatic change (Range et al., 2013).
    - → High sea temperatures with nutrient pollution increase the number, the frequency and intensity of coastal harmful algal blooms (e.g., Tsikoti & Genitsaris, 2021)
    - → Spreading and development in the Mediterranean Sea of Non Indigenous Species (NIS) originating from warmer waters is favoured by warming trends. Some of these species change and disturb Mediterranean Sea ecosystems, trophic networks and affect fisheries resulting in important socio-economic impacts. Some species, more resistant than others, or taking advantage of an ecological niche of a vulnerable or overexploited species, become invasive when encountering optimum conditions of development.
    - → High temperatures and low pH (acidification) appear to have negative effects on survival, settlement and growth of e.g. scleractinian recruits (Carbonne et al., 2022) although further studies are needed.
32. Many climate change impacts on the Mediterranean Sea and its ecosystems are still being investigated such as the effect of increased sea temperatures on the sea's dissolved oxygen, other possible impacts of acidification etc.

c) Climate change impacts on GES

33. Good Environmental Status is assessed generally in relation to baseline values with an accepted deviation that can be defined as the threshold values (see paragraph 2.7). In the current climate

change context, certain current baseline values (e.g. for state indicators) will most probably move away and GES will become more and more unattainable depending how baseline values and GES have been defined or if they will be re-evaluated/updated or not.

34. Climate change impacts on MSFD GES assessment have been discussed by Elliott et al. (2015). The authors present a table with the biodiversity-related descriptors, criteria and indicators which may be affected by climate change as well as the cause, evidence and examples. The authors predict that the descriptors the most affected by climate change will be D1 Biodiversity, D4 Food-webs, D6 seafloor integrity and D3 Fisheries.
35. Developing a risk-based approach of climate change impacts on the Mediterranean Sea ecosystems can help foresee the impact of cumulative pressures but also better apprehend how GES assessment will be impacted.

2.6. Developing risk-based approaches as well as cumulative pressure and impact assessment

36. To support the implementation of monitoring programmes and GES definition, risk-based approach can be useful. Although based on MSFD and not on the Mediterranean Sea, the report RAGES (2021) *Developing a Risk-based Approach to Good Environmental Status*, develops such an approach aiming to support MSFD implementation of 2017 GES Decision at regional and sub-regional scale. Further, outcomes and findings from the application of a risk-based approach for two Descriptors (D2 and D11) in the North-East Atlantic are provided by Verling et al. (2023).

2.7. Elements and references to define Good Environmental Status (GES)

37. In the Mediterranean Sea, GES is defined by components that describe the state of the biodiversity for a given area assessed through: 11 Descriptors, 29 Criteria and 56 Indicators for MSFD (Borja et al., 2013) and 11 Ecological Objectives, currently 27 Common Indicators (CIs) 4 of which are still candidate CIs, for IMAP (see Mediterranean 2017 Quality Status Report MED 2017 QSR). Both monitoring programmes are built under the overarching ecosystem approach. MSFD Criteria correspond to the IMAP Indicators although there is an important difference: a MSFD Criterion can serve several Descriptors (e.g. D1/D6, D1/D4), whereas an IMAP Indicator does not currently serve several EOs except EO3-CI12 that could be considered as an element of CI5 Population demographic characteristics (see UNEP/MED WG.502/Inf.10) but that hasn't yet been used as such.
38. To assess the environmental status and define whether it is in Good Environmental Status (**GES**) or not, elements such as aggregation rules, baseline values (**BV**), threshold values (**TV**), assessment criteria (**AC**) and monitoring and assessment scales (**MAS**) need to be defined.
39. General definitions of key elements for **IMAP** can be found in:

- UNEP/MAP. (2017). *Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria* (p. 52) [UN Environment/MAP]. Athens, Greece. Link
- UNEP/MAP. (2017). *Mediterranean 2017 Quality Status Report*. Link
- UNEP/MAP. (2016). *Integrated Monitoring and Assessment Guidance* (Meeting Report No. UNEP(DEPI)/MED IG.22/Inf.7; p. 282). Athens, Greece. Link

- Plan Bleu. (2019). *Science-Policy Interface (SPI) to support monitoring implementation plans as well as sub-regional and regional policy- developments regarding EcAp clusters on pollution, contaminants and eutrophication, marine biodiversity and fisheries, coast and hydrography* (Technical Paper No. 18). Link

- Updates and specific document for these elements can be found in **Annex A**: Data Dictionaries/Data Standards, Assessment Criteria, Threshold Values, Baseline Values, Guidance Factsheets, Guidelines and Monitoring Protocols available or in progress for each IMAP Common Indicator (CI) or Candidate Common Indicator (CCI)..

40. These elements and other important points for **MSFD** are defined in the following documents:

- A report produced by the Working Group on GES *Common Understanding of (Initial) Assessment, Determination of Good Environmental Status (GES) & Establishment of Environmental Targets (Articles 8, 9 & 10 MSFD)* (Claussen et al., 2011)

- Commission Decision (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU. Link

- The European Commission staff working document *Background document for the Marine Strategy Framework Directive on the determination of good environmental status and its links to assessments and the setting of environmental targets Accompanying the Report from the Commission to the European Parliament and the Council on the implementation of the Marine Strategy Framework Directive (Directive 2008/56/EC), SWD(2020) 62 final.*

- European Commission. (2019). *Reporting on the 2018 update of articles 8, 9 & 10 for the Marine Strategy Framework Directive. MSFD Guidance Document 14* (p. 72). Bruxelles: DG Environment.

- The MSFD guiding document to prepare 2024 reporting: *Article 8 MSFD Assessment Guidance* (European Commission., 2022).

- Tornero Alvarez, M. V., Palma, M., Boschetti, S., Cardoso, A. C., Druon, J.-N., Kotta, M., … Hanke, G. (2023). *Marine Strategy Framework Directive—Review and analysis of EU Member States' 2020 reports on Monitoring Programmes*. Link

Monitoring and assessment scales, and assessment units

41. The Ecosystem Approach requests to define whether the status of an *area* is or not in GES by assessing the status through 11 Descriptors for MSFD and 11 Ecological Objectives (EOs) for IMAP.
42. These *areas* can be ecologically or hydrologically relevant assessment areas, Spatial Assessment Units (SAU) used in Nested Environmental status Assessment Tool (NEAT) (Berg et al., 2016) as for IMAP pollution indicators, or more administrative defined areas such as national subdivisions, Marine Reporting Units (for MSFD reporting, see here), or IMAP geographical units at four scales, regional (Mediterranean Sea), sub-regional (4 sub-regions), coastal waters and other marine waters, subdivision of coastal national waters provided by Contracting Parties (see IMAP, 2017). These must be organised in a nested approach to be coherent.

43. Requests for **MSFD** Monitoring and Assessment Scales (MAS) can be found in Commission Decision (EU) 2017/848 and further guidance in document *SWD(2020) 62 final* and Article 8 MSFD Assessment Guidance (European Commission, 2022).
44. Documents defining monitoring and assessment scales for **IMAP** indicators can be found in **Annex A**.
45. Choosing the appropriate scale of assessment is important especially concerning biodiversity. It may indeed impact the assessment status (see e.g. Machado et al., 2020 for fish). A large scale can mask population patterns visible at smaller scale and for biodiversity, the different requirements of each species should be taken in consideration (Machado et al., 2020).

Assessment criteria

46. Assessment criteria are closely related to GES definition since they define information that is relevant for the GES assessment. They help define the conditions in which the assessments should be done and the elements to consider.
47. For **IMAP**, the general assessment criteria are defined in IMAP, 2017, and for the majority of the indicators, they have been further defined for each indicator and are available (see **Annexe A**).
48. For **MSFD**, the 11 Descriptors are based on defined Criteria which are subdivided in indicators. The Criteria are divided in primary criteria that must be used and secondary criteria that MS may choose to use. Assessment methodologies can be found in Cardoso et al. (2010).

Baseline and threshold values

49. Baseline and threshold values are used to compare the current assessments to determine whether GES is met or not. Baseline values can be considered in three different ways:
    - Un-impacted state or negligible impacted that is the state where human pressure and their impacts are considered negligible on marine environment. This state is also known as reference conditions. It can be determined through current or past measures or modelling.

    - Baselines can also be a state in the past usually the point when data collection on a parameter of the marine environment began. This implies also to know the level of the pressures on marine environment at the time to set the threshold values.

    - The baseline state can be determined as the situation when the policy started to be implemented with an objective of no deterioration accepted or improvements requested (e.g. decreasing trend of a pressure).

50. In the Mediterranean, due to the lack of data and of un-impacted areas, baseline values more frequently define the state described by the first assessment (initial assessment) (see European Commission, 2022). Threshold values will then be understood as the accepted deviation from the baseline values (Vasilakopoulos et al., 2022). If no deviation from the baseline values is accepted to meet GES, TVs and BV can be then the same.
51. In **MSFD**, TVs are required to be established by MSs through Union, regional or sub-regional cooperation following recommendations (see article 4 of Commission Decision (EU) 2017/848 of 17 May 2017 and Background document SWD(2020) 62 final)). The criteria D1C5, D2C2, D6C1, D6C2, D7C1, D8C3 and D8C4 do not need to have TV defined because the data of these criteria feed into and informs the assessment of other criteria, elements or features (European Commission, 2022). TVs should be consistent at regional or sub-regional scale and across Ecological Objectives or Descriptors.

52. The JRC Technical Report Thresholds for MSFD Criteria: state of play and next steps (Vasilakopoulos et al., 2022) reviews the availability of agreed threshold-setting approaches and methods and TVs for all criteria of the 11 MSFD Descriptors. Ways forward are also suggested to improve the availability of thresholds for MSFD criteria.
53. For IMAP, available documents defining baseline and threshold values where appropriate are listed in Annex A by indicator. Nevertheless, quantification of thresholds still remains an issue that is very much under development (UNEP/MED WG.502/Inf.10).

Aggregation rules

54. Assessment results of indicators need *in fine* to be aggregated and integrated to be able to determine the status of an Ecological Objective or a Descriptor, these needing also to be aggregated to define the environmental status of an area. These can differ between Ecological Objectives but need to be coherent to be able to integrate EOs' status into an evaluation of the environmental status of the area considered.
55. Aggregation rules are of importance in an integrative approach such as MSFD and IMAP. The choice of the aggregation method can have a considerable impact on the results of an assessment (Langhans, Reichert, & Schuwirth, 2014; Borja et al., 2015, 2014, 2013; Probst & Lynam, 2016). Therefore, it is of great significance that aggregation rules within an Ecological Objective but also between EOs, be coherent and laid down at Mediterranean scale.
56. Aggregation rules need also to be defined concerning geographical scales (European Commission, 2022). Choosing to work with nested areas, facilitates aggregation but rules still need to be clarified.

2.8. Key messages

57. Several points remain unclear concerning GES in both MSFD and IMAP: (i) can one consider attaining GES/ non GES at indicator and criterion level? What is the difference between a target/threshold/limit level and GES at this level? (ii) How to integrate and aggregate into a unique status assessment at EO level? At global status level? At national level?
58. Borja et al. (2013) and Prins et al. (2014) discuss these two points and proposes options using different decision rules to determine if an area is in GES. Efforts to clarify these points at Mediterranean scale could considerably enhance the quality and coherence of data but also further apprehend the impact of climate change on the element that define GES.

3. Ecological Objective 1: Biodiversity

3.1. General information on IMAP EO1 and MSFD D1 GES definition

59. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO1/D1 and GES determination under IMAP and MSFD can be found in Table 2.

Table 2: Relevant documents relative to GES definition for EO1 and D1.

Biodiversity	
IMAP	**MSFD**
EO1 GES: "*Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.*"	D1 GES: "*Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions.*"
Relative to species	
UNEP/MAP. (2021). *Comparative Analysis undertaken with regard to IMAP and the European Commission GES Decision 2017/848/EU for Biodiversity* (UNEP/MED WG.502/Inf.10). Link UNEP/MAP - RAC/SPA. (2019). *Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species* (*UNEP/MAP WG.467/16.)*Link UNEP/MAP (2017) *IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries)* (UNEP(DEPI)/MED WG.444/6/REV.1). Link **See Annex A, EO1-CI1 and 2 for technical documents specifically related to CIs**	Alonso, A. E., Palma, M., Palialexis, A., & Hanke, G. (2023). *Reference list of MSFD D1 species (2018-2020 update)*. Link Palialexis, A., & Boschetti, S. (2021). *Marine Strategy Framework Directive - Review and analysis of Member States' 2018 reports Descriptor 1: Species biological diversity*. Link Palialexis, A., Korpinen, S., Rees, A., Mitchell, I., Micu, D., Gonzalvo, J., … Tuaty-Guerra, M. (2021a). *Species thresholds: Review of methods to support the EU Marine Strategy Framework Directive MSFD Descriptor 1 biological diversity*. JRC Technical Report EUR 30680 EN. Link Palialexis, A., Kousteni, V., Boicenco, L., Enserink, L., Pagou, K., Zweifel, U. L., … Connor, D. (2021b). Monitoring biodiversity for the EU Marine Strategy Framework Directive: Lessons learnt from evaluating the official reports. *Marine Policy*, *128*, 104473. Doi : 10.1016/j.marpol.2021.104473. Link Palialexis, A., Boschetti, S., Vasilakopoulos, P., & Somma, F. (2020). *Alignment of the Marine Strategy Framework Directive and the Habitats Directive: current state and future perspectives*. Link

Biodiversity	
IMAP	**MSFD**
	Palialexis, A., Connor, D., Damalas, D., Gonzalvo, J., Micu, D., Mitchel, I., … Somma, F. (2019). *Indicators for status assessment of species, relevant to MSFD Biodiversity Descriptor: Identifying methods to set thresholds for the GES assessment*. Link Palialexis, A., De, J. C. A., & Somma, F. (2018). *JRC's reference lists of MSFD species and habitats: MSFD reporting for Descriptors 1 and 6*. Link
Relative to habitats	
Montefalcone, M., Tunesi, L., & Ouerghi, A. (2021). A review of the classification systems for marine benthic habitats and the new updated Barcelona Convention classification for the Mediterranean. *Marine Environmental Research*, *169*, 105387. doi: 10.1016/j.marenvres.2021.105387 UNEP/MAP-SPA/RAC. (2021). *Interpretation Manual of Marine Habitat Types in the Mediterranean Sea (UNEP/MED WG.502/Inf.4)* (p. 426). Tunis. Link UNEP/MAP. (2021). *Comparative Analysis undertaken with regard to IMAP and the European Commission GES Decision 2017/848/EU for Biodiversity (UNEP/MED WG.502/Inf.10)*. Link UNEP/MAP - RAC/SPA. (2019). *UNEP/MAP WG.467/16. Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species*. Link Plan Bleu. (2019). *Science-Policy Interface (SPI) to support monitoring implementation plans as well as sub-regional and regional policy-developments regarding EcAp clusters on pollution, contaminants and eutrophication, marine biodiversity and fisheries, coast and hydrography* (Technical Paper No. 18). Link UNEP/MAP (2017) *IMAP Common Indicator Guidance Facts Sheets (Biodiversity and*	Boschetti, S., Palialexis, A., & Connor, D. (2021). *Marine Strategy Framework Directive – Review and analysis of EU Member States' 2018 reports – Descriptor 6: Sea-floor integrity and Descriptor 1: Benthic habitats*. Link Palialexis, A., Kousteni, V., Boicenco, L., Enserink, L., Pagou, K., Zweifel, U. L., … Connor, D. (2021). Monitoring biodiversity for the EU Marine Strategy Framework Directive: Lessons learnt from evaluating the official reports. *Marine Policy*, *128*, 104473. Doi : 10.1016/j.marpol.2021.104473 Palialexis, A., De, J. C. A., & Somma, F. (2018). *JRC's reference lists of MSFD species and habitats: MSFD reporting for Descriptors 1 and 6*. Link **Pelagic habitats** Magliozzi, C., Palma, M., Druon, J.-N., Palialexis, A., Mcquatters-Gollop, A., Varkitzi, I., … Artigas, L. F. (2023). *Status of pelagic habitats within the EU-Marine Strategy Framework Directive: Proposals for improving consistency and representativeness of the assessment*. Link Magliozzi, C., Druon, J.-N., Boschetti, S., & Palialexis, A. (2021). *Marine Strategy Framework Directive - Review and analysis of EU Member States' 2018 reports - Descriptor 1: Pelagic habitats*. Link Magliozzi, C., Druon, J.-N., Palialexis, A., Artigas, L. F., Boicenco, L., González-

Biodiversity	
IMAP	MSFD
Fisheries) (UNEP(DEPI)/MED WG.444/6/REV.1). Link → UNEP/MAP. (2017). *Draft guidelines for the preparation of the country specific EcAp monitoring programme for biodiversity and NIS (UNEP(DEPI)/MED WG.444/Inf.14)* (p. 41) [6th Meeting of the Ecosystem Approach Coordination Group]. Link **See Annex A, EO1-CI3, 4 and 5 for technical documents specifically related to CIs** **Pelagic habitats** UNEP-MAP/SPA-RAC. (2021). *First elements to elaborate the List of Reference of Pelagic Habitat Types in the Mediterranean Sea (UNEP/MED WG.502/7)* (p. 13). Link	Quirós, R., … Varkitzi, I. (2021). *Pelagic habitats under MSFD D1: Current approaches and priorities.* Link Magliozzi, C., Druon, J.-N., Palialexis, A., Aguzzi, L., Alexande, B., Antoniadis, K., … Zervoudaki, S. (2021). *Pelagic habitats under the MSFD D1: Scientific advice of policy relevance*. doi: 10.2760/081368 Zampoukas, N., Palialexis, A., Duffek, A., Graveland, J., Giorgi, G., Hagebro, C., … Zevenboom, W. (2014). *Technical guidance on monitoring for the Marine Stategy Framework Directive*. Link

60. **Relations between MSFD D1 Criteria and IMAP EO1 indicators** have been addressed in the document *Comparative Analysis undertaken with regard to IMAP and the European Commission GES Decision 2017/848/EU for Biodiversity* (UNEP/MED WG.502/Inf.10).
61. Fraschetti et al. (2022) performed an **integrated assessment of the Good Environmental Status** of Mediterranean MPAs using the analytical tool NEAT and integrating data from seagrass *P. oceanica*, macroalgae, sea urchins and fish with thresholds defined to define GES set by dedicated workshops and literature review. The results on maps are available in the article accessible here.
62. **IMAP Ecological Objective 1** is declined in five indicators, which are state indicators designed to assess the state and changes of specific important aspects of ecosystems at habitat and species level. CI1 is related to habitats, CI2 to habitats and species and CI3, 4 and 5 are related to species or groups of species. The GES definition of these indicators are:

    EO1-CI1 – Habitat distributional range (EO1) to also consider habitat extent as a relevant attribute, should be maintained.

    EO1-CI2 – Condition of the habitat's typical species and communities is maintained.

    EO1-CI3 – Species distributional range (related to marine mammals, seabirds, marine reptiles) is maintained.

    EO1-CI4 – Population abundance of selected species (related to marine mammals, seabirds, marine reptiles) is maintained.

    EO1-CI5 – Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine mammals, seabirds, and marine reptiles) are maintained.

63. Each Common Indicator (CI) includes several habitats and groups of species.
64. **MSFD Descriptor 1** is declined in 6 criteria with the following GES definitions:

D1C1 – The mortality rate per species from incidental by-catch is below levels which threaten the species, such that its long-term viability is ensured.

D1C2 – The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured.

D1C3 – The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures.

D1C4 – The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions. Member States shall establish threshold values for each species through regional or sub-regional cooperation.

D1C5 – The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species.

Relating to pelagic habitats

D1C6 – The condition of the habitat type, including its biotic and abiotic structure and its functions (e.g. its typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), is not adversely affected due to anthropogenic pressures.

65. Each Criterion (C) includes several species or groups of species to be decided by the Member State (MS). **Compared to the EO1 indicators, D1 indicators concern mainly species or the habitat in relation with an assessed species. The benthic habitats are assessed through D6 seafloor[1] integrity by 5 primary (mandatory) criteria that assess "physical loss" and "physical disturbance" of seabed and habitats.**

66. To determine GES for IMAP EO1 Biodiversity, the assessment of the initial state is necessary, against which each future assessment of the indicators and parameters will be compared to define weather its status is "maintained" and therefore in GES, or not. This initial assessment of biodiversity at regional and sub-regional level had been attempted with the MED QSR 2017. However, for many indicators and in particular for EO1, the data available were not sufficient to have a complete initial assessment. MED QSR 2023 will be going beyond, towards building a complete image of the initial assessment at Mediterranean and when possible sub-regional scale. The results of MED 2023 QSR should serve as baseline values were baseline values have not yet been defined.

3.2. Elements for defining EO1 GES at indicator level in a climate change context

[1] Definition given in the context of MSFD for seafloor: "***Sea-floor*** is defined as a key compartment for marine life. It includes both the physical and chemical parameters of seabed (e.g. bathymetry, roughness (rugosity), substratum type, oxygen supply, etc.) as well as the biotic composition of the benthic community. Different kinds of habitats for sedentary and mobile marine species are formed inside and above the seabed." (see Link)

d) Indicators relative to habitats

Coralligenous habitats

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI1, EO1-CI2 Coralligenous habitat**
 EO1-CI1 GES: Habitat distributional range and habitat extent is maintained **EO1-CI2 GES: Condition of the habitat's typical species and communities is maintained**
Specific monitoring guidance documents available to assess and monitor coralligenous habitats: → Gennaro, P., Piazzi, L., Cecchi, E., Montefalcone, M., Morri, C., & Bianchi, C. N. (Eds.). (2020). *Monitoraggio e valutazione dello stato ecologico dell'habitat acoralligeno. Il coralligeno di parete.* ISPRA. Link → UNPE/MAP-SPA/RAC. (2019). *Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species* (Meeting Report No. UNEP/MED WG.467/16; p. 293). Tunis. Link → UNEP/MAP-SPA/RAC. (2019). *Monitoring protocols of the Ecosystem Approach Common Indicators 1 and 2 related to marine benthic habitats. Guideline for monitoring coralligenous and other calcareous bioconstructions* (Meeting Report No. UNEP/MED WG.474/3). Tunis. Link → JNCC. (2018). *Autonomous Underwater Vehicles for use in marine benthic monitoring* (JNCC). Peterborough. Link → RAC/SPA - UNEP/MAP. (2015). *A guide on environmental monitoring of rocky seabeds in Mediterranean marine protected areas and surrounding zones* (RAC/SPA-MedMPAnet Project). Tunis. Link → RAC/SPA-UNEP/MAP. (2014). *Monitoring protocol for coralligenous community. Case study—Croatia* (RAC/SPA-MedMPAnet Project). Tunis. Link **Habitat distributional range and habitat extent** Elements to define the actual distributional range and habitat extent of coralligenous habitats at regional, sub-regional and national scale: The EMODnet map of probability occurrence of Coralligenous habitats and maerl beds available here, could be used as the habitat distributional range at Mediterranean scale but they also include maerl beds. Distribution of coralligenous formations in the Mediterranean Sea (extracted from different sources) is presented by Giakoumi et al. (2013) and Martin et al., (2014). The latest also present a coralligenous habitat occurrence probability at the Mediterranean Sea scale. After registration through the site Donia Expert, the Medtrix platform gives access to a fine cartography of coralligenous habitats (up to 80 m) for France and some other areas (Sardania and Tunisian islands). On the same platform, RECOR presents the geographical distribution along the French coast (and some points in Sardinia) of monitored coralligenous habitats sites and gives the possibility to access to information on the sites as well as photos and sometimes 3D reconstruction. The environmental status for each year is indicated by the five category Coralligenous Assemblage Index (CAI) (Deter et al., 2012), the coverage percentage by sediments, the percentage covered by bioconstructors, an indicator of perturbation and an indicator of necrosis. Data are available for every year since 2010. Several recent publications have mapped localised coralligenous reefs at very fine scale such as (e.g. Pierdomenico et al., 2021 along the Latium continental shelf, Italy). Studies on distribution of certain gorgonians such as Ghanem et al. (2018) in Tunisia also inform on

coralligenous distribution since several species (*e.g. Paramuricea clavata, Eunicella cavolini, Leptogorgia sermentosa*) are characteristic species of coralligenous habitats.

All together with older publications on localized mapping of coralligenous habitats, the distribution and extent of coralligenous habitat at fine scale for number of sites in the Mediterranean is available in several Mediterranean countries.

Condition of habitats typical species and communities

To define GES for CI2, requires to determine the habitats' typical species and communities. For coralligenous habitats typical species may vary between sub-regions and even areas.

The multi-parametric index *Mesophotic Assemblages Conservation Status (MACS)* that combines status and impact indicators (Enrichetti et al., 2019) also applied by Pierdomenico et al. (2021) in Italian coralligenous outcrops seems a tool of interest to assess the condition of the coralligenous habitat's typical species and communities at least for the North-western Mediterranean. In this index the typical species considered are "*structuring species, here intended as arborescent or massive megabenthic species (e.g. sponges, anthozoans, bryozoans), reaching elevated sizes (decimetric) and densities, and hence able to shape the environment and support a complex biocoenosis*".

Given that the assessment of coralligenous habitats is now often based on images (video or photographies), it is of interest that typical species be identifiable on image.

Effects of climate change and other cumulative pressures in GES determination

Models integrating climate change projections indicate that environmental changes due to climate change will lead to a shift in the distribution of the coralligenous habitats as in the North Adriatic (Vitelletti et al., 2023).

Gómez-Gras et al. (2021) and Grenier et al. (2023) describe the impacts of recent Marine Heat Waves on habitat forming octocorals and sponges of coralligenous habitats in the NW Mediterranean, and consequent mass mortality events. This leads to assemblages that are deficient in key functional traits which could have consequences for ecosystem functioning. Reducing local impacts in MPAs may help coralligenous habitats face climate change impacts especially MHW (Zentner et al., 2023).

Predictive models show that under climate change conditions, floods will be more and more frequent. Impact of floods on coralligenous habitats has been underlined by Piazzi et al. (2021) that describes the changes in the assemblages and their degradation by floods.

Further, an indirect impact of climate change is the expansion and rapid instalment of thermophilic invasive NIS favoured by Mediterranean Sea warming (e.g. Costanzo et al., 2021; Zenetos & Galanidi, 2020) which have the potentiality to modify benthic habitats especially in coastal areas by e.g. completion for space, predation etc.

Katsanevakis et al., 2016, identify hot spot areas with high Cumulative Impact score on Coralligenous habitats using the cumulative impact of invasive alien species model (CIMPAL) score. Some limitations of the approach were underlined that are addressed under the ALAS project for the Aegean region (see Katsanevakis et al., 2020).

According to Zunino et al. (2019), ocean acidification will also directly and indirectly impact coralligenous habitats but also the related ecosystem services that could have impacts on human well-being as well.

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI1, EO1-CI2 Coralligenous habitat**
Carbonne et al. (2022) experimented the impact of acidification and sea warming on larval and recruit development of a Mediterranean coral. They observed that low PH and warm temperatures had a negative impact on survival, settlement and growth of recruits.

Maerl and rhodolith habitat

67. « …the GES evaluation of Mediterranean Rhodolith Beds is a challenging task. »

(Basso et al., 2016).

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI1, EO1-CI2 Maerl and rhodolith habitat**
EO1-CI1 GES: Habitat distributional range and habitat extent is maintained **EO1-CI2 GES: Condition of the habitat's typical species and communities is maintained**
Specific monitoring guidance documents available to assess and monitor maerl and rhodolith habitats: → UNEP/MAP-SPA/RAC. (2021). *Guidelines for the assessment of environmental impact on coralligenous and maërl assemblages* (UNEP/MED WG.502/Inf.3) (p. 58). Tunis: SPA/RAC. Link → UNEP/MAP-SPA/RAC. (2019). *Monitoring protocols of the Ecosystem Approach Common Indicators 1 and 2 related to marine benthic habitats. Guideline for monitoring coralligenous and other calcareous bioconstructions* (Meeting Report No. UNEP/MED WG.474/3). Tunis. Link → Basso, D., Babbini, L., Kaleb, S., Bracchi, V. A., & Falace, A. (2016). *Monitoring deep Mediterranean rhodolith beds.* Aquatic Conservation: Marine and Freshwater Ecosystems, 26(3), 549–561. → UNEP-MAP-RAC/SP. (2015). *Standard methods for inventorying and monitoring coralligenous and rhodoliths assemblages.* (RAC/SPA). Tunis. Link **Habitat distributional range and habitat extent** Elements to define the actual distributional range and habitat extent of maerl and rhodoliths habitats at regional, sub-regional and national scale: Basso et al. (2017) presents detailed maps of the presence of rhodolith beds in the Mediterranean, so does Martin et al. (2014) that presents in addition an occurrence probability map of maerl beds in the Mediterranean. Recent works focus on specific areas: rhodolith beds extent and integrity in the Tyrrhenian Sea off the Campania coast (Rendina et al., 2020), the Strait of Sicily (Maggio et al., 2022), around Malta (Deidun et al., 2022), at the south coast of Spain in the Alboran Sea (Del Rio et al. 2022). The distribution and measurable extent of sites in several areas of rhodolith beds (that include maerl beds see Basso et al., 2016) at fine scale and for the Mediterranean are available. **Condition of habitats typical species and communities** Typical species of these habitats are coralline red algae such as *Lithothamnion corallioides*, but the habitat is considered complex and variable (Jardim et al., 2022). Basso et al. (2016)

underlines the difficulties to assess the condition of this habitat which needs sampling and cannot be assessed solely by image (photo or video) according to the authors. These authors propose a monitoring methodology to acquire data on the extent and condition of this habitat and its typical species.

Effects of climate change and other cumulative pressures in GES determination

Martin & Hall-Spencer (2017) suggest that rhodolith habitats will be affected by long-term acidification and predict a decline of the calcareous algae that would be replaced by other non-calcareous species which would reduce complexity and biodiversity of the habitat. The impacts of climate change could be very species-specific which could result in the death of rhodoliths and associated fauna (de Araújo Costa et al., 2023).

The importance of sea surface currents and waves for rhodolith habitats distribution appear in several publications (Martin et al., 2014; Agnesi et al., 2020). Possibly, changes in these variables due to climate change could also impact the habitats assemblage on the long term.

Maerl and rhodolith beds thrive in rather deep waters in the Mediterranean Sea, rarely less than 25 m. Currently, the main anthropogenic impact that this habitat is undergoing is bottom otter trawling which can locally be devastating for these habitats.

Marine vegetation and Posidonia oceanica meadows

68. Under IMAP, the main marine vegetation that is assessed and monitored is *Posidonia oceanica* meadows. *Posidonia oceanica* meadows, are of great importance for the Mediterranean Sea functioning (see Addamo & La Notte, 2023), and it's degradation causes negative impacts on fisheries (El Zrelli et al., 2020) and more generally can cause economic loss by reduction of the ecosystem services (Zunino et al., 2019; El Zrelli et al., 2023). Nevertheless, other marine vegetation habitats are also of great importance and undergo climate change and other anthropogenic pressures.

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI1, EO1-CI2 Marine vegetation and *Posidonia oceanica* meadows**
EO1-CI1 GES: Habitat distributional range and habitat extent is maintained **EO1-CI2 GES: Condition of the habitat's typical species and communities is maintained**
Specific monitoring guidance documents available to assess and monitor marine vegetation: → UNEP/MAP-SPA/RAC. (2019). *Monitoring protocols of the Ecosystem Approach Common Indicators 1 and 2 related to marine benthic habitats. Guideline for monitoring marine vegetation* (Meeting Report No. UNEP/MED WG.474/3). Tunis. Link → UNEP/MAP-RAC/SPA. (2015). *Guidelines for the standardization of mapping and monitoring methods of marine magnoliophyta in the Mediterranean*. Tunis: RAC/SPA. Link **Habitat distributional range and habitat extent** Elements to define the actual distributional range and habitat extent of marine vegetation at regional, sub-regional and national scale can be found hereafter. Available information concerns mainly *Posidonia oceanica* meadows. The EMODnet map of probability occurrence of *Posidonia oceanica* meadows available here, could be used as the habitat distributional range at Mediterranean scale. Telesca et al. (2015) present the distribution of *Posidonia oceanica* meadows in the Mediterranean Sea (extracted from different sources), surface and linear coastline occupied and average regression over 50 years estimated at 10.1% of the total known area and 33.6% if only areas for which there is historical information are considered. The Medtrix platform gives access to a fine cartography of *Posidonia oceanica* meadows and mats after registration through Donia Expert for France and some other areas (Sardinia and Tunisian islands). Panagyotidis et al. (2022) have made available their datasets of seagrass spatial distribution (*P. oceanica, Cymodocea nododsa, Zostera noltei* and *Halophila stipulacea*) in the Hellenic territory. Seagrass which has been calculated as being over 2,749.09 km^2. Traganos et al., 2020 present coverage area for *P. oceanica* for the Mediterranean basin up to 25 m depth, using satellite images and machine learning. The surface estimated to be covered by *P. oceanica* in the Mediterranean by the authors is 19,020 km^2, which is significantly more than previous publications (Telesca et al., 2015; McKenzie et al., 2020). Such assessments should give the possibility to estimate the surface occupied at national level for some countries and possibly at sub-regional level. **Condition of habitats typical species and communities**

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI1, EO1-CI2 Marine vegetation and *Posidonia oceanica* meadows**
Typical species include at least the dominant magnoliophyte species of the seagrass meadows but should include also other species included in the Annex 2 to the SPA Protocol. Assemblages vary between sub-regions therefor the list of typical species should be defined at sub-regional level. The assessment approach of Houngnandan et al. (2020) concerning *Posidonia oceanica* meadows, environmental variables and anthropogenic pressures identified and mapped along the French coast, the good and bad environmental conditions for *P. oceanica* and compared it to a decline index and a cohesion index. Urbanisation, coastal population and human made coastline appear to be the anthropogenic pressures that degrade the most the *P. oceanica* meadows along the French coast (see Holon et al., 2018) although in this study, several other anthropogenic pressures were not taken in consideration such as climate change. By using maps of marine habitats and anthropogenic pressures the model predicts quite well the relation between human pressures and degradation status therefore being able to identify priority areas for management. **<u>Effects of climate change and other cumulative pressures in GES determination</u>** Sea temperature warming and Marine Heat Waves (MHW) could induce changes in *P. oceanica* meadows by affecting morphology and productivity (Guerrero-Meseguer, Marín, & Sanz-Lázaro, 2017; Stipcitch et al., 2022; Cantasano, 2023) and shoot production success (Marbà & Duarte, 2010) of the plant. Chefaoui et al. (2018) modelled *P. oceanica* meadow loss depending on different climate change scenarios and predict that the Mediterranean would lose up to 75% of suitable habitat by 2050 in the worst scenario. More recently, Llabrés et al. (2023) predict that in high greenhouse emissions, *Posidonia oceanica* meadows would lose 70% of its population by 2050. Further, an indirect impact of climate change is the expansion and rapid instalment of thermophilic invasive NIS favoured by Mediterranean Sea warming (Beca-Carretero et al., 2020; Zenetos & Galanidi, 2020; Mannino et al., 2023) which have the potentiality to modify benthic habitats especially in coastal areas by e.g. completion for space, predation etc. Katsanevakis et al., 2016, identify hot spot areas with high Cumulative Impact score on *Posidonia* habitats using the cumulative impact of invasive alien species model (CIMPAL) score. Some limitations of the approach were underlined that are addressed under the ALAS project for the Aegean region (see Katsanevakis et al., 2020).

e) Indicators relative to species

Marine mammals

69. Under MSFD marine mammals are assessed under D1 Biodiversity but can be referred to in D4 food webs, D8 contaminants, D10 marine litter and D11 underwater noise. However, Authier et al. (2017) indicate that several EU countries do not consider marine mammals in the GES description in particular of D10 and D4.
70. In IMAP, cetaceans are assessed under EO1 and can be referred to in EO3-CI12 that corresponds to a MSFD-D1-C1 indicator.

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI3, EO1-CI4, EO1-CI5 Cetaceans**
EO1-CI3 GES: Species distributional range is maintained The species are present in all their *natural* distributional range. **EO1-CI4 GES: Species population abundance is maintained** The species population has abundance levels allowing qualification to Least Concern Category of IUCN Red List or has abundance levels that are improving and moving away from the more critical IUCN category. (*Globicephala mela, Grampus griseus, Turciops truncates, Delphinus delphis, Stenella coeruleoalba, Physeter macrocephalus, Ziphius cavirostris, Balaenoptera physalus*) **EO1-CI5 GES: Population condition and demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates) is maintained** Decreasing trends in human induced mortality (only for *Turciops truncates, Stenella coeruleoalba, Balaenoptera physalus*).
Specific monitoring guidance documents available to assess and monitor cetaceans: → ACCOBAMS. (2020). Monitoring guidelines to assess cetaceans' distributional range, population abundance and population demographic characteristics (p. 12). Link → ACCOBAMS. (2023). *Evidence-based diagnostic assessment frameworks for cetacean necropsies on specific issues/threats* (p. 10). Link → ACCOBAMS guidelines and Best practices webpage. Link → Some technical aspects on GES determination and how to assess can be found in CetAMBICion project, WP1 - Review of MSFD second cycle reports and state of the art for cetaceans Deliverable 1.01 published in 2022. Link **Species distributional range and population abundance** Arcangeli et al., 2023 have tested some model approaches and indicators (MSFD) for assessing range and habitat short-term trends for cetaceans (*Grampus griseus, Globicephala melas, Ziphius cavirostris*) distribution range and presents the limits, weaknesses and give recommendations relatively to these approaches. Gnone et al. (2023) have analyzed data collected by 23 different research units over a period of 15 years concerning cetaceans in the Mediterranean Sea and present distributional patterns and relative abundance of the species. **It is the most complete and updated work in the Mediterranean on distribution and abundance.** Karamitros et al. (2020) have modelled geographical distribution of three Delphinidae in the Mediterranean Sea based on surveys from the Alboran Sea to the Aegean and covering a central strip of the Mediterranean Sea. Some species such as Cuviers beaked whale (*Ziphius cavironstris*) have low density in the Mediterranean Sea and make the estimation for their distributional range and abundance

challenging (Cañadas et al., 2018). The authors estimate that the total abundance of this species in the Mediterranean is about 5800 individuals.

Panigada et al. (2017) assessed cetacean abundance and distribution in the area covered (Pelagos Sanctuary, Tyrrhenian Sea, part of the Sea of Corsica and Sadrinia, Ionian Sea and the Gulf of Taranto) using systematic multispecies aerial surveys between 2009 and 2014. This data was used to create model-based estimates of density and abundance for several species. The results represent baseline data for the area to develop efficient, long-term, systematic monitoring programmes.

Some other localized or specie specific assessments have been published such as Awbery et al. (2022) along part of the Turkish coast, Torreblanca et al. (2022) in the Western Mediterranean Sea, Cañadas and Vazquez (2017) for *Delphinus delphis* in the Alboran Sea, Galili et al. (2023) in Israel.

Modelling species distribution and abundance of cetaceans is based on data collections and can be robust. But the lack of data in eastern and south Mediterranean Sea does not allow reasonable modelling of distribution and abundance of cetaceans (Mannocci et al., 2018), efforts are needed to collect and share data to cover the geographical gaps.

Species condition and demographic characteristics

Little is known on the species conditions and demographic characteristics, even for quite frequent species. Some studies have modelled niche partitioning of the different species as in the Alboran Sea (see Giménez et al., 2018), others studied association patterns between individuals of bottlenose dolphins (Pace et al. 2022).

Effects of climate change and other cumulative pressures in GES determination

Climate change impacts on cetaceans are little known and seem to be indirect by affecting their habitats and prey as in the Alboran Sea where an increase of sea surface temperature will potentially reduce the suitable habitat for common dolphins (Cañadas & Vázquez, 2017).

In parallel cetaceans undergo other threats such as fishing gear entanglement and by-catch, underwater noise and collision with marine traffic (see Awbery et al., 2022). Increase in marine traffic will increase collision probability and underwater noise.

71. **Mediterranean monk seal (*Monachus monachus*)** is strictly protected (Appendix II of the Bern Convention) and classified as endangered species by IUCN. An Action Plan for the management of the Mediterranean monk seal (*Monachus monachus*) has been established by UNEP/MAP-SPA/RAC and the Contracting Parties (Link) and a Regional Strategy for the conservation of Monk seals in the Mediterranean agreed on (Link).

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI3, EO1-CI4, EO1-CI5 Monk seal**
EO1-CI3 GES: Species distributional range is maintained **EO1-CI4 GES: Species population abundance is maintained** **EO1-CI5 GES: Population condition and demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates) is maintained** **Monk seal** (*Monachus monachus*)
Documents informing on methods for assessing monk seals: → Pietroluongo, G., Quintana Martín-Montalvo, B., Ashok, K., Miliou, A., Fosberry, J., Antichi, S., … Azzolin, M. (2022). Combining Monitoring Approaches as a Tool to Assess the Occurrence of the Mediterranean Monk Seal in Samos Island, Greece. *Hydrobiology*, *1*, 440–450. doi: 10.3390/hydrobiology1040026 → Bundone, L., Rizzo, L., Fai, S., Hernández-Milián, G., Guerzoni, S., & Molinaroli, E. (2023). Investigating Rare and Endangered Species: When a Single Methodology Is Not Enough-The Mediterranean Monk Seal *Monachus monachus* along the Coast of Salento (South Apulia, Italy). *Diversity*, *15*(6). doi: 10.3390/d15060740 **Species distributional range and population abundance** Within the upcoming MED QSR 2023, a section will be dedicated to the monk seal and its distribution in the Mediterranean. Further, the following publications inform on the Mediterranean monk seal distribution in the Mediterranean with a map included in the report NOAA (2017). Panou, A., Giannoulaki, M., Varda, D., Lazaj, L., Pojana, G., & Bundone, L. (2023). Towards a strategy for the recovering of the Mediterranean monk seal in the Adriatic-Ionian Basin. *Frontiers in Marine Science*, *10*. Link Nicolaou, H., Dendrinos, P., Marcou, M., Michaelides, S., & Karamanlidis, A. A. (2021). Re-establishment of the Mediterranean monk seal *Monachus monachus* in Cyprus: Priorities for conservation. *Oryx*, *55*(4), 526–528. doi: 10.1017/S0030605319000759 NOAA (2017). *Mediterranean Monk Seal (Monachus monachus) 5-Year Review: Summary and Evaluation* (p. 31). National Marine Fisheries Service Office of Protected Ressources. The report of the international conference on monk seal conservation (UNEP/MAP-SPA/RAC, 2006) gives some information on the distribution of the species through the communications. **Species condition and demographic characteristics** The species is discrete, avoiding contact with humans, and its population limited (estimated to 700 individuals in the Mediterranean), therefor little is known on the species condition and characteristics. However, Karamanlidis et al. (2021) published an article on maternal behaviour of monk seals in Greece and Saydam & Güçlüsoy (2023) on cave preferences in

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI3, EO1-CI4, EO1-CI5 Monk seal**
Türkiye and Kurt & Gücü, (2021) on demography and population structure of the NE Mediterranean population. **<u>Effects of climate change and other cumulative pressures in GES determination</u>** Mediterranean monk seals have a reduced population number and undergo anthropogenic impacts that result in: reduction of their habitat, accidental entanglements (Karamanlidis et al., 2008), mortality by deliberate killing from fishermen in certain areas (Androukaki et al., 1999; Karamanlidis et al., 2015). Limited food availability have little contributed directly to monk seal deaths, but contribute to increase interactions between monk seals and fishermen. Climate change and especially warming sea temperatures impacts food webs and could reduce food availability for monk seals resulting in increased interactions with fishermen and fishing gear and consequently increased mortalities. Another climate change consequence that could affect the population of monk seals is the increase of extreme events that could increase mortality of pups in caves.

Seabirds

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI3, EO1-CI4, EO1-CI5 Seabirds**
EO1-CI3 GES: The distribution of seabird species continues to occur in all their Mediterranean natural habitat. Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. **EO1-CI4 GES:** Population size of selected species of seabirds is maintained. The species population has abundance levels allowing to qualify of Least Concern Category of IUCN (less than 30% variation over a time period equivalent to 3 generation lengths. **EO1-CI5 GES:** Species populations are in good conditions: Natural levels of breeding success & acceptable levels of survival of young and adult birds. **Seabirds** Priority species *Falco eleonorae- Hydrobates pelagicus- Larus audouinii- Larus genei- Pandion haliaetus- Phalacrocorax aristotelis- Calonectris diomedea- Puffinus yelkouan- Puffinus mauretanicus- Sterna bengalensis- Sterna sandvicensis*
<u>Specific monitoring guidance documents available to assess and monitor seabirds</u> → UNEP/MAP RAC/SPA. (2007). *Guidelines for Management and Monitoring Threatened Population of Marine and Coastal Bird Species and their Important Areas in the Mediterranean.* By Joe Sultana (RAC/SPA). Tunis. Link → UNEP/MAP-RAC/SPA. (2009). *Guidelines for reducing by catch of seabirds in the Mediterranean region*. By Carles Carboneras (RAC/SPA). Tunis. Link → UNEP/MAP (2017) *IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries)* (UNEP(DEPI)/MED WG.444/6/REV.1). **<u>Identification guides</u>** Guide of Seabirds in the Mediterranean & adjacent Seas – CIESM Seabirds Program. Link **<u>Distribution of seabirds</u>** The majority of the scientific articles concern bycatch of seabirds. Few assess locally the distribution of specific seabirds: • Paracuellos, M., & Nevado, J. C. (2003). Nesting seabirds in SE Spain: Distribution, numbers and trends in the province of Almería. *Scientia Marina*, 67(Suppl.2), 125–128. • UNEP/MAP RAC/SPA. (2013). *Seabirds in the Gulf of Lions shelf and slope area.* By Carboneras, C. (RAC/SPA). Tunis. • UNEP/MAP. (2015). *Adriatic Sea: Status and conservation of Seabirds* (UNEP(DEPI)/MED WG.408/Inf.12). • UNEP/MAP RAC/SPA. (2015). *Alboran Sea: Status and conservation of seabirds*. By Arcos, J.M. (D. Cebrian & S. Requena, Eds.). Tunis. • UNEP/MAP RAC/SPA. (2015). *Sicily Channel/Tunisian Plateau: Status and conservation of Seabirds.* By Carboneras, *C.* (RAC/SPA; D. Cebrian & S. Requena Moreno, Eds.). Tunis. • Pettex, E., David, L., Authier, M., Blanck, A., Dorémus, G., Falchetto, H., … Ridoux, V. (2017). Using large scale surveys to investigate seasonal variations in seabird distribution and

abundance. Part I: The North Western Mediterranean Sea. Deep Sea Research Part II: *Topical Studies in Oceanography*, 141, 74–85. doi: 10.1016/j.dsr2.2016.11.008

- Militão, T., Sanz-Aguilar, A., Rotger, A., & Ramos, R. (2022). Non-breeding distribution and at-sea activity patterns of the smallest European seabird, the European Storm Petrel (Hydrobates pelagicus). *Ibis*, 164(4), 1160–1179. doi: 10.1111/ibi.13068

The most complete document on seabird distribution and abundance will be the MED QSR 2023 currently in preparation. Moreover, GES has tentatively been assessed for the different species and sub-regions with the available data.

Bycatch of seabirds

Seabirds prey are mainly fish and therefor interactions with fishing gear is frequent. Several documents treat of this subject in the Mediterranean Sea:

- Cooper, J., Baccetti, N., Belda, E. J., Borg, J. J., Oro, D., Papaconstantinou, C., & Sanchez, A. (2003). Seabird mortality from longline fishing in the Mediterranean Sea and Macaronesian waters: A review and a way forward. *Scientia Marina, 67*(Suppl. 2), 57–64.

- Genovart, M., Doak, D. F., Igual, J.-M., Sponza, S., Kralj, J., & Oro, D. (2017). Varying demographic impacts of different fisheries on three Mediterranean seabird species. *Global Change Biology*, 23(8), 3012–3029. doi: 10.1111/gcb.13670

- Cortés, V., Arcos, J. M., & González-Solís, J. (2017). Seabirds and demersal longliners in the northwestern Mediterranean: Factors driving their interactions and bycatch rates. *Marine Ecology Progress Series*, 565, 1–16.

- Cortés, V., & González-Solís, J. (2018). Seabird bycatch mitigation trials in artisanal demersal longliners of the Western Mediterranean. *PLOS ONE*, 13(5), e0196731. doi: 10.1371/journal.pone.0196731

- Cianchetti-Benedetti, M., Dell'Omo, G., Russo, T., Catoni, C., & Quillfeldt, P. (2018). Interactions between commercial fishing vessels and a pelagic seabird in the southern Mediterranean Sea. *BMC Ecology*, 18(1), 54. doi: 10.1186/s12898-018-0212-x

Bycatch is assessed through EO1-CI5 for seabirds and EO3-CI12 at a more general level for vulnerable and non-target species.

Effects of climate change and other cumulative pressures in GES determination

Impact of climate change has not been studied and is difficult to appreciate. However the main pray of seabirds is fish that will be impacted in its distribution area and abundance by warming sea. This could have impacts on the seabirds feeding areas and the availability of prey.

Use of fossil fuel participates in increasing climate change phenomenon. Therefore, states are currently turning towards sources of renewable energy including offshore wind energy. Such developments are currently taking place for example in the Gulf of Lion (France) and the impact of such structures on seabirds are not well known. Several studies have worked on possible impacts of offshore wind farms on seabirds and risk assessment approaches on the subject (Christel et al., 2013; Bray et al., 2016).

Marine turtles

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO1-CI3, EO1-CI4, EO1-CI5 Marine turtles**
EO1-CI3 GES: Species distributional range is maintained The species continues to occur in all its natural range in the Mediterranean, including nesting, mating, feeding and wintering and developmental sites from national to regional level. **EO1-CI4 GES: Species population abundance is maintained** The population size allows to achieve and maintain a favourable conservation status considering all life stages of the population **EO1-CI5 GES: Population condition and demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates) is maintained** Low mortality induced by incidental catch. Favourable sex ratio and no decline in hatching rates **Marine turtles** (*Caretta caretta* and *Chelonia mydas*)
Specific monitoring guidance documents available to assess and monitor marine turtles: → UNEP/MAP-SPA/RAC. (2017). Guidelines for the long term Monitoring programmes for marine turtles nesting beaches and standardized monitoring methods for nesting beaches, feeding and wintering areas (UNEP(DEPI)/MED WG.431/ Inf.4) (p. 60). Tunis. Link → Medpan free training course on *Getting started with marine turtle conservation across Mediterranean Marine Protected Areas* Link → Girard, F., Girard, A., Monsinjon, J., Arcangeli, A., Belda, E., Cardona, L., … Claro, F. (2022). Toward a common approach for assessing the conservation status of marine turtle species within the European marine strategy framework directive. Frontiers in Marine Science, 9. Link **Species distributional range** *Caretta caretta* is present in all the Mediterranean Sea either for nesting or foraging whereas *Chelonia mydas* is restricted to south-eastern part of the Mediterranean especially for nesting (see Camiñas et al., 2020), although nesting of *C. mydas* seems to expand lately with occasional nesting more northward (Jančič et al., 2022) and westward (Ben Ismail et al., 2022). A comprehensive and up-to-date map of the Mediterranean grounds, foraging, overwinter areas and nesting sites of both species can be found in Camiñas et al. (2020) Link. Past data exist for the Mediterranean Sea such as Groombridge (1990), Casale & Margaritoulis (2010), which should enable to define baseline values at least for nesting and allow assessment of GES. **Species population abundance, condition and demographic characteristics** Increase and expansion of nesting activity of *Caretta caretta* has been observed probably related to conservation measures and increased awareness (Casale et al., 2018; Hochscheid et al., 2022). This could suggest an increase in population abundance. Using models, estimates of abundance of *Caretta caretta* in the Mediterranean are given by Di Matteo et al. (2022) based on aerial survey and shipboard line transect survey data. Probably the most specific information on GES determination for CI3 to CI5 for marine turtles can be found in the collaborative work of Girard et al. (2022). Indicator measurements, data requirements, assessment approach are presented for each MSFD indicator related to

EO1 Biodiversity Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition EO1-CI3, EO1-CI4, EO1-CI5 Marine turtles
marine turtles (four of which are comparable to IMAP indicators) to adequately assess the status of marine turtles. **EO1-CI3, EO1-CI4, EO1-CI5 for marine turtles is considered currently as meeting GES requirements thanks to several years of active protection in the Mediterranean Sea**. **Effects of climate change and other cumulative pressures in GES determination** Increase and expansion of nesting activity of *Caretta caretta* has been observed probably related to conservation measures and increased awareness. But these nesting beaches undergo high touristic pressure (Hochscheid et al., 2022). Higher temperatures in nesting areas seem to increase the female-biased hatching sex ratios (Casale et al., 2018) which could be positive for the population but higher temperatures decrease hatching success for both species (Laloë et al., 2017; Bladow & Milton, 2019). Another climate change effect that could reduce reproduction of marine turtles and consequently population abundancy is Sea Level Rise (SLR). Coastal habitats and in particular beaches could shrink and offer less availability for turtles to nest (Dimitriadis et al., 2022). Only one fifth of the nesting beaches studied were found to be able to offer appropriate nesting zone farther inland giving the possibility to marine turtles to adapt to SLR for nesting (Dimitriadis et al., 2022). Patricio et al. (2021) suggest guidance for research and research priorities consequent to a review on climate change impacts on marine turtle populations. They imply that strategies for mitigating stressors could be helpful to increase resilience in climate change context. Higher temperatures decrease hatching success for both species (Laloë et al., 2017; Bladow & Milton, 2019) but if other anthropogenic pressures are lessened and conservation actions are maintained, marine turtles could adapt to climate change (Patricio et al., 2021). Field experience in an area with tide (Cabo Verde) gives information on potential impact of inundation on hatching success and phenotype of *C. caretta* (Martin et al., 2022). Results show that hatching success increases with increased distance from tidal inundation risk zone. Nevertheless, Casale et al. (2018) consider that climate change impacts on life-history parameters of marine turtles are poorly known therefor the impacts of climate change in comparison with others threat is difficult to estimate. Other anthropogenic threats consist of exposure to debris ingestion (see Darmon et al., 2017), by-catch (to link with CI12), collision with speed boats (see Hazel et al., 2007), inaccessibility to nesting beaches due to tourism.

3.3. Impediments and gaps identified in EO1 GES determination and assessment in a climate change context

a) *At the level of Ecological Objective 1*

72. "*Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.*"

73. The GES definition of EO1 implies several important points:
    1. That species and habitats assessed be representative of Mediterranean Sea biodiversity

    2. That baseline values and threshold values are the same. No decrease of biodiversity is accepted to be or stay in GES. Current and future assessments in terms of biodiversity should be the same as the baseline values or enhanced.

    3. Biodiversity assessment should be in line with prevailing climatic conditions.

74. Point **1.** The current lists of habitats and species effectively assessed through IMAP, need to be completed to better represent Mediterranean marine biodiversity. This point is further developed under *c) At the level of specific parameters or attributes*.
75. **Point 2 and 3**. These can be considered in contraction. How can biodiversity state be in line with already changing climatic conditions and be maintained at an initial state? Indeed, this needs to be clarified since due to climate change impacts, for some indicators/parameters, it will be very difficult or even impossible that close future assessments be the same as baseline values (initial assessment values) defined even only a few years back. Climatic and hydrographic conditions of the Mediterranean Sea have already started to change very rapidly under global change effects, making EO1 GES more and more difficult to attain.

76. Several possibilities can be considered to maintain GES for EO1 attainable in the near future:

- Threshold values could be regularly reconsidered and revaluated and progressively adapted (e.g. accepting 2 then 5, 10% of habitat loss)

- Baseline values could be regularly reconsidered and updated to the current situation. Reconsidering baseline values (BVs), which is having shifting BVs, means that GES definition changes in time.

- Baseline values and threshold values are defined for each assessment as the values obtained in the most unimpacted sites (predefined) of a sub-region and/or CP during the assessment. All sites undergoing climate change impacts that can be comparable in a sub-region, this method "neutralises" climate change direct impacts but not cumulative impacts. This method also implies that BV be shifting and GES definition changing.

77. Baseline and threshold values are crucial to define GES at all levels. Compared to other EOs, the definition of GES for an area's biodiversity will probably be one of the most rapidly affected by climate change impacts. Therefore, further clarifying the EO1 GES definition, the related baseline and threshold values is mandatory to enable a GES assessment in the close future.
78. **Climate change impacts on the Mediterranean Sea include an increase temperature and acidification, an increase of salinity (Parras-Berrocal et al., 2020), an increase in the frequency of floods that will affect coastal ecosystems. These changes need to be anticipated in a monitoring programme especially in the definition of BVs and TVs.**

b) At the level of indicators and criteria

79. **Impediments** to GES definition for the Mediterranean Sea at this level are partly related to the difference between D1 Criteria and EO1 Common indicators especially concerning benthic habitats. Benthic habitats in MSFD are assessed under D6 seafloor integrity. This results in EU countries not reporting on EO1 because equivalence between criteria and indicators as well as attributes are not evident. There is better coherence between EO1-CI 3, 4 and 5 on species groups which are similar to D1C2, C3 and C4.

80. Within IMAP, the factsheets and protocols for EO1-CI1 and CI2 on marine habitats would gain in efficiency in being simplified and more strait forward and by limiting the list of typical species or identifying the most pertinent.
81. Baseline and threshold values need to be clearly defined for benthic habitat assessment at sub-regional level.
82. Climate change is impacting habitats' and species' distribution in the Mediterranean Sea. EO1-CI3 GES definition is "The species continues to occur in all their natural habitats or range in the Mediterranean". Distributional range of several species and habitats are at high risk of shifting under climate change impacts and this shift can occur rapidly. Their "natural habitats" or "natural range" are terms that should be more specifically defined taking in consideration climate change impacts so that GES for this CI can be assessed. Under climate change context, some habitat extents and species distributional ranges could shift (e.g. to deeper waters or more to the north) without necessarily regressing in terms of extent. Are such changes of interest to monitor and if so, how should they be monitored?

c) *At the level of specific parameters or attributes*

<u>Representation of biodiversity</u>

83. The species and habitats currently assessed in IMAP do not sufficiently represent Mediterranean marine biodiversity. Starting the IMAP implementation by limiting the habitats and groups of species to monitor increased comprehension of the assessment and monitoring objectives and allowed CPs to focus on specific attributes to integrate IMAP. But major habitats such as Vulnerable Marine Ecosystems, pelagic habitats and other species groups (e.g; plankton, fish, cephalopods) could be progressively integrated to have a panel of species and habitats that further represents Mediterranean marine biodiversity. Deep-sea ecosystems are not assessed although they are vulnerable and affected also by climate change impacts (Le Bris & Levin, 2020).
84. Within the marine vegetation, P. oceanica is effectively assessed but other meadows such as Cymodosea noltei or Zoostera marina could be considered. Further, monitoring photophilic algae that also undergo anthropogenic pressures and climate change impacts is suggested (see Badreddine et al., 2018; Bahbah et al., 2020). Therein, assessments from littoral areas under Water Framework Directive could be interesting (see e.g. Bevilacqua et al., 2020).

<u>Data acquisition and availability</u>

85. Data acquisition and data availability is an impediment to GES definition for all indicators of EO1 Biodiversity.
86. Although international organisations exist such as ACCOBAMS dedicated to cetaceans, the assessment of marine mammals in the Mediterranean lacks data either because it is difficult to acquire or because it is little shared.
87. Unlike marine turtles that come to littoral areas for nesting, cetaceans distribution and abundance as well as demographic characteristics can only be assessed at sea and often out of territorial waters. In a large part of the Mediterranean Sea, few CPs have declared Exclusive Economic Zones (EEZ) resulting in large areas under High seas regime that aren't under national jurisdiction. This limits the assessment efforts of marine mammals by CPs. Several international structures, organisations and the ACCOMBAMS agreement acquire data on cetaceans in co-operation with SPA/RAC and CPs, but limited data sharing still seems a barrier to aggregating data to be able to define baseline values for the Mediterranean Sea cetaceans.
88. Further, bycatch of cetaceans was tentatively assessed but practically no data is available whereas data on stranding incidents exists. It could be envisaged to assess stranding incidents

for cetaceans and turtles instead and differentiate between incidents du to interaction with fisheries and other incidents (disease or other) to replace the bycatch indicator.

89. Seabird assessment as other biodiversity assessment suffer from a lack of data especially concerning EO1-CI5. The upcoming MED QSR 2023 should give a new state of the art of available data for biodiversity indicators but further assessments are needed in the Mediterranean to be in a position of assessing GES in good conditions.

Specific impediments

90. The Mediterranean monk seal is classified as being in danger by IUCN and there number is limited and estimated to about 700 individuals. This species has already suffered mass mortalities apparently due to a virus (see Osterhaus et al., 1998). Under warming Mediterranean Sea favouring disease outbreaks, this could happen again. Therefore, given the population dynamic and the limited number of individuals, "*maintaining their population*" (EO1-CI4) does not appear sufficient to safeguard the sustainability of this species in the Mediterranean.

3.4.Recommendations for way forward regarding EO1

91. Terms of the EO1 GES definitions could be further clarified and defined reducing different interpretations.
92. The method for defining baseline values and threshold values for EO1 should be decided. This could be discussed perhaps through a workshop, taking in consideration the effects that climate change and GES. The method selected should be coherent throughout the Mediterranean region and therefor comparable if not the same.
93. The panel of species and habitats assessed in IMAP should be more representative of Mediterranean Sea biodiversity so that Good Environmental Status of the Mediterranean Sea biodiversity can be effectively assessed.
94. For benthic habitats, it could be valuable to take in consideration the assessments of benthic ecosystems under Water Framework directive (e.g. Bevilacqua et al., 2020).
95. For benthic habitats, EO1-CI2 on Condition of the habitat's typical species and communities it is suggested to consider assessing a parameter on the impact of IAS (Invasive Alien Species). This could be envisaged with an indicator in relation with EO2 (see following chapter). Further, the current development of EO6 on seafloor integrity calls for an assessment of NIS impacts on seabed habitats which is not the case currently in IMAP.
96. Increase data sharing on species and habitat monitoring and assessment especially concerning marine mammals.
97. For EO1-CI5 relative to cetaceans and turtles, consider replacing bycatch assessment for which practically no data is available, by stranding incidents assessment that presents more data availability.
98. Assessment of Mediterranean Sea biodiversity is a difficult task and one of the most important ecological objectives. Progress has been done by CPs and organisations to collect and aggregate quality data, however efforts are still needed in data collection. Further, data needs to be available in order to proceed to sub-regional and regional assessments.
99. Basic terminology and what needs to be understood in GES definitions of EO1 needs to be better defined taking in consideration that environmental conditions are currently and will be changing under climate change context.

3.5.Key messages

100. Increase in sea temperature, acidification, increase of frequency and intensity of floods and storms are amongst the climate change impacts that will effect habitats' and species' spatial distribution but also their condition. In particular their spatial extension assessed under EO1 is dependant of environmental conditions which are currently affected by climate change. Spatial shifts of habitats and species are already occurring and expected to continue.

101. Clarifications are needed in GES definitions at EO1 level but also at indicator level since there is a contradiction between the terms. Biodiversity must be "*maintained or enhanced*" in its *distribution*, *extent* and *condition*, but at the same time "*in line with prevailing (..) climatic conditions*" which are currently changing. Further, "*natural habitats*" or "*natural range*" should be more specifically defined taking in consideration climate change impacts.

102. GES definition for EO1-CI1 and EO1-CI2 implies that baseline values and threshold values are the same. Habitat extent should remain the same or more extended than the baseline value which appears more and more difficult to attain or maintain for some benthic habitats under climate change conditions. There should be a consensus on which methodology to adopt to define baseline values taking in consideration climate change impacts on biodiversity and its assessment.

103. In parallel, methodologies for defining baseline values and threshold values especially for benthic habitats must be clear and strait foreword to be able to define these elements that are essential for assessing GES. For EO1-CI1 and EO1-CI2 (habitats) methodology for defining baseline values is <u>essential</u> in a climate change context.

104. Benthic habitats' spatial distribution data are available for some CPs. However, efforts are still needed in some areas to acquire spatial distribution of habitats, identification of typical species at sub-regional level and their condition. Further, typical species for coralligenous habitats should be defined taking in account the current monitoring methods mainly based on images.

105. The assessment of GES for IMAP EO1 Biodiversity is currently based on the assessment of the state of three main benthic habitats and several species of marine mammals, seabirds and marine turtles. The habitats and groups of species should be extended to better represent the Mediterranean Sea biodiversity.

106. *"Maintaining"* certain populations of species that are in danger, with a slow population dynamic and few individuals left does not appear sufficient in climate change conditions which enhance disease outbreaks that could severely affect the population size. For some species, such as monk seals, GES definition could be reconsidered to *favour* population development in order to have better chances to face climate change impacts.

107. To assess EO1 GES at Mediterranean Sea scale, data needs to be assembled from EU countries assessing GES under MSFD and non EU countries assessing GES under IMAP. However, benthic habitats are assessed under EO1 *biodiversity* in IMAP and D6 *seafloor integrity* in MSFD. This results in EU CPs not reporting on EO1 because analogies between criteria and indicators as well as attributes are not evident. Clarifying the equivalence between the elements of D6 and EO1 on habitats should contribute to increase reporting of EU CPs under IMAP and therefor increase data availability to assess GES.

108. Taking in consideration the current development of EO6 on seafloor integrity that calls for an assessment of NIS impacts, EO2 on NIS and the current spatial expansion and the impacts of Invasive Alien Species (IAS), a parameter relative to IAS impacts within EO1CI2 *Condition of the habitat's typical species and communities* could be developed in relation with EO2.

4. Ecological Objective 2: Non Indigenous species

109. From the EO2 factsheet[2]:

110. '**Non-indigenous species**' (**NIS**; synonyms: alien, exotic, non-native, allochthonous) are species, subspecies or lower taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential. This includes any part, gamete or propagule of such species that might survive and subsequently reproduce. Their presence in the given region is due to intentional or unintentional introduction resulting from human activities. Natural shifts in distribution ranges (e.g. due to climate change or dispersal by ocean currents) do not qualify a species as a NIS.

111. "**Invasive alien species**" (**IAS**) are a subset of established NIS which have spread, are spreading or have demonstrated their potential to spread elsewhere, and have an effect on biological diversity and ecosystem functioning (by competing with and on some occasions replacing native species), socioeconomic values and/or human health in invaded regions. Species of unknown origin which cannot be ascribed as being native or alien are termed **cryptogenic species**. They also may demonstrate invasive characteristics and should be included in IAS assessments.

4.1. General information on IMAP EO2 and MSFD D2 GES definition

112. Relevant documents relative to EO2/D2 and GES determination under IMAP and MSFD can be found in the following Table 3.

Table 3: Relevant documents relative to GES definition for EO2/D2.

Non-Indigenous Species	
IMAP	**MSFD**
EO2 GES: "*Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.*"	D2 GES: "*Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.*"
Galanidi, M., Aissi, M., Ali, M., Bakalem, A., Bariche, M., Bartolo, A. G., … Zenetos, A. (2023). Validated Inventories of Non-Indigenous Species (NIS) for the Mediterranean Sea as Tools for Regional Policy and Patterns of NIS Spread. Diversity, 15(9), 962. Link Galanidi, M., & Zenetos, A. (2022). Data-Driven Recommendations for Establishing Threshold Values for the NIS Trend Indicator in the Mediterranean Sea. *Diversity*, *14*(1), 57. Link UNEP/MAP. (2021). *UNEP/MED Comparative Analysis undertaken with regard to IMAP and the European Commission GES*	Magliozzi, C., Van, H. N., Živana, N. G., & Cardoso, A.-C. (2023). *Establishing thresholds: Workshop on the MSFD Newly Introduced NIS (D2C1)* (JRC Conference and Workshop Report No. JRC132962.). Luxembourg: Publications Office of the European Union. Link Tsiamis, K., Boschetti, S., Palialexis, A., Somma, F., & De, J. C. A. (2021). *Marine Strategy Framework Directive – Review and analysis of EU Member States' 2018 reports – Descriptor 2: Non-Indigenous Species*. Link Tsiamis, K., Palialexis, A., Connor, D., Antoniadis, S., Bartilotti, C., Bartolo, A.

[2] UNEP/MAP, 2017. IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries) (UNEP(DEPI)/MED WG.444/6/REV.1)

Non-Indigenous Species	
IMAP	**MSFD**
Decision 2017/848/EU for Biodiversity (WG.502/Inf.10). Link UNEP/MAP - RAC/SPA. (2019). *UNEP/MAP WG.467/16. Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species*. Link UNEP/MAP (2017) *IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries)* (UNEP(DEPI)/MED WG.444/6/REV.1). → UNEP/MAP. (2017). *Draft guidelines for the preparation of the country specific EcAp monitoring programme for biodiversity and NIS (UNEP(DEPI)/MED WG.444/Inf.14)* (p. 41) [6th Meeting of the Ecosystem Approach Coordination Group]. Link **See Annex A, EO2 for technical documents specifically related to CI6**	G., … De, J. C. A. (2021). *Marine Strategy Framework Directive – Descriptor 2, Non-Indigenous Species. Delivering solid recommendations for setting threshold values for non-indigenous species pressure on European seas* (JRC Science for Policy Report No. JRC124136). Luxembourg: Publications Office of the European Union. Link

113. **Relations between MSFD D2 Criteria and IMAP EO2 indicators** have been addressed in the document *Comparative Analysis undertaken with regard to IMAP and the European Commission GES Decision 2017/848/EU for Biodiversity* (UNEP/MED WG.502/Inf.10).

114. **IMAP Ecological Objective 2** includes currently only one indicator with the following GES definition and target:

EO2-CI6 – Decreasing abundance of introduced NIS in risk areas. Abundance of NIS introduced by human activities reduced to levels giving no detectable impact.

115. This indicator corresponds to D2C1 and D2C2 of the MSFD (see here after).

116. **MSFD Descriptor 2** is declined in one primary (mandatory) criterion and two secondary criteria with the following GES definitions:

D2C1 – Primary: The number of non-indigenous species which are newly introduced via human activity into the wild, per assessment period (6 years), measured from the reference year as reported for the initial assessment under Article 8(1) of Directive 2008/56/EC, is minimised and where possible reduced to zero. Member States shall establish the threshold value for the number of new introductions of non-indigenous species, through regional or sub-regional cooperation.

D2C2 – Secondary: Abundance and spatial distribution of established non-indigenous species, particularly of invasive species, contributing significantly to adverse effects on particular species groups or broad habitat types. No threshold value requested.

D2C3 – Secondary: Proportion of the species group or spatial extent of the broad habitat type which is adversely altered due to non-indigenous species, particularly invasive non-indigenous species. Member States shall establish the threshold values for the adverse alteration to species groups and broad habitat types due to non-indigenous species, through regional or sub-regional cooperation.

117. For MSFD it is the MS that should establish threshold values by regional and sub-regional cooperation for D2C1 and D2C3. For D2C2, MS shall refer to the list of EU Regulation N° 1143/2014 and cooperate regionally and sub-regionally to update the NIS inventory (Vasilakopoulos et al., 2022).

4.2. Elements for defining EO2 GES at indicator level in a climate change context

EO2 Non Indigenous Species Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO2-CI6**
EO2-CI6 GES: Decreasing abundance of introduced NIS in risk areas. CI6: Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas (in relation to the main vectors and pathways of spreading of such species) Each CP determines a list of Invasive Alien Species to monitor.
Specific monitoring guidance documents available to assess and monitor NIS: → Galanidi, M., Aissi, M., Ali, M., Bakalem, A., Bariche, M., Bartolo, A. G., … Zenetos, A. (2023). Validated Inventories of Non-Indigenous Species (NIS) for the Mediterranean Sea as Tools for Regional Policy and Patterns of NIS Spread. Diversity, 15(9), 962. Link → UNEP/MAP (2017) *IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries)* (UNEP(DEPI)/MED WG.444/6/REV.1). → Katsanevakis, S., Tempera, F., & Teixeira, H. (2016). Mapping the impact of alien species on marine ecosystems: The Mediterranean Sea case study. *Diversity and Distributions*, *22*(6), 694–707. Link **Mediterranean NIS species guides and related information :** → Hüseyinoğlu, M. F., Arda, Y., & Jiménez, C. (2023). *Manual of invasive alien species in the Eastern Mediterranean* (IUCN). Gland, Switerland: IUCN. Link → Öztürk, B. (2021). *Non-indigenous species in the Mediterranean and the Black Sea.* Rome, Italy: FAO. Link **Abundance of introduced NIS in risk areas** The rate of new NIS is variable throughout the Mediterranean Sea and between sub-regions (Galanidi & Zenetos, 2022). Even within a country, the rate varies depending on the sub-regions (e.g. Italy, Greece see in Ragkousis et al., 2023; Galanidi & Zenetos 2022) but trends are always positive. Therefor Galanidi & Zenetos (2022) suggest that the appropriate scale, to assess GES is the sub-regional scale given that methodology of assessment and selection of type of sites to monitor (ports, MPAs etc.) be common. Further, the authors suggest to use a time span for assessment of three years and not six. Creating refined baseline inventories appears as a necessary first step (see Tsiamis et al., 2019) to be able to assess a decrease in abundance of NIS in risk areas. In the Mediterranean

Sea this would request though to have a common approach in the assessment methods and the definition of types of areas to monitor (commercial ports, MPAs, already particularly impacted areas…).

However, Zenetos & Galanidi (2020) published the list of the 65 new NIS reported in the 3 year period (2017-2019) in the Mediterranean Sea with their year of introduction, country of introduction and whether they are considered established or not. The authors also list the 36 species which have expanded their distribution during the period.

More lately, Galanidi et al. (2023) have published valid updated sub-regional and regional NIS inventories for the Mediterranean Sea that will be used as **baselines** for IMAP and MED QSR 2023. The authors have totalised 1006 NIS in marine and brackish waters of the Mediterranean underlining a general increase in the yearly rate of new NIS introductions after the late 1990s.

A review of NIS records in Mediterranean ports has been published by Tempesti et al. (2020) and represents a first baseline for Mediterranean ports and underlines gaps.

Bartolo et al. (2021) have used the Cumulative IMPacts of invasive Alien (CIMPAL) model to determine priority hotspots areas of NIS impact in the Maltese islands.

In the process of defining threshold values for the MSFD criteria, Tsiamis et al. (2021b) have published recommendation for setting threshold values for NIS, discussing of a TV to decide sub-regionally that could be a 50% reduction for a sub-region of new NIS reported during the last 3 reporting cycles (see Tsiamis et al., 2021a). EU has recently dedicated a MSFD workshop to progress on the subject (Magliozzi et al., 2023).

e-DNA tools to monitor NIS appear as promising cost effective methods (Fonseca et al., 2023). These still need though to be used in parallel of conventional methods to validate uncertainties and refine molecular identifications. Also, e-DNA will need a common sampling approach and common types of sites to monitor in order to be comparable in time and space.

Protocols have been developed in other areas of the world for specific groups of species and could be tested in the Mediterranean as it has been done by Tamburini et al. (2021) that tested a North American standardized protocol four fouling communities that was tested in the Ligurian Sea.

Finally, the mitigation strategy proposed by Rotter et al. (2020) can also be used for prevention of NIS introduction. These could be considered in parallel of assessment strategies considering the high rate of NIS introduction and the number of Invasive Aquatic Species (IAS) in the Mediterranean Sea.

Effects of climate change and other cumulative pressures in GES determination

Increase in sea temperature is an impact of climate change; in the Mediterranean Sea, it is 20% higher than the global increase. This phenomenon has already contributed to the instalment, expansion and increase in number of thermophilic NIS in the Mediterranean Sea (Spanier & Zviely, 2023).

EO2 Non Indigenous Species Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO2-CI6**
Zenetos et al. (2022a) indicate that the instalment rate of NIS has greatly increased in the last years, with 21.5% of the new species that arrived between 2020 and 2021 that are considered installed which is over twice the rate expected (Zeneteos et al., 2022a). Globally, new NIS introductions in the Mediterranean have a positive trend since several decades and vertebrates have notably increased since 2000 (Zenetos et al., 2022b). The Mediterranean Sea is undergoing a warming trend that will continue due to climate change. A large number of NIS and IAS are thermophilic species therefor GES, as defined for CI6 "*decreasing abundance of introduced NIS in risk areas*", will be difficult to attain or maintain. However, if impacts of IAS on ecosystems and societies are assessed as well, effective mitigation and management actions can be designed to reduce adversely effects of NIS/IAS (Invasive Aquatic Species) that alter ecosystems and therefor act to be in capacity of attaining or maintaining GES for EO2. Katsanevakis et al. (2023) propose eight recommendations to improve the management of IAS.

4.3. Impediments and gaps identified in EO2 GES determination and assessment in a climate change context

118. IMAP defines GES for EO2 as "*Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.*"

119. Levels of introduction are being assessed at Mediterranean scale and efforts have been done to collect data to define baseline values at regional and sub-regional level. NIS being a transboundary pressure and their impact being partly related to climate change effects, the best scale of assessment seems to be the sub-regional level (see also Galanidi & Zenetos, 2022). These authors also suggest an adapted time span for assessments of 3 years due to the rapidity of arrival and instalment of NIS related to a warming Mediterranean Sea trend.

120. Moreover, considering that there is currently only one indicator in this Ecological Objective, one needs to answer the following question: Will attaining GES for CI6 be sufficient to attain GES for EO2? In other words, will "*decreasing abundance of introduced NIS in risk areas*" be effective and sufficient to attain levels of NIS "*that do not adversely alter the ecosystems*"? Having in hand the abundance and trends of NIS, how can one infer the impacts of NIS on marine ecosystems and human societies?

121. **To be able to determine GES at the EO level, it appears essential to assess in parallel the impacts of NIS on ecosystems and human societies which is not currently the case in IMAP.** Impacts of specific NIS have recently been described by several authors (e.g. Kleitou et al. (2021) on impact of Lionfish; Mannino et al. (2023) on *Halophila stipulacea* Mannino et al. (2018) on effects of NIS in the Egadi Island MPA), but quantifying impact of NIS on ecosystems remains a challenge. Further, the current development of EO6 on seafloor integrity calls for an assessment of NIS impacts on seabed habitats which is not the case currently in IMAP.

122. Katsanevakis et al., 2016 have mapped Cumulative IMPacts of invasive Alien (CIMPAL) on marine ecosystems based on a conservative additive model (also used by Bartolo et al., 2021). Gaps, heterogeneity of data and other matters have been underlined in this work emphasizing the need for quality and homogeneous data. To gain in robustness, CIMPAL needs

to be fed by more detailed and accurate data and knowledge on NIS and their impacts. The objective of the later ALAS program (see Katsanevakis et al., 2020) is precisely to acquire such data in the Aegean Sea to support marine policy and managers, define hotspots and prioritize mitigation actions.

123. Acquiring in depth knowledge of life cycles and life traits of Invasive Aquatic Species (IAS) (e.g. study of the blue crab *Callinectes sapidus* by Marchessaux et al. (2023) is essential to be able to establish risk assessments and mitigate efficiently if needed the impacts of IAS. Indeed, mitigation strategies and actions, whether they be carried out by inciting fishing, consumption of IAS and related industries (as in Tunisia for the blue crab (e.g. Mili et al., 2021), fishing the IAS to reduce its numbers (as for the puffer fish *Lagocephalus sceleratus* in Cyprus supported by an EU funded project[3]) or reducing other pressures affecting the ecosystem, need to be envisaged in parallel of assessment. Undeniably, mitigation actions are more efficient when they are implemented early in the expansion process of the IAS.

124. Climate change can also increase IAS impacts by reducing resilience of thermally sensitive native species, habitats and ecosystems (Birchenough et al., 2015; Katsanevakis et al., 2023).

125. As one of climate change's direct impact is a rapid increase of Mediterranean Sea temperatures, thermophilic Non-Indigenous Species (NIS), including Invasive Aquatic Species (IAS), of all phyla will tend to expand their geographical range and abundance. Some can have negative impacts on marine ecosystems but also they can impact littoral human societies. **NIS and IAS impacts on ecosystems and societies, should be assessed to be able to be able to act efficiently with mitigation actions and reduce abundance of NIS.**

4.4.Recommendations for way forward regarding EO2

126. To be able to attain and maintain GES for EO2-CI6, mitigation actions will most probably be necessary under climate change context. Identifying the most impacting species (e.g. by carrying out risk assessments such as for Golani's round herring (see Keramidas et al., 2023) and the most impacted areas and ecosystems would be helpful to identify the best mitigation actions. Further, assessing the impacts on benthic habitats would be of interest for EO6 on seafloor integrity (see chapter 8 on Ecological Objective 6).

127. Considering these points, EO2 could be completed by:

→ An indicator that assesses the impacts of NIS on ecosystems

→ An indicator equivalent to D2C3 "*Proportion of the species group or spatial extent of the broad habitat type which is adversely altered due to non-indigenous species, particularly invasive non-indigenous species"* to assess NIS/IAS impacts on benthic habitats (EO1/EO2 indicator)

→ An indicator that assesses socio-economic impacts of NIS.

---

[3] « An EU financed-project to limit the growth of the pufferfish population was set up in Cyprus. This project, implemented by professional fishers, puts pressure on the breeding pufferfish population through intensive fishing. To cover for the lack of commercial value, a funding scheme pays the fishers 3€ per kilo of pufferfish caught, landed and registered. The Cypriot Department of Fisheries and Marine Research (DFMR) is in charge of managing the project nationwide, while 14 fishers' associations are participating, each managing its own "sub-scheme"." See Link

128. Possibly, the first two could be assessed in an integrative indicator. Assessing impacts of NIS/IAS on ecosystems and socio-economic impacts requires an assessment scheme that can compare impacts across various taxa, ecosystems and socio-economic contexts (Galanidi, Zenetos, & Bacher, 2018). These authors used two methodologies to assessed environmental and socio-economic impacts of seven NIS which were classified on a five-level semi-quantitative scale. These approach seems of interest to assess NIS impacts.

129. Given the speed of instalment of certain NIS/IAS and the fact that mitigation actions are more efficient when they are implemented early in the expansion process of the IAS, it is recommended to have a short time span of 3 years between assessments (as proposed by Galanidi & Zenetos 2022).

130. The most appropriate scale of assessment for EO2-CI6 appears to be the sub-regional scale.

131. New methods such as e-DNA could be investigated and perhaps considered for NIS assessment in a near future.

132. Finally, integrating NIS in EO3-CI8 “Total landings” could be envisaged to inform on abundance of fished NIS.

4.5.Key messages

133. Data for abundance and expansion of NIS is available throughout the Mediterranean Sea and updates of species lists are regularly published which contribute to define baseline values for EO2-CI6. Assessment though needs to be continued because rapid expansion of these species is observed under climate change related sea temperature rise.

134. Methods of assessment and monitoring site selection need still to be harmonised.

135. Given that methodology of assessment and selection of type of sites to monitor (ports, MPAs etc.) be common, the most appropriate scale of EO2 GES assessment is the sub-regional scale.

136. Taking in consideration the rapid expansion of NIS, it has been suggested that the appropriate time span for EO2-CI6 assessment is three years.

137. Increase in sea temperatures clearly triggers the introduction, expansion, instalment and abundance of thermophilic Non-Indigenous Species (NIS) and Invasive Alien Species (IAS) in the Mediterranean Sea. This situation makes EO2-CI6 GES definition "*decreasing abundance of introduced NIS in risk areas"* very difficult or impossible to attain.

138. There is currently only one indicator in EO2 on NIS. Assessing EO2-CI6 "*Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas*" alone is not sufficient to assess GES at ecological objective level "*Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem"*. This is because the impacts of NIS are not assessed therefor it is not possible to evaluate if NIS effects, *adversely alter the ecosystems*. To be able to determine GES at the EO level, it appears essential to assess in parallel the impacts of NIS on ecosystems and human societies which is not currently the case in IMAP. Further mitigation actions are difficult to put in place when little is known on the most threatening NIS and which ecosystems are threatened and in which way.

5. Ecological Objective 3: Fisheries

5.1. General information on IMAP EO3 and MSFD D3 GES definition

139. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO3/D3 and GES determination under IMAP and MSFD can be found in Table 4.

Table 4: Relevant documents relative to GES definition for EO3/D3.

Fisheries	
IMAP	**MSFD**
EO3 GES: *"Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock"*	D3 GES: *"Populations of all commercially-exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock."*
UNEP/MAP (2017) *IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries)* (UNEP(DEPI)/MED WG.444/6/REV.1). Link	Probst, W. N., Kempf, A., Taylor, M., Martinez, I., & Miller, D. (2021). Six steps to produce stock assessments for the Marine Strategy Framework Directive compliant with Descriptor 3. *ICES Journal of Marine Science*, 78(4), 1229–1240. ICES. (2017). Report of the Workshop on guidance on development of operational methods for the evaluation of the MSFD criterion D3.3 (WKIND3.3ii), 1–4 November 2016, ICES HQ, Copenhagen, Denmark, ICES CM 2016/ ACOM: 44; p. 155. Vasilakopoulos, P., Konrad, C., Palialexis, A., & Boschetti, S. (2021). *Marine Strategy Framework Directive - Review and analysis of EU Member States' 2018 reports - Descriptor 3: Commercial species*. Link Simmonds, J., Bitetto, I., Cikes Kec, V., Guijarro, B., Isajlovic, I., Ligas, A., … Tsikliras, A. (2021). *Methods for supporting stock assessment in the Mediterranean (STECF-21-02).* [Report]. Publications Office of the European Union. Link ICES. (2014). *Report of the Workshop to draft recommendations for the assessment of Descriptor D3 (WKD3R), 13-17 January*

Fisheries	
IMAP	**MSFD**
	2014 (No. ICES CM 2014/ACOM:50.; p. 153). Copenhagen, Denmark: ICES. Link ICES. (2015). *Report of the Workshop on guidance for the review of MSFD decision descriptor 3 – commercial fish and shellfish II (WKGMSFDD3-II) 10-12 February 2015. ICES Headquarters, Denmark* (No. ICES CM 2015\ACOM:48; p. 36). ICES. Link

140. At the Mediterranean scale, it is the General Fisheries Commission for the Mediterranean (FAO-GFCM) that developed and assesses the Ecological Objective's 3 indicators in coordination with UNEP/MAP and feeds results in the MED QSRs.

141. **IMAP Ecological Objective 3,** is declined in six indicators. The GES definition of the three first indicators are:

EO3-CI7 –: Spawning stock biomass. Achieving or maintaining good environmental status requires that Spawning Stock Biomass (SSB) values are equal to or above SSBMSY, the level capable of producing maximum sustainable yield (MSY).

EO3-CI8 –: Total landings. Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

EO3-CI9 –: Fishing mortality. Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

142. **The following indicators do not have TVs and GES definition but include operational objectives**:

EO3-CI10 –: Fishing effort. Fishing effort should be reduced by means of a multi-annual management plan until there is an evidence for stock recovery.

EO3-CI11 –: Catch per unit of effort (CPUE) or Landing per unit of effort (LPUE) as a proxy. Population condition of selected species is maintained. Stable or positive trend in CPUE. Declines in CPUE may mean that the fish population cannot support the level of harvesting. Increases in CPUE may mean that a fish stock is recovering and more fishing effort can be applied.

EO3-CI12 –: Bycatch of vulnerable and non-target species. Incidental catch of vulnerable species (i.e. sharks, marine mammals, seabirds and turtles) are minimized.

143. In MED QSR 2017, EO3-CI7 to CI9 were assessed. EO3-CI12 is comparable to MSFD D1C1 "The mortality rate per species from incidental by-catch is below levels which threaten the species, such that its longterm viability is ensured" without being equivalent.

144. **MSFD Descriptor 3** on fisheries, includes 3 criteria with the following GES definitions:

D3C1 – Primary: The Fishing mortality rate of populations of commercially-exploited species is at or below levels which can produce the maximum sustainable yield (MSY). Appropriate scientific bodies shall be consulted in accordance with Article 26 of Regulation (EU) No 1380/2013.

D3C2 – Primary: The Spawning Stock Biomass of populations of commercially-exploited species are above biomass levels capable of producing maximum sustainable yield. Appropriate scientific bodies shall be consulted in accordance with Article 26 of Regulation (EU) No 1380/2013.

D3C3 – Primary: The age and size distribution of individuals in the populations of commercially-exploited species is indicative of a healthy population. This shall include a high proportion of old/large individuals and limited adverse effects of exploitation on genetic diversity. Member States shall establish threshold values through regional or subregional cooperation for each population of species in accordance with scientific advice obtained pursuant to Article 26 of Regulation (EU) No 1380/2013. Following the Commission Decision (EU) 2017/848, the threshold values for D3 shall be established by MS through regional or sub-regional cooperation for each population of species in accordance with scientific advice obtained pursuant to Article 26 of Regulation (EU° N° 1380/2013). The list of commercially exploited species for application of the criteria in each assessment area shall be established by Member States through regional or sub-regional cooperation and updated for each 6-year assessment period, taking into account Council Regulation (EC) No 199/2008 plus some other specified points.

146. **IMAP Indicators and MSFD Criteria** both assess the impact of fisheries with the objective of attaining and maintaining sustainable fisheries but the parallel between indicators and criteria is not obvious. The hereafter table presents analogies between IMAP indicators and MSFD criteria.

IMAP EO3 Fisheries indicators	MSFD criteria
EO3-CI7 Spawning stock Biomass	**D3C2**
EO3-CI8 Total landings	Not assessed through MSFD
EO3-CI9 Fishing mortality of main populations	**D3C1**
EO3-CI10 Fishing effort (currently not assessed in IMAP)	Not assessed through MSFD
EO3-CI11 Catch per unit effort (CPUE) or Landing per unit of effort (LPUE) (currently not assessed in IMAP)	Not assessed through MSFD
EO3-CI12 Bycatch of vulnerable and non-target species (currently not assessed within EO3)	Not assessed within D3 but through **D1-C1** on mortality rate per species from incidental by-catch
Not assessed through IMAP	**D3C3** on age and size distribution of individuals in the populations of commercially-exploited species

5.2. Elements for defining EO3 GES at indicator level in a climate change context

a) Indicators relative to targeted species

EO3 Fisheries Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO3-CI7, EO3-CI8, EO3-CI9, EO3-CI10, EO3-CI11**
EO3-CI7 GES: Spawning stock Biomass. Achieving or maintaining good environmental status requires that Spawning Stock Biomass (SSB) values are equal to or above SSBMSY, the level capable of producing maximum sustainable yield (MSY). *(Operational objective: The Spawning Stock Biomass is at a level at which reproduction capacity is not impaired)* *pelagic and demersal species* **EO3-CI8 GES: Total landings.** Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock. *(Operational objective: Total landing and/or catch of commercial species does not exceed the Maximum Sustainable Yield (MSY) and the by-catch is reduced.)* *pelagic and demersal species* **EO3-CI9 GES: Fishing Mortality.** Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock. *(Operational objective: Fishing mortality in the stock does not exceed the level that allows MSY (F≤FMSY).* *pelagic and demersal species* **EO3-CI10** Operational objective: Fishing effort should be reduced by means of a multi-annual management plan until there is an evidence for stock recovery. **EO3-CI11** Operational objective: Population condition of selected species is maintained: Stable or positive trend in CPUE.
<u>Specific monitoring guidance documents available to assess and monitor indicators for EO3 and D3</u> → Probst, W. N. (2023). An approach to assess exploited fish stocks compliant to the requirements of the Marine Strategy Framework Directive (MSFD) including criterion D3C3. *Ecological Indicators*, *146*, 109899. → Carpentieri, P., Bonanno, A., & Scarcella, G. (2020). *Technical guidelines for scientific surveys in the Mediterranean and the Black Sea Procedures and sampling for demersal (bottom and beam) trawl surveys and pelagic acoustic surveys* (FAO Fisheries and Aquaculture Technical Papers N No. N°641; p. 108). Rome: FAO. Link → Tsikliras, A., & Froese, R. (2018). Maximum Sustainable Yield. In Reference Module in Earth Systems and Environmental Sciences. → Standardized stock assessments on Mediterranean fisheries have been performed by the Scientific Technical Economic Committee for Fisheries (STECF) since 2009. All the reports can be found here as well as technical reports on methodology used. **<u>Commercial fish stock assessment</u>** Based on ICES stock assessment database, the state of European commercial fish and shellfish stocks (for which stock assessments were conducted between 2016-2020), in relation to the GES criteria for fishing mortality and reproductive capacity by marine region have been

mapped by the European Environmental Agency and available here. The great majority of Mediterranean European central and western stocks assessed, do not meet GES.

The report FAO (2022) *The State of Mediterranean and Black Sea Fisheries 2022* (Link) informs on the state of priority species stocks and compares them to previous assessments. Efforts are still required to extend assessment coverage but results on best available data show that since 2012 the average fishery exploitation ratio in the Mediterranean Sea has consistently decreased. Improvements in the exploitation ratios over the recent years in several priority species has been observed, though exploitation of others show an increasing trend. This document presents the most complete and up-to-date situation relatively to fishing pressure in the Mediterranean Sea.

It is worth noting that according to European Environmental Agency (2019), 93.9% of the Mediterranean Sea assessed stocks do not meet any of the two MSFD GES criteria D3C1 and D3C2.

GFCM estimates at 75% of the Mediterranean fish stock remain overexploited in 2020 FAO. (2022).

Effects of climate change and other cumulative pressures in GES determination

: "*Temperature has a major direct impact on the physiology, growth, reproduction, recruitment and behavior of marine organisms such as fish. Warming associated with climate change already affect the Mediterranean ecosystem for some benthic and pelagic species (Marbà et al. 2015). Warming combined with a decline in oxygen and resource availability reduces fish body size, with the average maximum body weight of fish expected to shrink by 4% to 49% from 2000 to 2050 (Cheung et al. 2013). Also, fish tend to adapt to local environmental temperatures. Therefore, among the most perceptible largescale consequences of climate change is the shift in spatial distribution range of marine organisms, which will make some Mediterranean sub-basins more vulnerable to drivers than the others. Seawater warming will induce a loss of climatically suitable habitats for various organisms, causing distribution shifts, as well as species extinction. The diversity of fish assemblages is predicted to be severely affected due to their loss of suitable climatic niches* » excerpt from MedECC, 2020 p.346

Climate change impacts on fisheries have been extensively studied at global level in Barange, M., Bahri, T., Beveridge, M. C. M., Cochrane, K. L., Funge-Smith, S., & Poulain, F. (Eds.). (2018). *Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options.* Rome: FAO. Link

In the Mediterranean Sea, it is expected that climate change will reduce fishery productivity in temperate regions including decreased fish stocks and a reduction of the average maximum body weight of fish (Gomei et al., 2021).

Further, geographical range distribution of exploited species are expected to be modified by climate change impacts and consequently lead to a redistribution of stocks (Farahmand et al., 2023). These authors also conclude that the southern Mediterranean countries would be the most vulnerable to climate-induced effects on marine fisheries. Higher climate risk level had also been identified for the south-eastern Mediterranean by the study of Hidalgo et al. (2022).

Changes in Mediterranean fisheries Maximum Catch Potential (MCP) by target fishing gears, under different climate scenarios throughout the 21st century were modelled by Ben Lamine

EO3 Fisheries Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO3-CI7, EO3-CI8, EO3-CI9, EO3-CI10, EO3-CI11**
et al. (2023). The authors estimate that MCP could decrease by the end of the century mainly in south eastern Mediterranean countries at various degrees depending on the emission scenario considered and the type of fishery. Moullec et al. (2023) investigated the possible effects of changes in fishing pressure on marine resources and ecosystem structure and functioning, under a worst-case climate change scenario (RCP8.5). The authors found that improvements in fishing management (decrease in fishing mortality, improving fishing selectivity) could increase the total biomass and catch but probably not compensate for the loss due to climate change. However, climate change could offer opportunities for some eastern Mediterranean countries to increase catches of thermophilic and exotic species. Cramer et al. (2018) underline the urgent need of a pan-Mediterranean integrated risk assessment since direct impacts on fisheries and other fields are amplified by the consequences of biodiversity loss on ecosystem services. Finally, Ramírez et al. (2018) have studied the convergence of climate change and human stressors that cumulate but also be synergetic to reduce Mediterranean Sea's resilience to climate change. To enhance resilience to climate change impacts, creation of Safe Operational Spaces (SOS) are discussed especially for the Adriatic region.

b) *Indicator relative to bycatch of species*

EO3 Fisheries Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO3-CI12**
EO3-CI12 Operational objective: Incidental catch of vulnerable species (i.e. sharks, marine mammals, seabirds and turtles) are minimized.
Specific monitoring guidance documents available to assess and monitor EO3-CI12: → FAO. (2019). *Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries. Methodology for data collection* (FAO Fisheries and Aquaculture Technical Papers N No. N°640). Rome. Link → Otero, M. del M., Serena, F., & Gerovasileiou, V. (2019). *Identification guide of vulnerable species incidentally caught in Mediterranean fisheries*. IUCN. Link → UNEP/MAP-RAC/SPA. (2009). *Guidelines for reducing by catch of seabirds in the Mediterranean region.* By Carles Carboneras (p. 49). Tunis: RAC/SPA. Link → UNEP-MAP RAC/SPA. (2006). *Guidelines for reducing the presence of sensitive chondrichthyan species within by-catch.* By Melendez, M.J. & D. Macias, IEO (p. 21). Tunis: RAC/SPA. **Incidental catch of vulnerable species** The recent review of Carpentieri et al. (2021) *Incidental catch of vulnerable species in Mediterranean and Black Sea fisheries – A review.* (Link) is probably the most complete assessment document on the subject for the Mediterranean Sea. Within IMAP assessment of this indicator is considered in the MED QSRs through EO1 assessment of species in particular cetaceans and turtles and not through EO3.

5.3. Impediments and gaps identified in GES determination and assessment in a climate change context, and recommendations for way forward

147. IMAP defines GES for EO3 as *"Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock"*

148. Indicators EO3-CI10 and EO3-CI11 are currently not assessed within IMAP. It should be decided whether there should be efforts done to assess these indicators or whether they should be taken out of EO3. Assessing whether EO3 is in GES or not includes an assessment of all its indicators if these indicators are not to be assessed, it is advised not to include them in EO3. However, assessing total landings (CI8) alone without fishing effort (CI10) associated, is of much less interest to inform on the state of the commercially exploited fish and shellfish. It is recommended to discuss these points with GFCM to determine the best way forward.

149. Methods for defining reference points that discriminate GES from non GES for EO3-CI7, EO3-CI8 and EO3-CI9 are quite well described. However, data to define these reference points is often lacking. Increased effort is needed by CPs to assess and share the assessment of these indicators.

150. Indicator EO3-CI12 hasn't been assessed in EO3, but has been partially and independently assessed in EO1-CI4 for cetaceans and marine turtles. Data need to be aggregated to be able to eventually assess this indicator. However data on bycatches are very difficult to acquire which could condemn the assessment of this indicator. Still, whereas bycatch data for cetaceans are indeed very poor, data on stranding incidents seem to be more abundant.

151. In the Identification guide of vulnerable species incidentally caught in Mediterranean fisheries Otero et al. (2019), the authors also include sponges and corals in addition to marine mammals, seabirds, sea turtles and chondrichtyans. If vulnerable marine ecosystems (VMEs) are to be assessed in EO1-CI1 and CI2, it would be of interest to consider sponges and corals as well in bycatch assessment (CI12).

152. EO3 indicators CI7 to CI9 are assessed against Maximum Sustainable Yield (MSY) and associated mortality rate FMSY which play the role of reference points or benchmarks between GES and non GES. However, these are both sensitive not only to stock characteristics, but also environmental conditions. In parallel, fish stocks are being affected by climate change. Travers-Trolet et al. (2020) studied MSY variations in the English Channel area and concluded that anticipation of climate change impacts on fish community would need to target a smaller fishing mortality than FMSY to ensure the sustainability of marine stocks. This means that this reference point should be reconsidered regularly taking the environmental climatic conditions in consideration.

153. Spatial and species aggregation rules to assess GES (i) for a stock at sub-regional or regional scale, or to (ii) assess fishing mortality of several stocks in an area, have not yet been defined. This is a barrier for assessing GES in an integrative way.

154. Combined effects of sea warming and fishing pressure could decrease the prey availability of certain groups of species such as mammals which in turn could increase interactions with fisheries and consequently bycatch. A threshold value for particularly vulnerable species could perhaps be studied with GFCM.

155. Including NIS species in EO3-CI9 would be of interest to assess abundance of certain NIS but also the degree of integration of new species in societies. Further exchanges and discussions with GFCM on the assessment of NIS landings could also be fruitful since several NIS species are already assessed in fisheries by GFCM.

5.4.Key messages

156. Indicators EO3-CI10 *Fishing effort* and EO3-CI11 on *CPUE* are currently not assessed within IMAP. Although CI10 is of high importance to better understand CI8 *Total landings*' variations, the pertinence of keeping CI10 and CI11 in EO3, should be reconsidered. It is recommended to discussions with GFCM on this point.

157. An important point concerning EO3 assessments in comparison with other EOs, is the fact that assessment is performed for all the Mediterranean Sea independently of the dichotomy EU/non EU states. EO3 is a spatially integrative ecological objective.

158. The appropriate scale of assessment for EO3 indicators is sub-regional or regional, therefor CP data need to be aggregated and aggregation rules defined.

159. Spatial and species aggregation rules to assess GES (i) for a stock at sub-regional or regional scale, or to (ii) assess fishing mortality of several stocks in an area, have not yet been defined. This is a barrier for assessing EO3 GES in an integrative way.

160. Methods for defining reference points (that discriminate GES from non GES) are well described. However, data needed for defining these reference points lack.

161. Data relative to EO3-CI12 are partially assessed through EO1 (cetaceans and turtles) and needs to be aggregated to inform EO3-CI12. Further, data on stranding incidents are much more reported than bycatch, therefor it could be considered to assess an indicators on stranding incidents rather than bycatch for marine mammals and turtles.

162. Increasing sea temperature is affecting the distribution but also the fitness of commercially exploited species. It will affect also Maximum Sustainable Yield (MSY) used to calculate reference points. To ensure the sustainability of marine stocks it appears important to anticipate climate change impacts on fish community and perhaps target a smaller fishing mortality than F_{MSY}. This means that this reference point should be reconsidered regularly taking the environmental conditions in consideration. Modelled projections on future status of fisheries in projected environmental conditions and main threats would be useful to anticipate how and when MSY needs to be reconsidered.

163. The increasing sea temperature triggers expansion and instalment of NIS in the Mediterranean Sea. Integrating their assessment within EO3-CI9 could bring precious information on their instalment but also regarding the acceptance of such species in sub-regional seafood especially since some species are already assessed by GFCM.

6. Ecological Objective 4: food webs

6.1. General information on IMAP EO4 and MSFD D4 GES definition

164. This ecological objective focuses on interactions between predators and preys and their functional aspects. It has not yet been developed in indicators under IMAP, and although criteria have been defined under MSFD, food webs are still little assessed at a regional and sub-regional scale within EU MS.

165. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO4/D4 and GES determination under IMAP and MSFD can be found in Table 5.

Table 5: Relevant documents relative to GES definition for EO4/D4 and climate change effects on GES definition.

Marine food webs	
IMAP	**MSFD**
EO4 GES: "*Alterations to components of marine food webs caused by resource extraction or human-induced environmental changes do not have long-term adverse effects on food web dynamics and related viability.*"	D4 GES: *"All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity."*

Several documents refer to food webs as defined in MSFD:

ICES 2014. *Report of the Workshop to develop recommendations for potentially useful Food Web Indicators (WKFooWI)*, 31 March–3 April 2014, ICES Headquarters, Copenhagen, Denmark. ICES CM 2014\ACOM:48. 75 pp.

ICES 2015. *Report of the Workshop on guidance for the review of MSFD decision descriptor 4 – foodwebs II (WKGMSFDD4-II)*, 24-25 February 2015, ICES Headquarters, Denmark. ICES CM 2015\ACOM:49. 52 pp

Tam, J. C., Link, J. S., Rossberg, A. G., Rogers, S. I., Levin, P. S., Rochet, Marie-Jo€el., Bundy, A., Belgrano, A., Libralato, S., Tomczak, M., van de Wolfshaar, K., Pranovi, F., Gorokhova, E., Large, S. I., Niquil, N., Greenstreet, S. P. R., Druon, Jean-N., Lesutiene, J., Johansen, M., Preciado, I., Patricio, J., Palialexis, A., Tett, P., Johansen, G. O., Houle, J., and Rindorf, A., 2017. Towards ecosystem-based management: identifying operational food-web indicators for marine ecosystems. – *ICES Journal of Marine Science*, 74: 2040–2052

European Academies' Science Advisory Council (EASAC) & and the Joint Research Centre (JRC) of the European Commission. (2016). *Marine sustainability in an age of changing oceans and seas* (EASAC Policy Report No. 28; p. 60). Link

Piroddi, C., Teixeira, H., Lynam, C. P., Smith, C., Alvarez, M. C., Mazik, K., … Uyarra, M. C. (2015). Using ecological models to assess ecosystem status in support of the European Marine Strategy Framework Directive. *Ecological Indicators*, *58*, 175–191. doi: 10.1016/j.ecolind.2015.05.037

This last document shows that several models can be considered to assess D4 Criteria 1 to 3.

Effects of climate change and other cumulative pressures in GES determination

Marine food webs
MedECC, 2020 p. 346 states: "*It is expected that the ocean's primary production will, in general, be reduced with environmental change. As a result, production zones may be redistributed and the natural habitat of commercially valuable species of fish may change (Izrael 1991). On the other hand, climate change can also lead to changes in the composition of the bottom of marine food webs. The rise in water temperature has already increased jellyfish population outbreaks in the Mediterranean Sea, such as Pelagia noctiluca, a planktonic predator of fish larvae and of their zooplankton prey. The outbreaks of this species, along with other jellyfish species, may become more frequent in the Mediterranean Basin in the future and extend over a longer period of the year than previously, causing changes to the pelagic food web and thereby reducing fishery production (Licandro et al. 2010).*" Moreover, the increase and expansion of NIS in relation with warming Mediterranean Sea impacts natively ecosystems by disturbing their equilibriums and food webs (e.g. Mannino et al., 2018). Several pollutants enter marine food webs and accumulate through food chains. Castro-Jiménez et al. (2021) show that the characterised food web could be used as a biodinidcator of chemical pollutions Further, the toxicity of these pollutants may also be impacted by climate change and impact indirectly food webs.

166. **IMAP** defines GES for EO4 as: "*Alterations to components of marine food webs caused by resource extraction or human-induced environmental changes do not have long-term adverse effects on food web dynamics and related viability.*" No indicators have been defined yet but a desk review is currently undertaken which will support the development of EO4 food web indicators.

167. **MSFD** defines GES for D4 as: *"All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity."*

168. MSFD D4 is closely linked to Descriptors 1 and 6 as marine food webs can only be in a good state if marine species and habitats are healthy and in a good condition.

169. MSFD Descriptor 4 is based on four criteria:

D4C1 – Primary: The diversity (species composition and their relative abundance) of the trophic guild is not adversely affected due to anthropogenic pressures.

D4C2 – Primary: The balance of total abundance between the trophic guilds is not adversely affected due to anthropogenic pressures.

D4C3 – Secondary: The size distribution of individuals across the trophic guild is not adversely affected due to anthropogenic pressures.

D4C4 – Secondary (to be used in support of criterion D4C2, where necessary): Productivity of the trophic guild is not adversely affected due to anthropogenic pressures.

170. The assessment should include at least three trophic guilds, two shall be non-fish trophic guilds, and at least one shall be a primary producer trophic guild. The selected trophic guilds should represent at least the top, middle, and bottom of the food chain (see Commission Directive (EU) 2017/845 and Boschetti et al., 2021).

171. For each criteria, Member States shall establish threshold values through regional or sub-regional cooperation as requested by the Commission Directive (EU) 2017/845.

172. However, no TVs or methods have yet been agreed on or discussed through regional or sub-regional cooperation between EU MS (Vassilakopoulos et al., 2022). Only a few threshold values have been reported by MS in 2018 (Boschetti et al., 2021) but not from the Mediterranean MS.

6.2. Impediments and gaps identified in GES determination and assessment in a climate change context, and recommendations for way forward

173. IMAP defines GES for EO4 as "Alterations to components of marine food webs caused by *resource extraction or human-induced environmental changes do not have long-term adverse effects on food web dynamics and related viability.*"

174. Indicators for EO4 food webs have not yet been defined therefor impediments and gaps cannot be identified. However, the ecosystem approach calls for an integrated assessment of the Mediterranean Sea and further links between Ecological Objectives should be searched for. EO4 on food webs could play a major role in linking several aspects of IMAP. Indeed, food webs are linked to biodiversity (habitats and species), fisheries and undergo several anthropogenic pressures such as climate change impacts, NIS, plastic and eutrophication enrichment etc. EO4 could be designed to integrate and synthesize these aspects and perhaps link more the EOs between them as well as the spatial scales (see European Academies' Science Advisory Council (EASAC) & and the Joint Research Centre (JRC) of the European Commission, 2016).

175. Modelling approaches seems to be of interest to understand and identify indicators for food webs (e.g. Piroddi et al., 2015; Tam et al., 2017), therefor investigating this domain to define indicators seems essential. The importance of fish in marine food webs also calls for close cooperation with GFCM for these aspects.

6.3. Key messages

176. Within IMAP, indicators have not yet been defined to be able to assess GES

177. Work is currently ongoing to define indicators for this Ecological Objective.

178. Although Criteria have been defined within MSFD for Descriptor 4 on marine food webs, methods and threshold values have not yet been agreed on at regional or sub-regional level and no Mediterranean European country has reported national threshold values.

179. Modelling approaches seem to be useful to identify indicators for food webs therefor it is advised to consider such approaches for defining the pertinent indicators for this Ecological Objective.

180. EO4 food webs could play a major role in connecting several EOs and therefor reinforcing the ecosystem approach of IMAP. EO4 is linked to several EOs and should be developed in close relation with several EOs as well as with GFCM.

181. Impacts of climate change on food webs is unclear yet, but as climate change impacts biodiversity it will also impact food webs starting from impacting primary production.

7. Ecological Objective 5: Eutrophication

7.1. General information on IMAP EO5 and MSFD D5 GES definition

182. Marine eutrophication is an increased development of primary production, algal and plant growth, stimulated by an enrichment of nutrients (mainly nitrogen and phosphorus) under favourable physico-chemical conditions. It is dependent of many variables and environmental conditions that can be monitored. Marine eutrophication with impacts on ecosystems, species and human health occur generally in coastal, rather localized areas in the Mediterranean Sea as revealed by the EEA map on eutrophication although insufficient data is available for many areas.

183. In the Mediterranean Sea waters are generally oligotrophic (low in nutrients) with decreasing levels from Gibraltar to the Levantine Sea (MedECC, 2020). Several coastal hotspots of human induced nutrient inputs have nevertheless been identified such as for example the lagoons of Venice and Bizerte, the Gulf of Lions and Gabès, northern Aegean Sea, eastern Adriatic and western Tyrrhenian Sea, North Lake of Tunis, Algerian-Provençal Basin and the Gibraltar Strait (MedECC, 2020; Tsikoti & Genitsaris, 2021). Coastal areas such as ports, lagoons and enclosed bays are the most impacted by eutrophication impacts in the Mediterranean.

184. Nutrient enrichment may also contribute to the outbreak of harmful and toxic algal blooms that can cause negative impacts on ecosystems, represent economic threats for fisheries, aquaculture and tourism and harm human health when toxins are produced (MedECC, 2020).

185. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO5/D5 and GES determination under IMAP and MSFD can be found in Table 4.

Table 6: Relevant documents relative to GES definition for EO5/D5.

Eutrophication	
IMAP	**MSFD**
EO5 GES: *"Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters."*	D5 GES: *"Human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters."*
UNEP/MAP-MED POL. (2021a). *Monitoring Guideline for Reporting Monitoring Data for IMAP Common Indicators 13, 14, 17, 18 and 20* (Meeting Report No. UNEP/MED WG.509/33; p. 77). Link UNEP/MAP-MED POL. (2021b). *Monitoring Guidelines/Protocols for Analytical Quality Assurance for IMAP Common Indicators 13, 14, 17, 18 and 20* (Meeting Report No. UNEP/MED WG.509/32; p. 21). Link UNEP/MAP-MED POL. (2021c). *Assessment Criteria Methodology for IMAP Common*	Dos Santos Fernandes De Araujo, R., & Boschetti, S. (2021). *Marine Strategy Framework Directive Review and analysis of EU Member States' 2018 reports - Descriptor 5: Eutrophication* (JRC Technical Report No. JRC124915). Luxembourg: Publications Office of the European Union. Link Salas Herrero . M. F., Dos, S. F. D. A. R., Claussen, U., Leujak, W., Boughaba, J., Dellsae, J., … Poikane, S. (2020). *Physico-chemical supporting elements in coastal waters: Links between Water and Marine Framework Directives and Regional Sea*

Eutrophication	
IMAP	MSFD
Indicator 13: Pilot Application in Adriatic Sub-region (Meeting Report No. UNEP/MED WG.509/13; p. 21). Link UNEP/MAP-MED POL. (2019). *IMAP Guidance Factsheets: Update for Common Indicators 13, 14, 17, 18, 20 and 21; New proposal for Candidate Indicators 26 and 27* (Meeting Report No. UNEP/MED WG.473/7; p. 62). Link	*Conventions* (JRC Technical Report No. JRC121759). Luxembourg: Publications Office of the European Union. Phillips, G., Kelly, M., Teixeira, H., Salas, H. M. F., Free, G., Leujak, W., … Poikane, S. (2018). *Best practice for establishing nutrient concentrations to support good ecological status*. Link Stips, A., Macias, M. D., Garcia, G. E., & Miladinova-Marinova, S. (2016). *Alternative assessments of large scale Eutrophication using ecosystem simulations: Hind-casting and scenario modelling* (JRC Technical Reports No. EUR 27904). Luxembourg. Link

186. **IMAP Ecological Objective 5** is declined in two indicators. The GES definition of these indicators are:

EO5-CI13 – Concentrations of nutrients in the euphotic layer are in line with prevailing physiographic, geographic and climate conditions

EO5-CI14 – Natural levels of algal biomass in line with prevailing physiographic, geographic and weather conditions

187. **MSFD Descriptor 5** is declined in eight criteria with the following GES definitions:

D5C1 – Primary: Nutrient concentrations are not at levels that indicate adverse eutrophication effects.

D5C2 – Primary: Chlorophyll a concentrations are not at levels that indicate adverse effects of nutrient enrichment.

D5C3 – Secondary: The number, spatial extent and duration of harmful algal bloom events are not at levels that indicate adverse effects of nutrient enrichment.

D5C4 – Secondary: The photic limit (transparency) of the water column is not reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment.

D5C5 – Primary (may be substituted by D5C8): The concentration of dissolved oxygen is not reduced, due to nutrient enrichment, to levels that indicate adverse effects on benthic habitats (including on associated biota and mobile species) or other eutrophication effects.

D5C6 – Secondary: The abundance of opportunistic macroalgae is not at levels that indicate adverse effects of nutrient enrichment.

D5C7 – Secondary: The species composition and relative abundance or depth distribution of macrophyte communities achieve values that indicate there is no adverse effect due to nutrient enrichment including via a decrease in water transparency.

D5C8 – Secondary (except when used as a substitute for D5C5): The species composition and relative abundance of macrofaunal communities, achieve values that indicate that there is no adverse effect due to nutrient and organic enrichment.

188. For all indicators except D5C3, the threshold values (TVs) are: (i) in coastal waters, the values set in accordance with Directive 2000/60/EC; (ii) should this criterion be relevant for waters beyond coastal waters, values consistent with those for coastal waters under Directive 2000/60/EC. For all these indicators it is requested that Member States establish values through regional or sub-regional cooperation.

The hereafter table presents analogies between IMAP indicators and MSFD criteria concerning eutrophication.

IMAP EO5 Eutrophication	MSFD criteria
EO5-CI13 Concentration of key nutrients in water column	**D5C1**
EO5-CI14 Chlorophyll-a concentration in water column	**D5C2**
Not assessed through IMAP	**D5C3** on harmful algal blooms
Assessed within **EO5-CI14**	**D5C4** transparency
Assessed within **EO5-CI14**	**D5C5** on dissolved oxygen
Not assessed through IMAP	**D5C6** on opportunistic macroalgae
Not assessed through IMAP	**D5C7** on macrophyte communities
Not assessed through IMAP	**D5C8** on macrofaunal communauties

7.2. Elements for defining GES at indicator level in a climate change context

189. Monitoring eutrophication in the Mediterranean started under MED POL and was framed by the Eutrophication Monitoring Strategy (see UNEP(DEPI)/MED WG.231/14).

190. Several types of coastal waters in the Mediterranean have been defined characterized by their density and salinity (see UNEP/MAP, 2016a). Reference conditions and boundaries have been defined for each type of water (see UNEP/MAP, 2016a).

EO5 Eutrophication Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO5-CI13, EO5-CI14**
EO5-CI13 GES: Concentrations of nutrients in the euphotic layer are in line with prevailing physiographic, geographic and climate conditions (Nitrate, nitrite, ammonium, total phosphorus, orthophosphate, total nitrogen, silicate) **EO5-CI14 GES**: Natural levels of algal biomass (chlorophyll-a) in line with prevailing physiographic, geographic and weather conditions (Water temperature, salinity, conductivity, dissolved oxygen, pH, Secchi disk (transparency), Chlorophyll-a)
Specific monitoring guidance documents available to assess and monitor nutrients and chlorophyll-a → UNEP/MAP-MED POL. (2021b). *Monitoring Guidelines/Protocols for Analytical Quality Assurance for IMAP Common Indicators **13, 14,** 17, 18 and 20* (Meeting Report No. UNEP/MED WG.509/32; p. 21). → UNEP/MAP-MED POL. (2019). *IMAP Guidance Factsheets: Update for Common Indicators **13**, **14**, 17, 18, 20 and 21; New proposal for Candidate Indicators 26 and 27* (Meeting Report No. UNEP/MED WG.473/7; p. 62). Link → Dos Santos Fernandes De Araujo, R., Somma, F., Aigars, J., Axe, P., Bartolo, A., De, C. K., … Wilkes, R. (2019). *Eutrophication in marine waters: Harmonization of MSFD methodological standards at EU level* (JRC Technical Report No. JRC117109). Publications Office of the European Union. Link → A toolkit for determining phosphorus and nitrogen boundaries: Phillips, G., Kelly, M., Teixeira, H., Salas, H. M. F., Free, G., Leujak, W., … Poikane, S. (2018). *Best practice for establishing nutrient concentrations to support good ecological status* (JRC Science for Policy Report No. JRC112667). Publications Office of the European Union. Link → Salas Herrero, M. F., Dos Santos Fernandes De Araujo, R., Leujak, W., & Poikane, S. (2022). *Physico-chemical supporting elements in coastal waters: WFD-MSFD-RSC Links* (JRC Technical Report No. JRC128107). Publications Office of the European Union. Link → Salas, H. M. F., Dos, S. F. D. A. R., Claussen, U., Leujak, W., Boughaba, J., Dellsae, J., … Poikane, S. (2020). *Physico-chemical supporting elements in coastal waters: Links between Water and Marine Framework Directives and Regional Sea Conventions* (JRC Technical Report No. JRC121759). Luxembourg: Publications Office of the European Union. Link

EO5 Eutrophication
Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition
EO5-CI13, EO5-CI14

→ Mapping: Giorgetti, A., Partescano, E., Barth, A., Buga, L., Gatti, J., Giorgi, G., … Wenzer, M. (2018). EMODnet Chemistry Spatial Data Infrastructure for marine observations and related information. *Ocean & Coastal Management*, *166*, 9–17. doi: 10.1016/j.ocecoaman.2018.03.016

→ Stips, A., Macias, M. D., Garcia, G. E., & Miladinova-Marinova, S. (2016). *Alternative assessments of large scale Eutrophication using ecosystem simulations: Hind-casting and scenario modelling* (JRC Technical Reports No. EUR 27904). Luxembourg. Link

Concentration of nutrients and chlorophyll-a

Modelled spatial distribution of waterbody silicate, phosphate, dissolved oxygen concentration, dissolved inorganic nitrogen and chlorophyll-a for the Mediterranean Sea are available on EMODnet (see here) and time series of observation reprocessing are available through Copernicus (see here).

Several observatory systems to assess essential ocean variables including nutrients and chlorophyll-a, exist in the Mediterranean Sea (see Coppola et al;, 2019).

The European Environment Agency (EEA) published in 2020 a map of eutrophication "problem" and "non-problem" areas in European seas (available here) with a 20x20 km grid in coastal areas, though many Mediterranean areas lack of data.

At sub-regional level, assessment criteria have been developed for the Adriatic sub-region through a pilot application (see UNEP/MAP (2021c), *Assessment Criteria Methodology for IMAP Common Indicator 13: Pilot Application in Adriatic Sub-region*, (UNEP/MED WG.509/13) Link. Boundaries for Chlorophyll-a and total phosphorus (TP) for the Adriatic sub-region are also indicated relative to the type of coastal waters encountered in the sub-region.

Within IMAP, several methodologies are currently tested to assess CI 13 and 14 (see UNEP/MED WG.550/10 documents for MED QSR2023), the Ecological Quality Ratio (EQR) methodology when data quality permitted and simplified methodology based on G/M comparison (using threshold values defined for the Adriatic sub-region) based on satellite derived Chlorophyll-a.

Preparation documents for MED QSR 2023 relative to CI 13 and 14 indicate that few data have been submitted by the CPs and the overall sub-regional and Mediterranean assessment was mainly based on satellite derived data on Chlorophyll-a.

In the analysis of satellite derived data from different sensors, mainly negative trends of surface chlorophyll-a concentration from 1998 to 2019 have been reported for the Spanish Mediterranean Sea by Gómez-Jakobsen et al. (2022) with some localized exceptions. In this work seasonal trends have also been investigated.

France has published an assessment for Descriptor 5 on eutrophication for the French Western Mediterranean Sea where 99% of surface area of the French seas in the area have been assessed and are considered in GES (Lefebvre & Devreker, 2020). The authors indicate the threshold used (e.g. WFD threshold for coastal waters when existing) and based the assessment on D5C1 (nutrients in the water column), D5C2 (Chlorophyll-a in the water column), D5C5 (dissolved oxygen in the bottom of the water column).

EO5 Eutrophication
Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition
EO5-CI13, EO5-CI14

Based on *in situ* collection of nutrient data (including temperature and salinity) from 24 cruises and 870 stations throughout the NW Mediterranean, Belgacem et al. (2020) analyze the dissolved inorganic nutrients. Data were made available through Pangae but no relation with related policies has been made.

Eutrophication in Italian transitional waters was assessed using a multi-index method by Bonometto et al. (2022), were 35% of the investigated sites appear as eutrophic. This highlights the importance of considering assessment of eutrophication in river estuaries and lagoons that connect directly with coastal waters, within an ICZM approach (see Ferreira et al., 2011) and to consider basin-coastal approach in an integrated way. This has been done at the Mediterranean scale by Malagó et al., (2019), who investigate also different scenarios of basin nutrients loads and the correspondent reduction of inputs in coastal waters. Friedland et al. (2021) have shown, based on models, how a reduction of riverine nutrient inputs contribute to reduce marine nutrients as well.

Basin wide model based analysis of offshore anthropogenic nutrient concentration trends between 1950 and 2030 (Powley et al., 2018) are made difficult because of inter-annual variations creating a noise. The model though estimates that in the Eastern Mediterranean Sea, annual primary production should be more sensitive to changes of nutrient inputs by the surrounding land than the Western Mediterranean Sea.

Polimene at al. (2023) question whether the current traditional way of assessing eutrophication should be reconsidered. The authors remind that "*increased biomass, nutrient concentrations and oxygen demand do not lead to undesirable environmental effects if the flow of carbon/energy from primary producers toward high trophic levels is consistently preserved*". They suggest in consequence to evaluate eutrophication by using a new index based on plankton trophic fluxes instead.

Effects of climate change and other cumulative pressures in GES determination

Eutrophication is a complex process depending on multiple variables including nutrient inputs and environmental parameters such as sea temperature, water movements etc. Possible impacts of climate change on eutrophication could occur at different levels of the process and may cumulate or not. Climate change impacts on eutrophication appears unclear.

Recent research on the Po river, suggests that although temperature of water increases, nitrogen loads decreases (Gervasio et al., 2022) having an unexpected negative feedback between climate change and eutrophication. Similar results were obtained by models for the NW Mediterranean region based on regional climatic projections (Temino-Boes et al., 2021). Gervasio et al. (2022) underline that the resulting effects of climate change on ecosystem functioning remain unclear and highlight that there is a lack of research forecasting global warming effects on nitrogen cycling in rivers and nitrogen loads.

Gómez-Jakobsen et al. (2022) that studied a time series of more than 20 years of chlorophyll-a concentrations along the Spanish Mediterranean marine waters, suggest that climate change may impact phytoplankton phenology.

Harmful Algal Blooms (HAB) that cause ecosystem damage, economic losses and healthcare issues, occur in localized eutrophic areas (Marampouti et al., 2021; Tsikoti et al., 2021). Climate change appears to increase HABs by changing environmental conditions in coastal areas (Marampouti et al., 2021).

EO5 Eutrophication Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition EO5-CI13, EO5-CI14
Several publications propose management approaches and mitigation strategies for HABs as mentioned in the review article by Nwankwegu et al., 2019. Although the effects of climate-driven changes on the intensification of HABs are becoming increasingly clear, further understanding and prediction of HABs is needed (Gobler, 2020). Ocean circulation impacts eutrophication in coastal areas (e.g. Androulidakis et al., 2021 in the Northern Thermaikos Gulf, Greece). Climate change is susceptible of impacting ocean circulation (see De la Vara et al., 2022) but also atmospheric circulations which both could have effects on coastal eutrophication.

7.3. Impediments and gaps identified in GES determination and assessment in a climate change context, and recommendations for way forward

191. IMAP defines GES for EO5 as "Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters."

192. Better data access and threshold values are an issue underlined for the Mediterranean Sea by European Environmental Agency (2019) although it is believed that data exists at national level. However, few data have been submitted for MED QSR 2023. Lack of harmonised data and coherence of data acquisition protocols have also been identified as key issues limiting a common assessment of GES at regional and sub-regional scale by Giorgetti et al. (2018).

193. IMAP indicators and MSFD criteria on eutrophication present differences.

194. Variability of data acquisition methods, sensors, correction methods and data treatment are important in nutrient assessment (see Ferreira et al., 2011; Daniel et al., 2020; Salas Herrero et al., 2022) and efforts must be done to standardize protocols at least at sub-regional level.

195. Assessment of EO5 Eutrophication in marine and coastal waters, highlights the need to increase linkage between marine and terrestrial coastal areas which include transitional waters. Within the ICZM Protocol framework and MSP, increased linkage with other policies concerned could perhaps result in a better management of coastal marine eutrophication.

196. Frequency and spatial extension of Harmful Algal Blooms (HAB) (see e.g. Tsikoti & Genitsaris 2020) that can be linked to eutrophication, could possibly be an indicator of interest for IMAP. Such an indicator is followed in the MSFD under D5C3 for which GES is "The number, spatial extent and duration of harmful algal bloom events are not at levels that indicate adverse effects of nutrient enrichment." Monitoring networks already exist and could be used as a basis (e.g. see REPHYTOX for France).

197. The GES definition of CI13 "*Concentrations of nutrients in the euphotic layer are in line with prevailing physiographic, geographic and climate conditions*" would mean that under changing climatic conditions, TV and BV will have to be updated and adapted. Increasing temperature is probably one of the climate change factors that will have the most effect on eutrophication. Semi-closed areas, which are already more vulnerable to eutrophication (gulfs, ports, estuaries), could also undergo further increase in water temperature as well as less freshwater inputs and therefor further affect the relation between nutrient enrichment and eutrophication.

7.4.Key messages

198. In the Mediterranean Sea, a rather oligotrophic sea, eutrophication is a generally a localised, coastal threat.

199. The approach of "problem" and "non problem" areas adopted by EEA for European countries could be informative to apply at the entire Mediterranean Sea.

200. Although assessment criteria, baseline values, rules of integration and aggregation etc. have been agreed on for IMAP, there is still a lack of harmonised data, protocols and methods for EO5 eutrophication assessment limiting the possibilities of assessing GES at regional and sub-regional scale. Available data is an impediment to GES assessment.

201. Further integration between IMAP indicators on eutrophication and MSFD criteria could contribute to more reporting of European CPs to IMAP and better quality data. The analogy between indicators and criteria could be further developed.

202. Within IMAP, it could be considered to assess Harmful Algal Blooms (HAB) that can be in relation with eutrophication. Extent, duration and frequency of HABs could inform on vulnerable areas.

203. Climate change impacts sea temperature which increases and fresh water inputs will be decreasing. Therefore, semi-enclosed areas (e.g. lagoons, ports, gulfs) already vulnerable to eutrophication will be most probably further affected in climate change context. But GES definition of CI13 is relative to "*prevailing climate conditions*". As for other indicators this means that either threshold values or baseline values or both will have to be reconsidered regularly for GES to be attainable.

8. Ecological Objective 6: Seafloor integrity

8.1. General information on IMAP EO6 and MSFD D6 GES definition

204. This ecological objective focuses on seafloor. Indicators have not yet been developed under IMAP but work is ongoing and propositions have been done to be considered. Under MSFD the Descriptor 6 seafloor integrity has been defined through several criteria.

205. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO6/D6 and GES determination under IMAP and MSFD can be found in Table 7. These are mostly based on MSFD D6.

Table 7: Relevant documents relative to GES definition for EO6/D6 and climate change effects on GES definition.

Seafloor	
IMAP	**MSFD**
EO6 GES: "*Seafloor integrity is maintained, especially in priority benthic habitats.*"	D6 GES: "*Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.*"

Indicators of seafloor integrity

→ Guérin, L., & Lizińska, A. (2022). *Analysis of the main elements of the 'Good Environmental Status' from the 1st and 2nd MSFD cycles, reported by the European Member States for the Descriptor 6 (sea floor integrity)—Links with Regional Seas' Conventions and D4 (food webs integrity) and D5 (eutrophication)* (p. 53 pages + 26 pages d'annexes) [Report]. PatriNat (OFB-CNRS-MNHN). Link

→ Boschetti, S., Palialexis, A., & Connor, D. (2021). *Marine Strategy Framework Directive – Review and analysis of EU Member States' 2018 reports – Descriptor 6: Sea-floor integrity and Descriptor 1: Benthic habitats*. Link

→ ICES. (2019a). *EU request to advise on a seafloor assessment process for physical loss (D6C1, D6C4) and physical disturbance (D6C2) on benthic habitats*. Link

→ ICES Advisory Committee. (2019b). *Workshop on scoping for benthic pressure layers. D6C2—From methods to operational data product (WKBEDPRES1), 24-26 October 2018* (No. ICES CM 2018/ACOM:59; p. 69). ICES HQ, Copenhagen, Denmark. Link

→ ICES. (2019c). *Workshop on scoping of physical pressure layers causing loss of benthic habitats D6C1– methods to operational data products (WKBEDLOSS).* (ICES Scientific Reports No. 1:15; p. 37). Link

→ IDEM Project. (2019). *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* (p. 77) [IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project]. UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM. Link

→ Rice, J., Arvanitidis, C., Borja, A., Frid, C., Hiddink, J. G., Krause, J., … Norkko, A. (2012). Indicators for Sea-floor Integrity under the European Marine Strategy Framework Directive. *Ecological Indicators*, *12*(1), 174–184. doi: 10.1016/j.ecolind.2011.03.021

→ ICES. (2014b). *Introduction and general advice. EU request to ICES for review of the Marine Strategy Framework Directive: Descriptor 6_Seafloor integrity*. Link

Methodology for assessing impacts on benthic habitats

Seafloor	
IMAP	MSFD

→ Armelloni, E. N., Tassetti, A. N., Ferrà, C., Galdelli, A., Scanu, M., Mancini, A., … Scarcella, G. (2021). AIS data, a mine of information on trawling fleet mobility in the Mediterranean Sea. *Marine Policy*, *129*, 104571. doi: 10.1016/j.marpol.2021.104571

→ Jac, C., Desroy, N., Certain, G., Foveau, A., Labrune, C., & Vaz, S. (2020a). Detecting adverse effect on seabed integrity. Part 1: Generic sensitivity indices to measure the effect of trawling on benthic mega-epifauna. *Ecological Indicators*, *117*. doi: 10.1016/j.ecolind.2020.106631

→ Jac, C., Desroy, N., Certain, G., Foveau, A., Labrune, C., & Vaz, S. (2020b). Detecting adverse effect on seabed integrity. Part 2: How much of seabed habitats are left in good environmental status by fisheries? *Ecological Indicators*, *117*, 106617. doi: 10.1016/j.ecolind.2020.106617

→ Quemmerais-Amice, F., Barrere, J., La Rivière, M., Contin, G., & Bailly, D. (2020). A Methodology and Tool for Mapping the Risk of Cumulative Effects on Benthic Habitats. *Frontiers in Marine Science*, *7*. Link

See also section EO1 on benthic habitats

Effects of climate change and other cumulative pressures in GES determination

Since indicators have not yet been defined for EO6, it is here considered that EO6 GES "*Seafloor integrity is maintained, especially in priority benthic habitats*" will be based on assessment of seafloor disturbance by anthropogenic pressures and seafloor loss. The elements considered in EO1 on benthic habitats (chapter 3.) are pertinent also for EO6. Further, they are direct relations with other EOs especially with EO3 fisheries, EO7 hydrography and EO8 Coastal ecosystems and landscapes.

Climate change impacts will primarily impact benthic habitats GES assessed under EO1. This point has been discussed in chapter 3. for the habitats assessed. However, few benthic habitats are assessed under EO1. The list of habitats assessed should be extended to further assess seafloor integrity by including habitats undergoing severe disturbances (e.g. habitats under trawling pressure etc.).

Relatively to the loss of seafloor, relations can be made with EO8 to include artificialized coastline (see document on EO6 working document UNEP/MED WG.567/Inf.17 submitted to EcAp CG, 11th of September 2023) but will not be sufficient since e.g. marine platforms and sand extraction impacts are not assessed under EO8.

It is in the coastal areas that climate change impacts the most the seafloor, either directly (e.g. habitat degradation and loss) or indirectly (e.g. increase of coastal artificial structures on the littoral to protect from sea level rise and storms), but less known deep-sea habitats seem also to undergo climate change impacts (Sweetman et al., 2017).

206. **IMAP** defines GES for EO6 as: "*Seafloor integrity is maintained, especially in priority benthic habitats.*" No indicators have been defined yet but a document developing indicators is under process of validation by CORMONs to be submitted to UNEP/MAP CPs (see document UNEP/MED WG.567/Inf.17 submitted to EcAp CG, 11th of September 2023).

207. **MSFD** defines GES for D6 as: *"Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected."*

208. MSFD D6 is closely linked to Descriptors 1.

209. MSFD Descriptor 6 is based on five criteria:

D6C1 – Primary: Spatial extent and distribution of physical loss (permanent change) of the natural seabed.

D6C2 – Primary: Spatial extent and distribution of physical disturbance pressures on the seabed.

D6C3 – Primary: Spatial extent of each habitat type which is adversely affected, through change in its biotic and abiotic structure and its functions (e.g. through changes in species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), by physical disturbance. Member States shall establish threshold values for the adverse effects of physical disturbance, through regional or sub-regional cooperation.

D6C4 – Primary: The extent of loss of the habitat type, resulting from anthropogenic pressures, does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.

D6C5 – Primary: The extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions (e.g. its typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.

210. At EU level, it is required to define threshold values for D6C4 and D6C5 on the extent of adverse effects or loss and the level of adverse effects. They are currently being defined with propositions that have been made and are discussed.

8.2. Impediments and gaps identified in GES determination and assessment in a climate change context including recommendations for way forward

211. IMAP defines GES for EO6 as "*Seafloor integrity is maintained, especially in priority benthic habitats.*"

212. In the current situation GES for seafloor integrity is assessed only by EO1-C1 and EO2-C2 on few benthic habitats and partly through EO8-CI16 on physical disturbance and loss on coastal areas. Assessing GES for seafloor needs to be completed and work is ongoing to define indicators.

213. Difficulties encountered in MSFD with GES definition and threshold values should be taken in consideration for further defining the assessment of EO6.

214. It is suggested to develop EO6 in close relation with EO1-CI1 and EO1-CI2 as well as an eventual indicator on NIS/AIS impacts on benthic habitats, with EO3-CI10, EO4, EO5, EO8, EO9 and EO10 to contribute to cohesion between EOs and further reflect the integrative ecosystem approach within IMAP.

8.3. Key messages

215. Indicators to assess IMAP EO6 *seafloor integrity* are currently discussed but not yet agreed on.

216. Within MSFD, D6 *seafloor integrity* is defined by 5 criteria and thresholds are being defined currently for D6C4 and D6C5.

217. IMAP assesses benthic habitats through EO1 and includes indicators on distributional range and extent of habitat (that can be somewhat compared to D6C4) as well as condition of the habitat's typical species (that can be somewhat compared to D6C5). However, correspondence between IMAP and MSFD indicators/descriptors on habitats and seafloor integrity is unclear.

218. Climate change impacts benthic habitats and species and therefor will impact the *condition of the habitats* which can also result in *a loss* of habitat extent.

219. It is unclear if "anthropogenic pressures" referred to in MSFD criteria, include or not climate change. In IMAP EO6, depending on how indicators will be defined, such precisions would be of interest.

9. Ecological Objective 7: Hydrography

220. Human constructions along the coastline but also offshore impact the environment and change hydrological conditions at various scales. Such construction can create a loss of habitat but also an alteration due to changes in currents, turbidity, salinity, sea temperature and wave dynamics. Ecological Objective 7 on Hydrography is currently defined by one indicator (EO7-CI15) within IMAP that assesses the *Location and extent of habitats impacted directly by hydrographic alterations*.

9.1. General information on IMAP EO7 and MSFD D7 GES definition

221. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO7/D7 and GES determination under IMAP and MSFD can be found in Table 8.

Table 8: Relevant documents relative to GES definition for EO7 and D7.

Hydrography	
IMAP	**MSFD**
EO7 GES: "*Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.*"	D7 GES: *"Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems."*
Spiteri, C. (2015). *Guidance document on how to reflect changes in hydrographical conditions in relevant assessments* (p. 38). UNEP/MAP PAP/RAC. PAP/RAC. (2023). *2023 Quality Status Report (QSR) Content on IMAP Ecological Objectives (EO) 7 and 8. Contribution to the 2023 Med QSR for the cluster on Coast and Hydrography* (p. 37). Split: PAP/RAC. Link **See Annex A, EO7 for technical documents specifically related to parameters**	González, D., Coughlan, C., Stips, A., Stolk, C., González Pola, C., Moreno Aranda, I. M., … Krzyminski, W. (2015). *Review of the Commission Decision 2010/477/EU concerning MSFD criteria for assessing Good Environmental Status. Descriptor 7 Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems* (JRC Technical Reports No. JRC97721; p. 32). Link

222. **IMAP Ecological Objective 7** is defined by one indicator: *Location and extent of habitats impacted directly by hydrographic alterations*. The GES definition of this indicator is:

EO7-CI15 – Negative impacts due to new structure are minimal with no influence on the larger scale coastal and marine system.

223. **MSFD Descriptor 7** is declined in two secondary criteria with the following GES definitions:

D7C1 – Secondary: Spatial extent and distribution of permanent alteration of hydrographical conditions (e.g. changes in wave action, currents, salinity, temperature) to the seabed and water column, associated in particular with physical loss of the natural seabed.

D7C2 – Secondary: Spatial extent of each benthic habitat type adversely affected (physical and hydrographical characteristics and associated biological communities) due to permanent alteration of hydrographical conditions. Member States shall establish threshold values for the adverse effects of permanent alterations of hydrographical conditions, through regional or sub-regional cooperation.

224. **MSFD D7 is comparable to IMAP EO7 together with EO8, although detailed impact by habitat is not requested in IMAP.**

9.2. Elements for defining EO7 GES at indicator level in a climate change context

EO7 Hydrography Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO7-CI15**
EO7-CI15 GES : Negative impacts due to new structure are minimal with no influence on the larger scale coastal and marine system.
Specific monitoring guidance documents available to assess and monitor negative impacts due to new structure → Spiteri, C. (2015). *Guidance document on how to reflect changes in hydrographical conditions in relevant assessments* (p. 38). UNEP/MAP PAP/RAC. Link **Assessment of negative impacts due to new structures** Littoral habitats such as marine vegetation habitats can be affected by changes in hydrological conditions due to littoral constructions. Offshore platforms such as wind farms could potential change hydrological conditions sufficiently to impact the ecosystems but information is lacking (Galparsoro Iza et al., 2022). However, EO7-CI15 has been recently endorsed by the Offshore Oil and Gas Group (OFOG) to be assessed and monitored for offshore activities. A localised baseline assessment of EO7 in Montenegro throughout the GEF Adriatic Programme was done and the report is available here (PAP/RAC, UNEP/MAP, SPA/RAC, 2021). **Effects of climate change and other cumulative pressures in GES determination** Under climate change conditions, the number and strength of storms is expected to increase. The tropical-like *medicanes* create hydrographic alterations that can be strong but short-scale (Kassis & Varlas, 2021). Hydrological conditions are already changing under climate change impacts with an increase in sea temperature which in turn could impact thermohaline and surface circulations and further alter hydrographic conditions (Somot et al., 2018).

EO7 Hydrography Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO7-CI15**
PAP-RAC (2023), outlines the hydrographic alterations caused by climate change in the Mediterranean Sea. To face the increase of sea level and increased storm events due to climate change, it is probable that littoral constructions to protect populations and constructions will be done leading to an increase in manmade structure on the coastline (CI16) and changes in hydrography. Adverse effects on hydrography is expected due to climate change (Stein et al., 2019). Further development of coastal regions and development of blue economy will also contribute to increase coastal and offshore constructions and create hydrological alterations (European Commission, Directorate-General for Maritime Affairs and Fisheries (European Commission), & Joint Research Centre (European Commission), 2019).

9.3. Impediments and gaps identified in EO7 GES determination and assessment in a climate change context including recommendations for way forward

225. IMAP defines GES for EO7 as "*Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.*"

226. Although guidelines have been published to assess EO7, reporting is insufficient or even inexistent. Therefor GES cannot be assessed.

227. Baseline values have not yet been defined by non-EU Mediterranean countries, neither have threshold values even in EU MS. Without a baseline situation this indicator cannot be assessed.

228. Taking in consideration the insufficient reporting, the lack of baseline values and common monitoring strategies, the definition of this unique indicator in EO7 could be reconsidered or reformulated and perhaps simplified.

9.4. Key messages

229. Data reported are not sufficient to define baseline values and therefor assess GES.

230. Assessment of human induced hydrographic alterations and their impacts on ecosystems appears as inconsistent even in Mediterranean EU countries. Implementation of this EO7-CI15 indicator at national level and integration in coastal and marine plan as well as environmental assessment studies is needed.

231. Climate change impacts already alters hydrographical conditions by increasing Mediterranean Sea temperature which could also affect thermohaline and surface circulations in the Mediterranean Sea. Impacts of climate change on hydrographic alterations are important.

232. The overlap of EO7 assessment with Environmental Impact Assessment (EIA), Water Framework Directive, Strategic Environmental Assessment (SEA), MSP and ICZM brings perhaps confusion and could be redundant. Further integration and clearer interrelations could help support the assessment of EO7-CI15 indicator.

233. EO7-CI15 could perhaps be reconsidered and simplified or integrated in other Ecological Objectives such as EO1 on habitats and EO6 on seafloor integrity.

10.Ecological Objective 8: Coastal ecosystems and landscapes

10.1. General information on IMAP EO8 and MSFD D8 GES definition

234. Construction of structures (e.g. ports, break walls, jetties, structures to reduce erosion) along the coastline cause irreversible damage to landscape, loss of habitats and biodiversity and change shoreline configuration impacting natural dynamics of coastal zones. Therefore, monitoring the rate and spatial distribution of coastline artificialisation in the Mediterranean is of high importance. This will also contribute to better understand the impact of structures on the shoreline dynamics and hydrography (UNEP/MED WG.550/11).

235. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO8/D8 and GES determination under IMAP and MSFD can be found in Table 9.

Table 9: Relevant documents relative to GES definition for EO8 and D7.

Coastal ecosystems and landscapes	
IMAP	**MSFD**
EO8 GES: "*The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved.*"	D7 GES: *"Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems."*
UNEP/MAP - PAP/RAC. (2019). *Indicator guidance factsheets for EO7 and EO8 Coast and Hydrography Common Indicators 15, 16 and 25 (UNEP/MED WG.467/6)* (p. 32) [7th Meeting of the Ecosystem Approach Coordination Group]. Link **See Annex A, EO8 for technical documents specifically related to CIs**	González, D., Coughlan, C., Stips, A., Stolk, C., González Pola, C., Moreno Aranda, I. M., … Krzyminski, W. (2015). *Review of the Commission Decision 2010/477/EU concerning MSFD criteria for assessing Good Environmental Status. Descriptor 7 Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems* (JRC Technical Reports No. JRC97721; p. 32). Link

236. **IMAP Ecological Objective 8** is defined by one indicator common indicator: *Length of coastline subject to physical disturbance due to the influence of man-made structure*, and a candidate indicator on land use change. GES definition of this indicator is:

EO8-CI16 – Physical disturbance to coastal areas induced by human activities should be minimized.

EO8-CCI25 – Linear coastal development minimised, with perpendicular development being in balance with integrity and diversity of coastal ecosystems and landscapes. Mixed land-use structure achieved in predominantly man-made coastal landscapes.

237. For EO8-CI16, GES, targets and measures cannot be expressed quantitatively (as a threshold value) but due to country specific circumstances (socio-economic, cultural, and historical) should be defined by the countries themselves (UNEP/MED WG.467/6).

238. MSFD **Descriptor 7** is declined in two secondary criteria with the following GES definitions:

D7C1 – Secondary: Spatial extent and distribution of permanent alteration of hydrographical conditions (e.g. changes in wave action, currents, salinity, temperature) to the seabed and water column, associated in particular with physical loss of the natural seabed.

D7C2 – Secondary: Spatial extent of each benthic habitat type adversely affected (physical and hydrographical characteristics and associated biological communities) due to permanent alteration of hydrographical conditions. Member States shall establish threshold values for the adverse effects of permanent alterations of hydrographical conditions, through regional or sub-regional cooperation.

239. There is no direct analogy of EO8 with MSFD, but EO8-CI16 can be considered as included in D7C1.

240. In MSFD, no criteria corresponds to EO8-CCI25.

10.2. Elements for defining EO8 GES at indicator level in a climate change context

EO8 Coastal ecosystems and landscapes Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO8-CI16** **EO8-CCI25**
EO8-CI16 GES: Physical disturbance to coastal areas induced by human activities should be minimized with the operational objective that natural dynamics of coastal areas is maintained and coastal ecosystems and landscapes are preserved. (km of artificial coastline and % of total length of coastline, percentage (%) of natural coastline in the total coastline length) **EO8-CCI25 GES:** Linear coastal development minimised, with perpendicular development being in balance with integrity and diversity of coastal ecosystems and landscapes. Mixed land-use structure achieved in predominantly man-made coastal landscapes
<u>Specific monitoring guidance documents available to assess and monitor</u> → *UNEP/MAP - PAP/RAC. (2023). Definition of GES for the CI 16 "Length of coastline subject to physical disturbance due to the influence of human-made structures". Assessment criteria and the Guiding document for application of assessment criteria for the IMAP Common Indicator 16 (UNEP/MAP WG.549/6) (p. 27) [Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Coast and Hydrography].* Link → UNEP/MAP - PAP/RAC. (2023). *Upgraded Guidance Factsheet for Candidate Common Indicator 25 "Land cover change" – Rationale and background (UNEP/MAP WG.549/Inf.3)* (p. 34) [Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Coast and Hydrography]. Split: UNEP/MAP PAP/RAC.

EO8 Coastal ecosystems and landscapes
Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition
EO8-CI16
EO8-CCI25

→ UNEP/MAP-PAP/RAC (2015) *Pilot project in the Adriatic on testing the candidate common indicator « Land use change in the Mediterranean;* Link

Physical disturbance to coastal areas

MED QSR 2017 revealed that Italy has implemented the monitoring of this indicator at national level whereas France and Montenegro had assessed artificialisation of their coast but does not fully resemble CI16.

For CI16, definition of GES requires two sets of monitoring data (for comparison), it is country specific, but hasn't yet been defined by CPs (UNEP/MED WG.550/11). However, progress is ongoing with baseline data provided by 17 CPs for MED QSR 2023, which represents 57% of the total Mediterranean coastline (see UNEP/MED WG.550/11 and UNEP/MAP-PAP/RAC, 2023).

The approach used by Smiraglia et al., 2023 to assess coastal urbanisation in Italy is of great interest. The authors have evaluated land consumption at national, regional and municipal level which reveals an intense process of urbanisation in the first 1000 m, especially at less than 300 m from the coastline. Such an approach brings elements also for CCI25.

Land use change

A pilot assessment of EO8-CCI25 was done for the Adriatic sub-region including Low Elevation Coastal Zone (LECZ) assessment (see UNEP/MAP-PAP/RAC, 2023 and UNEP/MAP-PAP/RAC, 2015).

Effects of climate change and other cumulative pressures in GES determination

Two climate change effects will impact coastal areas in general including artificial coastline: sea level rising and extreme climatic events especially floods and storms.

These climatic risks might lead to additional artificialisation of the coastal rime to protect urbanised areas that are farther inland.

Sea level rising projections in the Mediterranean varies depending on the climate change scenario and will be variable across the Mediterranean. The NASA Sea level projection tool allows to visualise and download sea level projection data from IPCC Assessment Report for a given period and following selected warming scenario for over 50 points in the Mediterranean.

Such data could be of interest in the development of a coastal risk or vulnerability assessment for the Mediterranean coast taking also in consideration EO8-CCI25 on land use change.

10.3. Impediments and gaps identified in EO8 GES determination and assessment in a climate change context including recommendations for way forward

241. IMAP defines GES for EO8 as "*The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved*."

242. GES cannot be assessed currently for this ecological objective because of lack of data. However, baseline data has considerably increased for EO8-CI16 which should allow to evaluate GES for this indicator for the next assessment. CPs that have not submitted data on coastal artificialisation baseline data should be urged to do so. Further, it is the CPs that should define threshold values and if they are in GES for EO8. In consequence, it seems difficult to assess whether GES is attained or not at sub-regional and regional scale unless threshold values are decided at sub-regional and regional scale.

243. Climate change will impact Mediterranean coastline by rising sea level and increasing storms and floods which will probably lead to increasing man-made structures to protect infrastructure and societies along the coast but also farther inland. In such climate context, planning strategies and modelling future scenarios is important to anticipate impacts. Further integration of EO8 indicators CI16 but also CCI25 is needed with spatial planning and impact assessment.

244. CCI25 appears mature enough to be proposed as an indicator.

245. Several Indexes have been used relative to coastal risk or vulnerability in the Mediterranean basin (e.g., Vandarakis et al., 2021 and Komi et al., 2022 in Greece; Agharroud et al., 2023 in Mororcco). What could be of interest is to apply an index which identifies vulnerable/risk areas that evaluates potential effects of climate change with physical, environmental and socio-economic features. As suggested by Agharroud et al., 2023, such a tool could be easily integrated in ICZM and contribute to coastal community and biodiversity protection. This would also farther link IMAP with MSP and ICZM.

246. A parameter on the number and location of coastal foods could be interesting to consider in the context of climate change.

10.4. Key messages

247. Data reported are not sufficient to define baseline values for EO8-CI16 but progress is ongoing. Given the importance of EO8 with regard to increasing touristic interest of the Mediterranean area and the impacts of climate change that will affect coastal areas, CPs which have not submitted data are advised to do so.

248. GES for EO8 at sub-regional and regional scale cannot be assessed for the moment due to the lack of data, but also because threshold values and GES should be defined by each CP. Therefor to assess GES at sub-regional and regional scale, threshold values will have to be defined at sub-regional and regional and data aggregated.

249. Climate change impacts will result in important changes along the Mediterranean coastline either by direct impacts (erosion, sea level rise etc.), or by the increase in protective constructions to shelter from these impacts (e.g. dams, docks, boulders). These climate change impacts on coastal ecosystems are currently not assessed within IMAP. Identifying such vulnerable areas by defining a parameter within EO8 related to climate change impacts could be discussed.

11. Ecological Objective 9: Pollution

11.1. General information on IMAP EO9 and MSFD D8 and D9 GES definitions

250. IMAP Ecological Objective 9 corresponds to MSFD Descriptor 8 Contaminants and Descriptor 9 Contaminants in seafood.

251. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO9/D8 and D9 and GES determination under IMAP and MSFD can be found in Table 10.

Table 10: Relevant documents relative to GES definition for EO9, D8 and D9.

Pollution	
IMAP	**MSFD**
EO9 GES: "*Contaminants cause no significant impact on coastal and marine ecosystems and human health.*"	D8 GES: "*Concentrations of contaminants are at levels not giving rise to pollution effects.*" D9 GES: "*Contaminants in fish and other seafood for human consumption do not exceed levels established by Union legislation or other relevant standards.*"
UNEP/MAP. (2017a). *IMAP Common Indicator Guidance Facts Sheets (Pollution and Marine Litter) (UNEP(DEPI)/MED WG.439/12)* (p. 75) [Meeting of the MED POL Focal Points]. Link UNEP/MAP. (2017b). *Pollution Assessment Criteria and Thresholds (UNEP(DEPI)/MED WG.444/12)* (p. 22) [6th Meeting of the Ecosystem Approach Coordination Group]. UNEP/MAP. Link	Tornero Alvarez, M. V., Boschetti, S., & Hanke, G. (2021). *Marine Strategy Framework Directive - Review and analysis of EU Member States' 2018 reports - Descriptor 8: Contaminants in the environment - Descriptor 9: Contaminants in seafood* (JRC Technical Report No. JRC124588). Luxembourg: Publications Office of the European Union. Link Tornero Alvarez, M. V., Hanke, G., Haber, A., Kuenitzer, A., Mauffret, A., Munch, C. A., … Leon, V. (2021). *Guidance on potential exclusion of certain WFD priority substances from MSFD monitoring beyond coastal and territorial waters* (JRC Technical Report No. JRC124593). Luxembourg: Publications Office of the European Union. Link Mauffret, A., Bajt, O., Bellas, J., Chalkiadaki, O., Dassenakis, M., Giannoudi, L., … Zeri, C. (2019). *Report on the approaches implemented in the Mediterranean countries for GES descriptor 8 Proposition of a road map for a better harmonization* (p. 72). MEDCIS project (Support Mediterranean Member States towards

Pollution	
IMAP	MSFD
	coherent and Coordinated Implementation of the second phase of the MSFD). Link

252. IMAP **Ecological Objective 9** is declined in five indicators. The GES definitions, Operational objectives of these indicators have been agreed on (see latest update UNEP/MED WG.473/7 and UNEP/MED WG.482/21) and are as follows:

EO9-CI17 – Level of pollution is below a determined threshold defined for the area and species. Operational Objective: Concentration of priority contaminants is kept within acceptable limits and does not increase.

EO9-CI18 – Concentrations of contaminants are not giving rise to acute pollution events. Operational Objective: Effects of released contaminants are minimized.

EO9-CI19 – Occurrence of acute pollution events is reduced to the minimum. Operational Objective: Acute pollution events are prevented and their impacts are minimized.

EO9-CI20 – Concentrations of contaminants are within the regulatory limits for consumption by humans. Operational Objective: Levels of known harmful contaminants in major types of seafood do not exceed established standards.

EO9-CI21 – Concentrations of intestinal enterococci are within established standards. Operational Objective: Water quality in bathing waters and other recreational areas does not undermine human health.

253. **MSFD Descriptor D8** on contaminants includes two primary and two secondary criteria as follows:

D8C1 – Primary: Within coastal and territorial waters, the concentrations of contaminants do not exceed the following threshold values:

(a) for contaminants set out under point 1(a) of criteria elements, the values set in accordance with Directive 2000/60/EC;
(b) when contaminants under point (a) are measured in a matrix for which no value is set under Directive 2000/60/EC, the concentration of those contaminants in that matrix established by Member States through regional or sub-regional cooperation;
(c) for additional contaminants selected under point 1(b) of criteria elements, the concentrations for a specified matrix (water, sediment or biota) which may give rise to pollution effects. Member States shall establish these concentrations through regional or sub-regional cooperation, considering their application within and beyond coastal and territorial waters.

254. Beyond territorial waters, the concentrations of contaminants do not exceed the following threshold values:

(a) for contaminants selected under point 2(a) of criteria elements, the values as applicable within coastal and territorial waters;
(b) for contaminants selected under point 2(b) of criteria elements, the concentrations for a specified matrix (water, sediment or biota) which may give rise to pollution

effects. Member States shall establish these concentrations through regional or sub-regional cooperation.

D8C2 – Secondary: The health of species and the condition of habitats (such as their species composition and relative abundance at locations of chronic pollution) are not adversely affected due to contaminants including cumulative and synergetic effects. Member States shall establish those adverse effects and their threshold values through regional or sub-regional cooperation.

D8C3 – Primary: The spatial extent and duration of significant acute pollution events are minimized.

D8C4 – Secondary (to be used when a significant acute pollution event has occurred): The adverse effects of significant acute pollution events on the health of species and on the condition of habitats (such as their species composition and relative abundance) are minimized and, where possible, eliminated.

255. Guidance for threshold methods for D9C1 are available from the Water Framework Directive, no guidance is available for D8C2 and D8C3 and C4, no threshold value is requested.

256. **MSFD D9 on contaminants in seafood** which corresponds to EO9-CI20 is defined by one criterion as follows:

D9C1 – Primary: The level of contaminants in edible tissues (muscle, liver, roe, flesh or other soft parts, as appropriate) of seafood (including fish, crustaceans, molluscs, echinoderms, seaweed and other marine plants) caught or harvested in the wild (excluding fin-fish from mariculture) does not exceed:

(a) for contaminants listed in Regulation (EC) No 1881/2006, the maximum levels laid down in that Regulation, which are the threshold values for the purposes of this Decision;

(b) for additional contaminants, not listed in Regulation (EC) No 1881/2006, threshold values, which Member States shall establish through regional or sub-regional cooperation.

257. Guidance for methods and threshold values are available in Food Regulation 1881/2006.

The following table presents the analogies between IMAP indicators, MSFD criteria and other EU regulations

IMAP Indicators	MSFD criteria/Other EU regulation	Assessment objective
EO8-CI17	D8C1 Water Framework Directive	Assessment of contaminants in seawater, sediment and biota
EO8-CI18	D8C2	Assessment of adverse effects of contaminants on species
EO8-CI19	D8C3	Assessment of acute pollution events
EO8-CI20	D9C1 Food Regulation 1881/2006	Assessment of contaminants in seafood
EO8-CI21	Bathing Water Directive (2006/7/EC)	Assess water quality in bathing waters

11.2. Elements for defining EO9 GES at indicator level in a climate change context

258. Common Indicator 17, CI18 and CI20 concern contaminants either by assessing their concentration directly in different matrixes, or by assessing their effects on biota (CI18).

259. Common Indicator 19 concerns acute pollution events and CI21 water quality in bathing waters.

a) Contaminant and contaminant effects assessment

EO9 Pollution Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO9-CI17 in sediment, water column and biota** **EO9-CI18 in biota** **EO9-CI20 in crustaceans, bivalves, fish**
EO9-CI17 GES: Level of pollution is below a determined threshold defined for the area and species. **Marine biota:** Trace/Heavy Metals (TM): Total mercury (HgT), Cadmium (Cd) and Lead (Pb) Organochlorinated compounds (PCBs, Hexachlorobenzene, Lindane and *Σ*DDTs) Polycyclic Aromatic Hydrocarbons (PAHs) **Marine sediments:** In coastal and marine areas, continental platform and offshore, sediments should be collected by mechanical means and processed at the laboratory (< 2 mm particle size fraction). Further the following hazardous substances should be measured:Trace/Heavy Metals: Total mercury (HgT), Cadmium (Cd) and Lead (Pb), Organochlorinated compounds (PCBs (at least, congeners 28, 52, 101, 118, 138, 153, 180, 105 and 156) , aldrin, dieldrin, Hexachlorobenzene, Lindane and *Σ*DDTs)Polycyclic Aromatic Hydrocarbons (PAHs) **Seawater:** The monitoring and assessment of contaminants in seawater samples collected in coastal, marine and open-sea areas presents specific challenges and higher costs. For the mid/longterm monitoring programmes, such as IMAP, these are recommended to be carried out on a country decision basis. **EO9-CI18 GES: Concentrations of contaminants are not giving rise to acute pollution events.** Assessment of biomarkers namely, Acetylcholinesterase activity (AChE), Lysosomal membrane stability (LMS) and Micronuclei frequencies (MN) on first instance **EO9-CI20 GES: Concentrations of contaminants are within the regulatory limits for consumption by humans.**
Specific monitoring guidance documents available to assess and monitor pollution by heavy metals, organochlorinated compounds and Polycyclic Aromatic Hydrocarbons (PAHs): → UNEP/MAP-MED POL. (2021a). *Monitoring Guideline for Reporting Monitoring Data for IMAP Common Indicators 13, 14, 17, 18 and 20* (Meeting Report No. UNEP/MED WG.509/33; p. 77). Link → UNEP/MAP-MED POL. (2019). *IMAP Guidance Factsheets: Update for Common Indicators 13, 14, 17, 18, 20 and 21; New proposal for Candidate Indicators 26 and 27* (Meeting Report No. UNEP/MED WG.473/7; p. 62). Link

EO9 Pollution Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO9-CI17 in sediment, water column and biota** **EO9-CI18 in biota** **EO9-CI20 in crustaceans, bivalves, fish**
✓ EU 1881/2006. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. European Commission. Link **Assessment of contaminants** Chemical contamination mainly originates from land-based sources consequently they are more important in coastal waters and near industrialised and urbanised areas which represent contaminant hot spots. EMODnet has mapped and modelled several pollutants relevant to CI17 in biota, water body and sediments in the Mediterranean. Data and maps are available here: Link. See also Giorgetti et al. (2018). The European Environment Agency, (22/08/2022) has published a series of maps with hazardous substances in marine organisms in European seas including the Mediterranean underlining the high concentrations of certain polychlorinated biphenyls (PCBs) and other hazardous substances in the assessed areas of the Mediterranean Sea. Link. The report EEA (2018) presents maps of problem/non-problem areas relative to concentration of contaminant in seawater, sediments and biota for European countries of the Mediterranean Sea. Problem areas are above politically agreed threshold values and represent 87.3%[4] of the assessed areas in the Mediterranean Sea (EEA, 2019)). Through the GEF Adriatic Project, EO9 (excluding CI18 on toxicological effects) has been assessed at national level and constitutes an example of how EO9 can be assessed at national level (see GEF Adriatic Project. (2021). *Towards a Marine Good Environmental Status (GES) in Montenegro. Assessment of Contaminants (EO9)* (p. 40). UNEP/MAP, PAP/RAC, SPA/RAC, Ministry of Ecology, Spatial Planning and Urbanism of Montenegro. Link). Several publications have studied local pollution in seawater (e.g. Sakellari et al., 2021 in the Saronik Gulf), in sediments (e.g. Pitacco et al., 2021; Bonamano et al., 2021 both in the Tyrrhenian Sea) and in biota and pelagic food webs(e.g. Castro-Jiménez et al., 2021 in the NW Mediterranean pelagic food web; Impellitteri et al., 2023 on fish and invertebrate physiology) and overviews of sediment pollution in the Mediterranean Sea have been conducted by Merhaby et al. (2019) and Gómez-Gutiérrez et al. (2007). **Assessment of contaminant effects on biota through biomarkers** High or long term exposure of biota to contaminants are toxic and will create a reaction in the organisms. Assessing biomarkers informs on the impacts of contaminants on species. Several biomarkers exist and will inform on different toxic elements. Bivalves are often used as sentinel organisms to assess biomarkers being filter feeders and frequently available organisms. Biomarker assessment in mussels have been carried out by e.g. Zorita et al., 2007 in the NW Mediterranean, Mitrić & Ramšak 2021 in the Adriatic. An overview and state of the art in terms of pollution biomarkers used within the framework of MSFD is presented by Lionetto et al. (2021). The authors underline the interest of such

[4] The NEAT tool used to classify the areas uses the precautionary approach based on the "one out, all out" principle when integrating indicators.

EO9 Pollution Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO9-CI17 in sediment, water column and biota** **EO9-CI18 in biota** **EO9-CI20 in crustaceans, bivalves, fish**
tools for environmental assessment monitoring but also the assessment of health status of species at risk. They also emphasise the need for further research in this field. **Assessment of contaminants in seafood** Fliedner et al. (2018) have assessed seafood contamination of the German environmental specimen bank and have found that over 30 years, contaminants were well below the maximum levels allowed for human consumption. Although these did not come from Mediterranean Sea, using such sample banks retrospectively could be of interest for assessing contaminants in seafood and eventually identifying areas of risk and for retrospective analysis of currently unknown or unassessed compounds (see e.g. Chaplow et al., 2021). Several studies have been led in localised areas (e.g. Ramon et al., 2021 for the south-eastern Mediterranean Sea; Kuplulu et al., 2018 in the Black, Marmara and Aegean Seas; Sala et al., 2022 in the north-western Mediterranean) and concentrations of contaminants were, in the great majority, under the maximum levels allowed. Where data exists and studies have been led in the Mediterranean Sea, results show that levels of known harmful contaminants in seafood, do not exceed established standards. **Effects of climate change and other cumulative pressures in GES determination** The release, degradation, transport and evolution of pollutants could be enhanced by climate change impacts such as increased temperatures and extreme events (Kibria et al., 2021). Further, the toxicity of several pollutants may increase with increasing levels of climate change stressors (Kibria et al., 2021), the effects of contaminants on biota could change under future climate scenarios. A review on the effects of temperature rise due to climate change on the toxicity of metals for freshwater organisms reveals that in 80% of the studies analysed, a temperature rise was responsible for increasing toxicity of metals for the aquatic organisms (Nin & Rodgher, 2021). Pollution by plastic seems to play a role in the transport of different elements including contaminants. It is able to concentrate metal at much higher levels than in surrounding waters and could therefor exerting the toxicity for marine biota (Squadrone et al., 2022). Pathogen contamination of filter feeders represents a biological risk but also a public health concern–when affecting consumed bivalves. Concentration of microbial pathogens in consumed marine bivalves show a positive correlation with increase of sea temperature (Zgouridou et al., 2021). Currently, microbial loads are not included in the IMAP assessment of contaminants in seafood and could represent a new parameter of interest to assess in warming sea temperatures context.

b) Acute pollution events

EO9 Pollution Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO9-CI19**
EO9-CI19 GES: Occurrence of acute pollution events is reduced to the minimum.

Oil and Hazardous and Noxious Substances (HNS)

Specific monitoring guidance documents available

→ UNEP/MAP, REMPEC, & IMO. (2021). *IMAP Guidance Fact Sheets: Common Indicators 6 and 19 (REMPEC/WG.51/9/1)* (p. 26) [Fourteenth Meeting of the Focal Points of the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC)].

→ At European level there is currently no consistent spill reporting framework (REMPEC, 2020).

→ Interpol. (2007). *Interpol illegal oil discharges from vessels investigative manual.* Assessment methods in this manual are of interest.

Acute pollution events assessment

The assessment of acute pollution events is mainly based on the reports under Prevention and Emergency Protocol and the International Maritime Organization (IMO) coordinated by REMPEC. Data is accessible through MEDGIS-MAR.

The document REMPEC (2022) dresses a parallel between EO9-CI19 and MSFD criteria. It discusses elements and thresholds to define “acute pollution events” and gives recommendations regarding the definition and the elements that should be considered when declaring these events.

Polinov et al. (2021) have aggregated data on oil spills in the Mediterranean Sea and present spatial and temporal assessment. The authors conclude that an open-access database of oil spills that could be based on reporting but also on remote sensing acquisition methods is needed.

Accidental pollution by ships in the Mediterranean shows a downward trend (Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea, 2021). No threshold value can be defined for CI19 but the decreasing trend observed in the occurrence of accidental pollution by ships, could be considered as an important element to consider that the Mediterranean Sea is in GES for CI19.

However, illicit discharges from ships are much more difficult to assess and consequently are little reported (see REMPEC/WG.52/8. This source of pollution represents a long term threat to marine biodiversity (Topouzelis et al., 2006). Current methods of surveillance include Remotely Piloted Aircraft Systems (RPAS), manned aerial means, Automatic Identification System (AIS), Maritime Traffic Live Ships Map but also satellite mapping (Topouzelis et al., 2006) and semi-automatic detection systems based on Earth Observation data (e.g. Blondeau-Patissier et al., 2023).

Effects of climate change and other cumulative pressures in GES determination

Acute pollution events are mainly in relation with the maritime traffic increase and the number of coastal industries, less of climate change impacts. However, the increasing frequency of extreme climatic events in the Mediterranean Sea could contribute to some extent to an increase in accidental pollution events either from vessels, platforms or industries implemented along the coast or along main rivers that can undergo recurrent flooding events.

Kibria et al. (2021) suggest that toxicity of several high-risk pollutants may increase with increasing levels of climate stressors.

On the other hand, the toxicity of the chemical products discharged in the sea may vary under changing climate change conditions. This is a additional reason to consider assessing the effects of acute pollution on biota in areas impacted by such pollutions.

c) Water quality in bathing waters

EO9 Pollution Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO9-CI21**
EO9-CI21 GES: Concentrations of intestinal enterococci are within established standards. Intestinal enterococci
Specific monitoring guidance documents available → World Health Organization, 2021 *Guidelines on recreational water quality. Volume 1: Coastal and fresh waters*. Geneva. Link → Criteria and Standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol (IG 20/9), 2012 Link → Directive 2006/7/EC concerning the management of bathing water quality and repealing Directive 76/160/EEC. (2006). Link **Water quality in bathing areas** European bathing water quality for 2022 can be found in a brief publication of EEA here. Bathing water quality in Europe in 2022 more than 85.6% of bathing water sites were of excellent quality. A hydrodynamic model was applied to the Adriatic Sea to better understand the transport and diffusion dynamic of *Escherichia coli* (Ferrarin et al., 2021). At Mediterranean Sea level, no document was found integrating water quality assessments of all the Mediterranean countries on water quality. The water quality of several non-European countries can be found by searching journals but data is scattered (e.g. Tunisia where 71% of the Tunisian beaches have good quality for swimming in 2022, Israel were 92.4% of the beaches were rated clean in June 2023 according to local journals). Ecolabels such as the blue flag for European beaches seems to be a good indicator of water quality and enhances efforts for maintaining good water quality (see Merino et Prats, 2022 for NW Mediterranean). Tselemponis et al. (2023) resorted to modelling and machine learning to assess the quality of coastal waters concerning *Escherichia coli* concentration in NE Greece taking in consideration several variable including meteorological parameters. Although further research is need and the use of multiple methods recommended, the results of this study were considered satisfactory. Foreseeing the limitation of typical indicators for bathing water quality assessment, Rodrigues & Cunha (2017) present a critical literature review of the traditional and innovative methodologies for the analysis of faecal indicators in recreational waters. **Effects of climate change and other cumulative pressures in GES determination** Changing environmental conditions under climate change context is affecting microbial contamination of coastal waters. This will likely require to develop water quality indicators

beyond the current ones used, to guarantee water quality of bathing areas (Rodrigues & Cunha, 2017; Brandão et al., 2022).

Climate change has intensified the frequency and the intensity of storms leading to more frequent water runoffs which are a source of water quality degradation in coastal waters (Manini et al., 2022). Such events contribute to spatially localised increase in intestinal enterococci concentration.

Increase of water temperatures triggers the development of microbial concentration and their diversity in bathing waters, therefor it is important to make sure that the indicator used (intestinal enterococci) is sufficient to assess bathing water quality.

Further, the increase of storm intensity and frequency under climate change context affects the frequency of acute microbial pollution events leading to closing the access to beaches.

11.3. Impediments and gaps identified in EO9 GES determination and assessment in a climate change context, including recommendations for way forward

260. IMAP defines GES for EO9 as "*Contaminants cause no significant impact on coastal and marine ecosystems and human health.*"

Relatively to EO9-CI17, CI18, CI20

261. Improvement in monitoring activities in the Mediterranean Sea regarding EO9-CI17 and CI18 is needed also regarding offshore coverage. Little data is available for non-European countries making GES difficult to assess for EO9 at regional and sub-regional level. Enforcement and compliance of policies relative to the assessment of contaminants and contaminant sources is needed. A review and reduction of the number of elements to assess, or a classification in terms of importance, could perhaps be considered.

262. Little is known on the cumulated effects of climate change and pollutants, research is needed to understand and foresee the interactions of these anthropogenic threats and their cumulated impacts on marine ecosystems and seafood. This will contribute to better define GES for EO9.

263. MedECC (2020) informs that emerging contaminants (related to recently discovered chemicals or materials) are enhanced by increasing flow of untreated wastewater in the Mediterranean which may cause physiological disorders. It is therefore important to regularly update the list of contaminants assessed within CI17, CI19 and CI20.

264. Concerning seafood (EO9-CI20), microbial loads of consumed marine bivalves seem to be in correlation with sea temperature (Zgouridou et al., 2022). Pathogen contamination of filter feeders represents a biological risk but also a public health concern-when affecting consumed bivalves. Currently, microbial loads are not assessed through IMAP CI20 on contaminants in seafood and could represent a new parameter of interest to assess in warming sea temperatures context.

Relatively to EO9-CI19

265. Monitoring of EO9-CI19 on acute pollution events is relatively feasable and available at national level but there is little reporting. Perhaps reporting can be simplified.

266. The impacts of acute events on biota is not assessed within IMAP. This could be an indicator to consider adding, so as to better assess EO9 GES "*Contaminants cause no significant impact on coastal and marine ecosystems and human health"*. It could be considered also to assess CI18 specifically in areas with high risk of acute pollution events in addition of regular sampling areas. Assessing CI17 in biota could also be considered in the same conditions.

Relatively to EO9-CI21

267. Increased measurements of CI21 is needed to assess GES (see MED QSR, 2017). Data for European countries are available through European Environmental Agency but no publication was found collating data of the Mediterranean Sea countries.

11.4. Key messages

268. Awareness on pollution of the Mediterranean Sea has clearly increased and efforts have been made by all countries to better control the sources which results in a decrease of some contaminants but not all (see EEA, 2020). Several contaminants show high concentrations values (e.g. PCBs) in the assessed areas of the Mediterranean Sea (EEA, 2020). Overall, problem areas which include at least on parameter above politically agreed threshold values, represent over 87% of the assessed areas in the Mediterranean Sea (EEA (2019).

269. Important efforts are still needed in monitoring contaminants and their effects in coastal and offshore areas to be in the capacity of assessing GES at sub-regional and regional scale.

270. Persisting efforts to integrate marine contaminant assessment with LBS Protocol, ICZM and MPS will contribute to better understand relations between drivers, activities, pressures, sources and impacts on marine environment and acquire data.

271. Background Assessment Criteria, Environmental Assessment Criteria and methodology for GES assessment of EO9 Pollution are clearly defined in most cases, but Background Concentration are in majority not yet agreed on at sub-regional level for CI17.

272. Little data is available on combined effects of climate change stressors and pollutants.

273. Little data is available concerning effects of contaminants on biota (CI18). With the increase of sea temperature, it is foreseen that the toxicity of contaminants will increase.

274. Elements to assess GES on Pollution are quite similar between IMAP and MSFD although partitioned differently. However, impacts of acute pollution events on biota are not assessed in IMAP whereas they are in MSFD. Such an assessment could be consider for IMAP.

275. Where data exists and studies have been led in the Mediterranean Sea, results show that levels of assessed harmful contaminants (chemical contaminants) in seafood, do not exceed established standards.

276. Currently, microbial loads are not included in the IMAP assessment of contaminants in seafood (CI20) and could represent a new parameter of interest to assess in warming sea temperatures context and associated probability of increased pathogen development in concentration and diversity.

277. Bathing water quality (CI21) has improved (see EEA publication of 9/06/2023 Link and Jozić et al., 2021) with nearly 89% of EU coastal bathing sites classified as excellent. There is a lack of available data from the southern part of the Mediterranean Sea which hinders GES assessment for this indicator at regional level.

278. For CI21, the number and frequency of closed beaches for microbial contamination could also be considered as an indicator which would be easy to assess.

279. Given the positive trend of seawater temperatures, monitored contaminants for CI21 (and CI20 if pathogens are included) should be regularly reviewed and updated with the research findings on the subject.

12. Ecological Objective 10: Marine litter

12.1. General information on IMAP EO10 and MSFD D10 GES definitions

280. IMAP Ecological Objective 10 as MSFD Descriptor 10, concerns the assessment of marine litter.

281. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO10/D10 and GES determination under IMAP and MSFD can be found in Table 11.

Table 11: Relevant documents relative to GES definition for EO10 and D10.

Marine litter	
IMAP	**MSFD**
EO10 GES: "*Marine and coastal litter do not adversely affect coastal and marine environment.*"	D10 GES: *"Properties and quantities of marine litter do not cause harm to the coastal and marine environment"*
UNEP/MAP. (2017a). *IMAP Common Indicator Guidance Facts Sheets (Pollution and Marine Litter) (UNEP(DEPI)/MED WG.439/12)* (p. 75) [Meeting of the MED POL Focal Points]. Link	Fleet, D., Vlachogianni, T., & Hanke, G. (2021). *A Joint List of Litter Categories for Marine Macrolitter Monitoring* (JRC Scientific and Technical Reports No. EUR 30348; p. 55). Luxembourg: Publications Office of the European Union. Link Ruiz, O. S. P. L., Tornero, A. M. V., Boschetti, S., & Hanke, G. (2021). *Marine Strategy Framework Directive - Review and analysis of EU Member States' 2018 reports - Descriptor 10: Marine litter.* Link Werner, S., Fischer, E., Fleet, D., Galgani, F., Hanke, G., Kinsey, S., & Mattidi, M. (2020). *Threshold values for marine litter. General discussion paper on defining threshold values for marine litter* (JRC Technical Reports No. EUR 30018 EN; p. 27). Luxembourg. Link Hanke, G., Galgani, F., Werner, S., Oosterbaan, L., Nilsson, P., Fleet, D., … Liebezeit, G. (2014). *Guidance on Monitoring of Marine Litter in European Seas*. Link MSFD Technical Group on Marine Litter. (2013). *Guidance on Monitoring of Marine Litter in European Seas. A guidance document within the Common Implementation Strategy for the Marine*

Marine litter	
IMAP	MSFD
	Strategy Framework Directive (JRC Scientific and Policy Reports No. EUR 26113 EN; p. 128). Luxembourg: European Commission. Link

282. **IMAP Ecological Objective 10** is declined in two common indicators and one candidate indicator. The GES definitions and operational objectives of these indicators have been agreed on and are as follows:

EO10-CI22 – Number/amount of marine litter items on the coastline do not have negative impact on human health, marine life and ecosystem services. Operational Objective: The impacts related to properties and quantities of marine litter in the marine and coastal environment are minimised.

EO10-CI23 – Number/amount of marine litter items in the water surface and the seafloor do not have negative impacts on human health, marine life, ecosystem services and do not create risk to navigation. Operational Objective:–The impacts related to priorities and quantities of marine litter in the marine and coastal environment are minimized.

EO10-CCI24 – Trends in the amount of litter ingested by or entangling marine organisms, especially mammals, marine birds and turtles are minimised. Operational Objective: Impacts of litter on marine life are controlled to the maximum extent practicable

283. **MSFD Descriptor D10** on marine pollution includes two primary and two secondary criteria as follows:

D10C1 – Primary: The composition, amount and spatial distribution of **litter** on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment.

D10C2 – Primary: The composition, amount and spatial distribution of **micro-litter** on the coastline, in the surface layer of the water column, and in seabed sediment, are at levels that do not cause harm to the coastal and marine environment

D10C3 – Secondary: The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned.

D10C4 – Secondary: The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.

284. For all indicators, Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or sub-regional specificities.

285. Concerning marine litter assessment, equivalence between IMAP indicators and MSFD criteria is difficult in the case of EO10CI22 and EO10CI23 since the distinction between IMAP

indicators is based on where the litter is found (ashore/sea an seafloor), whereas the MSFD criteria D10C1 and D10C2 differ by the size of the litter (litter/micro-litter).

286. However, it can be considered that as MSFD D10C1 and C2 comprise the 3 compartments coastline, surface layer of the water column and seabed, the assessment for coastline compartment of D10C1 and C2 corresponds to EO10-CI22 and the compartments surface layer of the water column and seabed to EO10-CI23.

287. EO10CCI24 can be compared to D10C3 and D10C4 together.

12.2. Elements for defining EO10 GES at indicator level in a climate change context

a) Marine litter on coastline, floating and seafloor

EO10 Marine litter Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO10-CI22** **EO10-CI23**
EO10-CI22 GES: Number/amount of marine litter items on the coastline do not have negative impact on human health, marine life and ecosystem services. **EO10-CI23 GES:** Number/amount of marine litter items in the water surface and the seafloor do not have negative impacts on human health, marine life, ecosystem services and do not create risk to navigation. **(A) Seafloor marine litter (B) Floating marine Litter**
Specific monitoring guidance documents available to assess and monitor marine litter: → UNEP/MAP. (2021). *Updated Baseline Values and Proposal for Threshold Values for IMAP Common Indicator 22 (UNEP/MED WG.514/7)* (p. 29) [8th Meeting of the Ecosystem Approach Coordination Group]. Link → UNEP/MAP. (2023). *Updated Baseline Values (BV) and Threshold Values (TV) for IMAP Common Indicator 23 (Seafloor macro-litter, Floating microplastics) (UNEP/MED WG.555/3)* [Meeting of the Ecosystem Approach Correspondence Group on Marine Litter Monitoring]. UNEP/MAP-MED POL. Link → Van Loon, W., Hanke, G., Fleet, D., Werner, S., Barry, J., Strand, J., … Walvoort, D. (2020). A European threshold value and assessment method for macro litter on the coastlines: Guidance developed within the Common Implementation strategy for the Marine Strategy Framework Directive MSFD Technical Group on Marine Litter [JRC Technical Reports]. LU: Publications Office of the European Union. Link → Fleet, D., Vlachogianni, T., & Hanke, G. (2021). *A Joint List of Litter Categories for Marine Macrolitter Monitoring* (JRC Scientific and Technical Reports No. EUR 30348; p. 55). Luxembourg: Publications Office of the European Union. Link → Vighi, M., Ruiz-Orejón, L. F., Hanke, G., & MSFD Technical Group on Marine Litter. (2022). *Monitoring of Floating Marine Macro Litter. State of the art and literature overview*

EO10 Marine litter
Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition
EO10-CI22
EO10-CI23

(JRC Technical Reports No. JRC129261). Luxembourg: Publications Office of the European Union. Link

→ Vlachogianni, Th., & Kalampokis, V. (2014). *Methodology for Monitoring Marine Litter on the Seafloor (Shallow coastal waters (0–20m) Visual surveys with SCUBA/snorkeling* (p. 10) [DeFishGear]. MIO-ECSDE.

→ Cheshire, A. C., Adler, E., Barbière, J., Cohen, Y., Evans, E., Jarayabhand, S., … Westphalen, G. (2009). *UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter* (UNEP Regional Seas Reports and Studies No. No. 186; p. 120). Link

Assessment of amount of litter washed ashore and/or deposited on coastline

Assessment of litter washed ashore or on coastline is well defined in MSFD framework (Van Loon et al., 2020) but also in the framework of IMAP (UNEP/MAP, 2017a, UNEP/MAP, 2021).

According to the Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE), in 2015 and 2016 the average beach litter quantity for European beaches was 150 items (over 2.5 cm long) per 100m with the **Mediterranean Sea region presenting the highest average of 274 items/100 m** (see here).

UNEP/MAP updated baseline value proposed for marine litter on coastline in 2021 is 369 items/100m. Decreasing trends in the assessments are required to attain the threshold value of 130 items/100m (UNEP/MAP, 2021). The threshold value will be difficult to attain in certain areas and will need much effort and time as in Southern Adriatic that presents high average litter abundance (Fortibuoni et al., 2021; GEF Adriatic Project, 2021; Mandić et al., 2022).

A model was defined by Walvoort et al. (2021) to predict when the threshold value could be reached for Germany and Netherlands; threshold should be respectively reached in 2026 and 2047. The model presents and interest for evaluating if current reduction rate of litter on beaches is sufficient or if further measures of reduction should be taken.

Marine litter on beaches presents seasonal and geographic important variations due to recreational activities which should be taken in account in assessment plans (Grelaud & Ziveri, 2020; Orthodoxou et al., 2022).

To contribute to fill data gaps, Vlachogianni (2019) proposes to consider completing assessments with participatory science policy initiatives for which methodology is given in the documents.

Although progress is ongoing to reduce litter on coastline and increase assessments at Mediterranean Sea regional scale, it can be considered that there is a lack of data but that available data show that GES for EO10-CI22 has not been attained yet.

Assessment of amount of litter floating including microplastics

EO10 Marine litter Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition EO10-CI22 EO10-CI23
Assessment of floating macro litter is well defined in MSFD (see Vighi et al., 2022) and IMAP (UNEP/MAP, 2017a, UNEP/MAP, 2023). The Mediterranean Sea is considered as one of the most affected by floating plastic litter. It is estimated that 650 billion plastic particles are floating on the surface of the Mediterranean (Pedrotti et al., 2022). Floating mega debris (>30 cm) have been estimated at 2.9 million items (Lamber et al., 2020). The mega-debris presence probability map produced by these authors show that central and north-western Mediterranean and Adriatic Seas are the most impacted areas. New technics, such as Unmanned Aerial Survey coupled with machine learning, could be promising for assessing floating macro litter although for the moment manual counting remains more precise (Almeida et al., 2022). Macias et al. (2019) show through a model approach that there are seasonal patterns and hotspots of floating litter in the Mediterranean Sea which should be considered in assessment campaigns. Dispersion of micro-plastics in the Mediterranean has been modelled underlining the need also to couple dynamics of microplastics with the chemical exchange occurring through them (see Guerrini et al., 2021). Studies and assessments of micro-plastics in the water column are few and in specific locations (see e.g. Galli et al., 2023 for macro and microplastics assessed around the Pelagos Sanctuary). Cross-road regions of plastic debris in the Mediterranean Sea were studied by Baudena et al. (2022) and reveal that about 20% of the plastics released pass by only 1% of the basin surface. Understanding plastic transport is important to develop efficient mitigation strategies. Correlation has been made between marine litter distribution in the Mediterranean Sea and marine maritime routes but no specific estimation of litter origination from ships is available (Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea, 2021). **<u>Assessment of amount of litter on the seafloor</u>** Assessment of litter on seafloor has been quite well studied in different areas of the Mediterranean (e.g. Spedicato et al., 2019 by bottom trawling in the northern Mediterranean Sea; Garofalo et al., 2020 in the central Mediterranean; Saladié & Bustamante, 2021 in the western Mediterranean; Constatino et al., 2018 in the eastern Mediterranean). Further the presence of litter on specific habitats, such as coralligenous habitats that present often a high abundance of fishing gear, have been studied using images from Remotely Operated Vehicles (ROVs) (e.g. Angiolillo et al., 2021, 2023; Costanzo et al., 2020; Angiolillo & Fortibuoni, 2020). Litter on the seafloor can be assessed by different methods depending on the depth and substrate. These methods are quite different either direct counts in small depths using diving

EO10 Marine litter Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO10-CI22** **EO10-CI23**
equipment, assessment on ROV videos or assessment using benthic trawling methods. Therefor the operation guidelines and data to be acquired need to be well defined. **<u>Effects of climate change and other cumulative pressures in GES determination</u>** Climate change impact on marine litter has been little studied. However Ford et al. (2022) and Lincoln et al. (2022) studied the fundamental links that exist between litter and climate change and underline the role of marine litter in decreasing ecosystem resilience to climate change and the impact of climate change on the breakdown of marine litter. Seasonality of marine litter on beaches has been underlined with summer months with an increase of coastal litter during peak frequentation periods (summer). when frequentation of coastal areas

b) Marine litter ingested by marine species

EO10 Marine litter Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO10-CCI24**
EO10-CCI24 GES: Trends in the amount of litter ingested by or entangling marine organisms, especially mammals, marine birds and turtles are minimised.
<u>Specific monitoring guidance documents available to assess and monitor ingestion of litter and entangling of organisms:</u> → UNEP/MAP. (2017c). *Defining the Most Representative Species for IMAP Candidate Indicator 24 (UNEP(DEPI)/MED WG.444/Inf.11)* (p. 38) [6th Meeting of the Ecosystem Approach Coordination Group]. Link → Indicit II. (2021). *Standard protocol to monitor entanglement of sea turtles and biota in marine litter.* Link Work is currently ongoing on the development of the assessment elements of candidate indicator 24 including defining baseline and threshold values. **<u>Assessment of litter ingested by marine organisms (mammals, seabirds, marine turtles)</u>** Macro-litter ingestion by organisms in the Mediterranean Sea concerns a variety of species, even deep-sea sharks (Valente et al., 2020), but has been more thoroughly studied for marine turtles (e.g. Duncan et al., 2019 on green turtles in eastern Mediterranean; Digka et al., 2020 in Greece; . Duncan et al., 2021 on juveniles; Camedda et al., 2022 in western Mediterranean). Increasing number of studies concern the ingestion of microplastics by various organisms and there effects (e.g. McIvor et al., 2023 concerning monk seals; Anastasopoulou et al., 2018 concerning fish in the Adriatic; El-Sayed et al., 2022 in commercial fish in Egypt).

EO10 Marine litter Available information useful for defining GES at indicator and parameter level and climate change effects on GES definition **EO10-CCI24**
Although plastic ingestion appears as an important threat to seabirds (Clark et al., 2023), it has been little studied in the Mediterranean Sea. Codina-García et al. (2013) identified though seabird species that could be the most appropriate to monitor. **Assessment of entangling by marine organisms (mammals, seabirds, marine turtles) with litter and derelict fishing gear** Entangling of species in derelict fishing gear or other litter leads to injury or death of the individual. Many marine species are concerned including fish but also benthic species. However, sea turtles that are among the most threatened species (see Duncan et al., 2017) and entangling could participate in the Mediterranean Sea to impact populations. Together with plastic ingestion and by-catch, entanglement represent the most important threats for sea turtles in the Mediterranean. Perroca et al. (2022) present an overview assessment of negative impacts of ghost nets in the Mediterranean Sea and report the number of ghost fishing events recorded by Mediterranean country. **Effects of climate change and other cumulative pressures in GES determination** Climate change impact on litter entanglement and ingestion are not direct and impacts on GES determination for this indicator do not appear prominent. It is mainly increase in frequentation of costal Mediterranean areas and of the Mediterranean Sea in general that is the main threat for this indicator.

12.3. Impediments and gaps identified in EO10 GES determination and assessment in a climate change context, including recommendations for way forward

288. EO10 GES: "*Marine and coastal litter do not adversely affect coastal and marine environment.*"
289. Indicators defined including the candidate indicator 24 appear as sufficient to determine adverse effects of marine and coastal letter. Framework for assessment appears as well defined however methods currently used still need to be harmonised.
290. Harmonisation in litter categories is needed. The Joint List of Litter Categories (Fleet et al., 2021) should be increase harmonisation in categorisation of litter assessed.
291. Valid and comparable data is lacking in particular to be able to assess temporal and spatial trends.
292. Further integration of IMAP and MSFD methodology and clarification would contribute to data availability and harmonisation, especially given the difficult correspondence between EO10-CI22 and CI23 with D10C1 and D10C2 (see comparison in part 12.1).
293. Also limits of litter size in assessment of litter on coastlines should be clearer between MSFD limit of 2.5 cm long and IMAP (UNEP(DEPI)/MED IG.22/Inf.7) that suggests 0.5 cm.

294. Seasonality and spatial variability of marine litter on coastline has been underlined, therefor the sampling designs should take in consideration these elements. This is important for EO10-CI22 relative to coastline litter and EO10-CI23 relative to floating litter.

295. Extending litter ingestion to other species (than marine mammals, sea turtles and seabirds) such as fish could be considered. Trends in micro plastic ingestion by certain fish could contribute to better understand contamination of food webs by micro plastics.

12.4. Key messages

296. Given that the Mediterranean Sea is one of the most impacted areas by marine litter, its quantification and impacts on the environment should be a priority for CPs.

297. Assessment methods, guidelines baseline and threshold values are quite well defined for EO10 indicators but need to be applied and used to produce harmonised and comparable data.

298. Differences between IMAP EO10 indicators and MSFDF D10 Criteria may represent an impediment for EU Mediterranean countries reporting. Clear relations between parameters/features/elements relative to marine litter in IMAP and MSFD would probably contribute to increase reporting by EU CPs.

299. There has been much progress to frame the data acquisition and methodology for assessing amount of litter ingested by or entangling marine organisms (candidate indicator 24). However, distinction between bycatch of vulnerable species (CI12) and entanglement of marine organisms by derelict fishing gear must be clear to avoid overlap.

300. Candidate indicator 24 appears as well defined in terms of assessment methods and elements defining GES with clear propositions of representative groups to follow. This indicator could be integrated as a common indicator especially since impact of marine litter on ecosystems and environment is needed to be able to assess EO10 GES.

301. Climate change impacts on marine litter are unclear but relate to litter degradation and spatial distribution of marine litter.

13.Ecological Objective 11: Energy including underwater noise

13.1. General information on IMAP EO11 and MSFD D11 GES definitions

302. IMAP Ecological Objective 11 and MSFD Descriptor 11 concern energy and underwater noise assessment.

303. Adding to the general documents on MSFD and IMAP referred to in section 2.7, relevant documents relative to EO11/D11 and GES determination under IMAP and MSFD can be found in Table 12.

Table 12: Relevant documents relative to GES definition for EO11 and D11.

Energy including underwater noise	
IMAP	**MSFD**
EO11 GES: "*Noise from human activities cause no significant impact on marine and coastal ecosystems.*"	D11 GES: *"Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment"*
Several guidance documents refer to energy and underwater noise Sigray, P., Andersson, M., Andre, M., Azzellino, A., Borsani, J. F., Bou, M., … Weilgart, L. (2023). *Setting EU Threshold Values for impulsive underwater sound* (No. JRC133477). Luxembourg: Publications Office of the European Union. Link Borsani, J. F., Andersson, M., Andre, M., Azzellino, A., Bou, M., Castellote, M., … Weilgart, L. (2023). *Setting EU Threshold Values for continuous underwater sound* (No. JRC133476). Luxembourg: Publications Office of the European Union. Link UNEP/MAP-MED POL. (2019). *IMAP Guidance Factsheets: Update for Common Indicators 13, 14, 17, 18, 20 and 21; New proposal for Candidate Indicators 26 and 27* (Meeting Report No. UNEP/MED WG.473/7; p. 62). Link Dekeling, R., Tasker, M., Van, D. G. S., Ainslie, M., Andersson, M., André, M., … Young, J. (2014). *Monitoring Guidance for Underwater Noise in European Seas- Part II: Monitoring Guidance Specifications* [JRC Scientific and policy reports]. Luxembourg: Publications Office of the European Union. Link **Assessment of energy including underwater noise** Vighi, Boschetti, & Hanke, (2021) indicated that few EU MS have reported on D11 and there was a lack of common thresholds and targets in the reported. Since then, progress has been done in better defining these elements (Sigray et al., 2023). Nonetheless, under the impulsion of this policy, some progress has been made concerning knowledge on underwater noise and energy and how to monitor this pressure (see Merchant et al., 2022). At IMAP level, there was no reporting concerning this EO11 since the two indicators are still candidate indicators but progress is ongoing to further define this EO.	

Energy including underwater noise	
IMAP	**MSFD**
The document (ACCOBAMS & CMS, 2019) an assessment of the EO11 and D11 implementation level and how this can be improved. Further, the report on noise hotspots (ACCOBAMS, 2021) presents and maps available data at Mediterranean scale, as well as overlap with important cetacean habitats. Impacts of climate change on underwater energy and noise have not been studied yet. It is the increase of Mediterranean Sea frequentation by ships that currently threatens marine animals.	

304. **IMAP Ecological Objective 11** is declined in two candidate indicators. The GES definitions, Operational objectives of these indicators have been agreed on and are as follows:

EO11-CCI26 – Proportion of days and geographical distribution where loud, low and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animals. GES: Noise from human activities causes no significant impact on marine and coastal ecosystems Operational Objective: Energy inputs into the marine environment, especially noise from human activities, are minimized.

EO10-CCI27 – Levels of continuous low frequency sound with the use of models as appropriate. GES: Noise from human activities causes no significant impact on marine and coastal ecosystems. Operational Objective: Energy inputs into the marine environment, especially noise from human activities, are minimized.

305. **MSFD Descriptor D11** on Energy and noise includes two primary criteria as follows:

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

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

306. Member States shall establish threshold values for these levels through cooperation at Union level, taking into account regional or sub-regional specificities.

307. EO11 is quite comparable to D11.

13.2. Impediments and gaps identified in EO11 GES determination and assessment in a climate change context, including recommendations for way forward

308. E011 GES: "Noise from human activities cause no significant impact on marine and coastal ecosystems."

309. The two indicators of EO11 are still candidate indicators and therefor have not yet been implemented at national level.

310. Current assessment of energy including underwater noise in the Mediterranean Sea is not sufficient to assess GES.

311. Continuously measuring underwater sounds to be in capacity of assessing Candidate indicator 26 appears as a difficult operation even in EU countries. This indicator will have to be based on models

13.3. Key messages

312. Work has progressed in defining the elements and methods for assessing underwater energy within IMAP but also MSFD.

313. Some data is available at Mediterranean level which allowed to map noise hotspots in the Mediterranean.

314. Further knowledge seems to be needed in particular concerning operational implementation of such assessment.

14. Impact of climate change on integrated GES assessment

315. When currently assessing GES in an integrated way through the 11 Ecological Objectives, although anthropogenic climate change will affect the majority of the Mediterranean marine ecosystems, this pressure is not assessed as such. There is no Ecological Objective assessing climate change impacts. The development of an EO on climate change could be considered based on already existing parameters assessed through IMAP that could be perhaps adapted in different ways to assess the climate change pressures on biodiversity and ecosystems. It would contribute in a better understanding of cumulative effects including climate change on marine biodiversity, as well as help identify particular sensitive areas or ecosystems.

316. EcAp Roadmap is in the process of being renewed which gives the opportunity to consider, with climate change specialists, the interest of integrating climate change impacts in IMAP and how this can be done to be efficient but without adding new indicators to an already important monitoring programme.

References

ACCOBAMS. (2020). *Monitoring guidelines to assess cetaceans' distributional range, population abundance and population demographic characteristics* (p. 12). Retrieved from https://accobams.org/wp-content/uploads/2020/05/GL_Comprehensive_Population_estimates_distribution.pdf

ACCOBAMS. (2021). *Noise hotspot report II* (14th Meeting of the Scientific Committee No. ACCOBAMS-SC14/2021/Doc21; p. 42). Monaco: ACCOBAMS -CMS.

ACCOBAMS. (2023). *Evidence-based diagnostic assessment frameworks for cetacean necropsies on specific issues/threats* (p. 10). Retrieved from https://accobams.org/wp-content/uploads/2023/07/ACCOBAMS-Best-Practices-on-Cetacean-Strandings.pdf

ACCOBAMS, & CMS. (2019). *Report of the workshop: 'Best practice workshop: Fostering inter-regional cooperation in underwater noise moitoring and impact assessment in waters around Europe, within the context of the European Marine Strategy Framework Directive' held at 31st ECS Conference, Middelfart, Denmark, 29th April 2017* (Seventh Meeting of the Parties to ACCOBAMS No. ACCOBAMS-MOP7/2019/Inf 21; p. 24).

Addamo, A., & La Notte, A. (2023). *Towards an ecosystem-based approach in marine ecosystem accounting. Seagrass ecosystems in the Mediterranean Sea: From diversity to restoration*. doi: 10.2760/612075

Agharroud, K., Puddu, M., Ivčević, A., Satta, A., Kolker, A. S., & Snoussi, M. (2023). Climate risk assessment of the Tangier-Tetouan-Al Hoceima coastal Region (Morocco). *Frontiers in Marine Science*, *10*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2023.1176350

Agnesi, S., Annunziatellis, A., Inghilesi, R., Mo, G., & Orasi, A. (2020). The contribution of wind-wave energy at sea bottom to the modelling of rhodolith beds distribution in an off-shore continental shelf. *Mediterranean Marine Science*, *21*(2), 433–441. doi: 10.12681/mms.22462

Almeida, S., Radeta, M., Kataoka, T., Canning-Clode, J., Pessanha Pais, M., Freitas, R., & Monteiro, J. G. (2023). Designing Unmanned Aerial Survey Monitoring Program to Assess Floating Litter Contamination. *Remote Sensing*, *15*(1), 84. doi: 10.3390/rs15010084

Alonso, A. E., Palma, M., Palialexis, A., & Hanke, G. (2023). *Reference list of MSFD D1 species (2018-2020 update)*. doi: 10.2760/910867

Anastasopoulou, A., Kovač Viršek, M., Bojanić Varezić, D., Digka, N., Fortibuoni, T., Koren, Š., … Tutman, P. (2018). Assessment on marine litter ingested by fish in the Adriatic and NE Ionian Sea macro-region (Mediterranean). *Marine Pollution Bulletin*, *133*, 841–851. doi: 10.1016/j.marpolbul.2018.06.050

Androukaki, E., Adamantopoulou, S., Dendrinos, P., Tounta, E., & Kotomatas, S. (1999). Causes of mortality in the Mediterranean Monk seal (*Monachus monachus*) in Greece. *Contr. Zoogeogr. Ecol. East Med. Reg.*, *1*.

Androulidakis, Y., Kolovoyiannis, V., Makris, C., Krestenitis, Y., Baltikas, V., Stefanidou, N., … Moustaka-Gouni, M. (2021). Effects of ocean circulation on the eutrophication of a Mediterranean gulf with river inlets: The Northern Thermaikos Gulf. *Continental Shelf Research*, *221*, 104416. doi: 10.1016/j.csr.2021.104416

Angiolillo, M., Bo, M., Toma, M., Giusti, M., Salvati, E., Giova, A., … Tunesi, L. (2023a). A baseline for the monitoring of Mediterranean upper bathyal biogenic reefs within the marine strategy framework directive objectives. *Deep Sea Research Part I: Oceanographic Research Papers*, *194*, 103963. doi: 10.1016/j.dsr.2023.103963

Angiolillo, M., & Fortibuoni, T. (2020). Impacts of Marine Litter on Mediterranean Reef Systems: From Shallow to Deep Waters. *Frontiers in Marine Science*, *7*. doi: 10.3389/fmars.2020.581966

Angiolillo, M., Gerigny, O., Valente, T., Fabri, M.-C., Tambute, E., Rouanet, E., … Galgani, F. (2021). Distribution of seafloor litter and its interaction with benthic organisms in deep waters of the Ligurian Sea (Northwestern Mediterranean). *Science Of The Total Environment*, *788*. doi: 10.1016/j.scitotenv.2021.147745

Arcangeli, A., Atzori, F., Azzolin, M., Babey, L., Campana, I., Carosso, L., … David, L. (2023). Testing indicators for trend assessment of range and habitat of low-density cetacean species in the

Mediterranean Sea. *Frontiers in Marine Science*, *10*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2023.1116829

Armelloni, E. N., Tassetti, A. N., Ferrà, C., Galdelli, A., Scanu, M., Mancini, A., … Scarcella, G. (2021). AIS data, a mine of information on trawling fleet mobility in the Mediterranean Sea. *Marine Policy*, *129*, 104571. doi: 10.1016/j.marpol.2021.104571

Assessment of Spatio-Temporal Variability of Faecal Pollution along Coastal Waters during and after Rainfall Events. (n.d.).

Authier, M., Commanducci, F. D., Genov, T., Holcer, D., Ridoux, V., Salivas, M., … Spitz, J. (2017). Cetacean conservation in the Mediterranean and Black Seas: Fostering transboundary collaboration through the European Marine Strategy Framework Directive. *Marine Policy*, *82*, 98–103. doi: 10.1016/j.marpol.2017.05.012

Awbery, T., Akkaya, A., Lyne, P., Rudd, L., Hoogenstrijd, G., Nedelcu, M., … Öztürk, B. (2022). Spatial Distribution and Encounter Rates of Delphinids and Deep Diving Cetaceans in the Eastern Mediterranean Sea of Turkey and the Extent of Overlap With Areas of Dense Marine Traffic. *Frontiers in Marine Science*, *9*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2022.860242

Badreddine, A., Abboud-Abi Saab, M., Gianni, F., Ballesteros, E., & Mangialajo, L. (2018). First assessment of the ecological status in the Levant Basin: Application of the CARLIT index along the Lebanese coastline. *Ecological Indicators*, *85*, 37–47. doi: 10.1016/j.ecolind.2017.10.006

Bahbah, L., Bensari, B., Chabane, K., Torras, X., Ballesteros, E., & Seridi, H. (2020). Cartography of littoral rocky-shore communities to assess the ecological status of water bodies through the application of CARLIT method in Algeria (South-Western Mediterranean Sea). *Marine Pollution Bulletin*, *157*, 111356. doi: 10.1016/j.marpolbul.2020.111356

Barange, M., Bahri, T., Beveridge, M. C. M., Cochrane, K. L., Funge-Smith, S., & Poulain, F. (Eds.). (2018). *Impacts of climate change on fisheries and aquaculture. Synthesis of current knowledge, adaptation and mitigation options*. Rome: FAO. Retrieved from https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1152846/

Bartolo, A. G., Tsiamis, K., & Küpper, F. C. (2021). Identifying hotspots of non-indigenous species' high impact in the Maltese islands (Central Mediterranean Sea). *Marine Pollution Bulletin*, *164*, 112016. doi: 10.1016/j.marpolbul.2021.112016

Basso, D., Babbini, L., & Espla, A. A. (2017). Mediterranean Rhodolith Beds. In R. Riosmena-Rodriguez, W. Nelson, & J. Aguirre (Eds.), *Rhodolith/Maerl Beds: A Global Perspective* (Springer). doi: 10.1007/978-3-319-29315-8_11 https://www.researchgate.net/publication/307437298_Mediterranean_Rhodolith_Beds

Basso, D., Babbini, L., Kaleb, S., Bracchi, V. A., & Falace, A. (2016). Monitoring deep Mediterranean rhodolith beds. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *26*(3), 549–561. doi: 10.1002/aqc.2586

Baudena, A., Ser-Giacomi, E., Jalón-Rojas, I., Galgani, F., & Pedrotti, M. L. (2022). The streaming of plastic in the Mediterranean Sea. *Nature Communications*, *13*(1), 2981. doi: 10.1038/s41467-022-30572-5

Beca-Carretero, P., Teichberg, M., Winters, G., Procaccini, G., & Reuter, H. (2020). Projected Rapid Habitat Expansion of Tropical Seagrass Species in the Mediterranean Sea as Climate Change Progresses. *Frontiers in Plant Science*, *11*. dataset associated. Retrieved from https://www.frontiersin.org/article/10.3389/fpls.2020.555376

Belgacem, M., Chiggiato, J., Borghini, M., Pavoni, B., Cerrati, G., Acri, F., … Schroeder, K. (2020). Dissolved inorganic nutrients in the western Mediterranean Sea (2004–2017). *Earth System Science Data*, *12*(3), 1985–2011. doi: 10.5194/essd-12-1985-2020

Ben Ismail, M., Imed, J., Kaska, Y., Nakhla, L., Fraj, A., Dibej, M., … Bredai, M. (2022). The Westernmost Green Turtle (Chelonia mydas) Nest Recorded in the Mediterranean from Tunisia. *MedTurtle Bulletin*, *1*(1), 19–23.

Ben Lamine, E., Schickele, A., Guidetti, P., Allemand, D., Hilmi, N., & Raybaud, V. (2023). Redistribution of fisheries catch potential in Mediterranean and North European waters under climate change scenarios. *Science of The Total Environment*, 163055. doi: 10.1016/j.scitotenv.2023.163055

Berg, T., Murray, C., Carstensen, J., & Jesper, H. A. (2016). *NEAT - Nested Environmental status Assessment Tool. Manual—Version 1.3* (p. 38). Devotes project report. https://www.azti.es/wp-content/uploads/2019/11/NEAT-manual-v1.3.pdf. Retrieved from https://www.azti.es/wp-content/uploads/2019/11/NEAT-manual-v1.3.pdf.
Bevilacqua, S., Katsanevakis, S., Micheli, F., Sala, E., Rilov, G., Sarà, G., … Fraschetti, S. (2020). The Status of Coastal Benthic Ecosystems in the Mediterranean Sea: Evidence From Ecological Indicators. *Frontiers in Marine Science*, *7*. Retrieved from https://www.frontiersin.org/article/10.3389/fmars.2020.00475
Birchenough, S., Reiss, H., Degraer, S., Mieszkowska, N., Borja, A., Buhl-Mortensen, L., … Wätjen, K. (2015). Climate change and marine benthos: A review of existing research and future directions in the North Atlantic. *Wiley Interdisciplinary Reviews: Climate Change*, *6*, 6: 203-223. doi: 10.1002/wcc.330
Bladow, R. A., & Milton, S. L. (2019). Embryonic mortality in green (Chelonia mydas) and loggerhead (Caretta caretta) sea turtle nests increases with cumulative exposure to elevated temperatures. *Journal of Experimental Marine Biology and Ecology*, *518*, 151180. doi: 10.1016/j.jembe.2019.151180
Blondeau-Patissier, D., Schroeder, T., Suresh, G., Li, Z., Diakogiannis, F. I., Irving, P., … Steven, A. D. L. (2023). Detection of marine oil-like features in Sentinel-1 SAR images by supplementary use of deep learning and empirical methods: Performance assessment for the Great Barrier Reef marine park. *Marine Pollution Bulletin*, *188*, 114598. doi: 10.1016/j.marpolbul.2023.114598
Bonamano, S., Piazzolla, D., Scanu, S., Piermattei, V., & Marcelli, M. (2021). Trace-metal distribution and ecological risk assessment in sediments of a sheltered coastal area (Gulf of Gaeta, central-eastern Tyrrhenian Sea, Italy) in relation to hydrodynamic conditions. *Mediterranean Marine Science*, *22*(2), 372–384. doi: 10.12681/mms.24996
Bonometto, A., Ponis, E., Cacciatore, F., Riccardi, E., Pigozzi, S., Parati, P., … Boscolo Brusà, R. (2022). A New Multi-Index Method for the Eutrophication Assessment in Transitional Waters: Large-Scale Implementation in Italian Lagoons. *Environments*, *9*(4), 41. doi: 10.3390/environments9040041
Borja, A., Elliott, M., Andersen, J. H., Cardoso, A. C., Carstensen, J., Ferreira, J., … Menchaca, I. (2015). *Potential Definition of Good Environmental Status. Deliverable 6.2 DEVOTES Project* (p. 62).
Borja, Angel, Elliott, M., Andersen, J. H., Cardoso, A. C., Carstensen, J., Ferreira, J. G., … Zampoukas, N. (2013). Good Environmental Status of marine ecosystems: What is it and how do we know when we have attained it? *Marine Pollution Bulletin*, *76*(1), 16–27. doi: 10.1016/j.marpolbul.2013.08.042
Borja, Angel, Prins, T. C., Simboura, N., Andersen, J. H., Berg, T., Marques, J.-C., … Uusitalo, L. (2014). Tales from a thousand and one ways to integrate marine ecosystem components when assessing the environmental status. *Frontiers in Marine Science*, *1*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2014.00072
Borsani, J. F., Andersson, M., Andre, M., Azzellino, A., Bou, M., Castellote, M., … Weilgart, L. (2023). *Setting EU Threshold Values for continuous underwater sound* (No. JRC133476). Luxembourg: Publications Office of the European Union. Retrieved from Publications Office of the European Union website: https://publications.jrc.ec.europa.eu/repository/handle/JRC133476
Boschetti, S., Piroddi, C., Druon, J.-N., & Palialexis, A. (2021). *Marine Strategy Framework Directive – Review and analysis of Member States' 2018 reports – Descriptor 4: Food webs*. doi: 10.2760/32522
Boschetti, S. T., Palialexis, A., & Connor, J. (2021). *Marine Strategy Framework Directive. Review and analysis of EU Member States' 2018 reports. Descriptor 6: Sea-floor integrity and Descriptor 1: Benthic habitats* (Technical Report No. JRC125288/EUR 30716 EN; p. 90). Joint Research Centre (JRC). Retrieved from Joint Research Centre (JRC) website: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC125288/d6_jrc_ida.pdf
Brandão, J., Weiskerger, C., Valério, E., Pitkänen, T., Meriläinen, P., Avolio, L., … Sadowsky, M. J. (2022). Climate Change Impacts on Microbiota in Beach Sand and Water: Looking Ahead. *International Journal of Environmental Research and Public Health*, *19*(3), 1444. doi: 10.3390/ijerph19031444
Bray, L., Reizopoulou, S., Voukouvalas, E., Soukissian, T., Alomar, C., Vázquez-Luis, M., … Hall-Spencer, J. (2016). Expected Effects of Offshore Wind Farms on Mediterranean Marine Life. *Journal of Marine Science and Application*, *4*. doi: 10.3390/jmse4010018

Bundone, L., Rizzo, L., Fai, S., Hernández-Milián, G., Guerzoni, S., & Molinaroli, E. (2023). Investigating Rare and Endangered Species: When a Single Methodology Is Not Enough-The Mediterranean Monk Seal Monachus monachus along the Coast of Salento (South Apulia, Italy). *Diversity*, *15*(6). doi: 10.3390/d15060740

Camedda, A., Matiddi, M., Vianello, A., Coppa, S., Bianchi, J., Silvestri, C., … de Lucia, G. A. (2022). Polymer composition assessment suggests prevalence of single-use plastics among items ingested by loggerhead sea turtles in the western mediterranean sub-region. *Environmental Pollution*, *292*, 118274. doi: 10.1016/j.envpol.2021.118274

Camiñas, J. A., Kaska, Y., Hochscheid, S., Casale, P., Panagopoulou, A., Báez, J. C., … Alcázar, E. (2020). *Conservation of marine turtles in the Mediterranean Sea* (p. 12). IUCN. Retrieved from IUCN website: https://www.iucn.org/sites/default/files/content/documents/2020/conservation_of_mediterranean_turtles_in_the_mediterranean_sea.pdf

Cañadas, A., Aguilar de Soto, N., Aissi, M., Arcangeli, A., Azzolin, M., B-Nagy, A., … Roger, Th. (2018). The challenge of habitat modelling for threatened low density species using heterogeneous data: The case of Cuvier's beaked whales in the Mediterranean. *Ecological Indicators*, *85*, 128–136. doi: 10.1016/j.ecolind.2017.10.021

Cañadas, A., & Vázquez, J. A. (2017). Common dolphins in the Alboran Sea: Facing a reduction in their suitable habitat due to an increase in Sea surface temperature. *Deep Sea Research Part II: Topical Studies in Oceanography*, *141*, 306–318. doi: 10.1016/j.dsr2.2017.03.006

Cantasano, N. (2023). The effects of climate changes on *Posidonia oceanica* meadows in the Mediterranean Basin. *Natural Resources Conservation and Research*, *6*(1), 1961. doi: 10.24294/nrcr.v6i1.1961

Carbonne, C., Comeau, S., Chan, P. T. W., Plichon, K., Gattuso, J.-P., & Teixidó, N. (2022). Early life stages of a Mediterranean coral are vulnerable to ocean warming and acidification. *Biogeosciences*, *19*(19), 4767–4777. doi: 10.5194/bg-19-4767-2022

Cardoso, A., Cochrane, S., Doerner, H., Ferreira, J., Galgani, F., Hagebro, C., … Van, D. B. W. (2010). *Scientific Support to the European Commission on the Marine Strategy Framework Directive—Management Group Report* (No. EUR 24336 EN). Luxembourg: Publications Office of the European Union. doi: 10.2788/86430

Carpentieri, P., Bonanno, A., & Scarcella, G. (2020). *Technical guidelines for scientific surveys in the Mediterranean and the Black Sea Procedures and sampling for demersal (bottom and beam) trawl surveys and pelagic acoustic surveys* (FAO Fisheries and Aquaculture Technical Papers N No. N°641; p. 108). Rome: FAO. Retrieved from FAO website: https://www.fao.org/gfcm/publications/series/technical-paper/641/en/

Carpentieri, P., Nastasi, A., Sessa, M., & Srour, A. (2021). *Incidental catch of vulnerable species in Mediterranean and Black Sea fisheries – A review.* (Studies and Reviews No. N°101; p. 338). Rome: General Fisheries Commission for the Mediterranean, FAO. Retrieved from General Fisheries Commission for the Mediterranean, FAO website: https://www.fao.org/gfcm/publications/studies-reviews/101/en/

Casale, P., & Margaritoulis, D. (Eds.). (2010). *Sea turtles in the Mediterranean: Distribution, threats and conservation priorities*. Gland, Switerland: IUCN. Retrieved from https://portals.iucn.org/library/sites/library/files/documents/2010-012.pdf

Casale, Paolo, Broderick, A., Camiñas, J., Cardona, L., Carreras, C., Demetropoulos, A., … Türkozan, O. (2018). Mediterranean sea turtles: Current knowledge and priorities for conservation and research. *Endangered Species Research*, *36*. doi: 10.3354/esr00901

Castro-Jiménez, J., Bănaru, D., Chen, C.-T., Jiménez, B., Muñoz-Arnanz, J., Deviller, G., & Sempéré, R. (2021). Persistent Organic Pollutants Burden, Trophic Magnification and Risk in a Pelagic Food Web from Coastal NW Mediterranean Sea. *Environmental Science & Technology*, *55*(14), 9557–9568. doi: 10.1021/acs.est.1c00904

CetAMBICion project. (2022). *WP1—Review of MSFD second cycle reports and state of the art for cetaceans Deliverable 1.01*.

Chaplow, J. S., Bond, A. L., Koschorreck, J., Rüdel, H., & Shore, R. F. (2021). 6—The role of environmental specimen banks in monitoring environmental contamination. In S. Johnson (Ed.),

Monitoring Environmental Contaminants (pp. 123–138). Elsevier. doi: 10.1016/B978-0-444-64335-3.00002-5
Chefaoui, R. M., Duarte, C. M., & Serrão, E. A. (2018). Dramatic loss of seagrass habitat under projected climate change in the Mediterranean Sea. *Global Change Biology*, *24*(10), 4919–4928. doi: 10.1111/gcb.14401
Cheshire, A. C., Adler, E., Barbière, J., Cohen, Y., Evans, E., Jarayabhand, S., … Westphalen, G. (2009). *UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter* (UNEP Regional Seas Reports and Studies No. No. 186; p. 120).
Cheung, W. W., Watson, R., & Pauly, D. (2013). Signature of ocean warming in global fisheries catch. *Nature*, *497*(7449), 365. doi: https://doi.org/10.1038/nature12156
Christel, I., Certain, G., Cama, A., Vieites, D. R., & Ferrer, X. (2013). Seabird aggregative patterns: A new tool for offshore wind energy risk assessment. *Marine Pollution Bulletin*, *66*(1–2), 84–91. doi: 10.1016/j.marpolbul.2012.11.005
Cianchetti-Benedetti, M., Dell'Omo, G., Russo, T., Catoni, C., & Quillfeldt, P. (2018). Interactions between commercial fishing vessels and a pelagic seabird in the southern Mediterranean Sea. *BMC Ecology*, *18*(1), 54. doi: 10.1186/s12898-018-0212-x
Clark, B. L., Carneiro, A. P. B., Pearmain, E. J., Rouyer, M.-M., Clay, T. A., Cowger, W., … Dias, M. P. (2023). Global assessment of marine plastic exposure risk for oceanic birds. *Nature Communications*, *14*(1), 3665. doi: 10.1038/s41467-023-38900-z
Claussen, U., Connor, D., de Vrees, L., Leppänen, J.-M., Percelay, J., Kapari, M., … Rendell, J. (2011). *Common Understanding of (Initial) Assessment, Determination of Good Environmental Status (GES) & Establishment of Environmental Targets (Articles 8, 9 & 10 MSFD)*. Retrieved from https://circabc.europa.eu/sd/d/ce7e2776-6ac6-4a41-846f-a04832c32da7/05_Info_Common_understanding_final.pdf
Codina-García, M., Militão, T., Moreno, J., & González-Solís, J. (2013). Plastic debris in Mediterranean seabirds. *Marine Pollution Bulletin*, *77*(1), 220–226. doi: 10.1016/j.marpolbul.2013.10.002
Constantino, E., Martins, I., Sierra, J., & Bessa, F. (2018). Abundance and composition of floating marine macro litter on the eastern sector of the Mediterranean Sea. *Marine Pollution Bulletin*, *138*, 260–265. doi: 10.1016/j.marpolbul.2018.11.008
Cooper, J., Baccetti, N., Belda, E. J., Borg, J. J., Oro, D., Papaconstantinou, C., & Sanchez, A. (2003). Seabird mortality from longline fishing in the Mediterranean Sea and Macaronesian waters: A review and a way forward. *Scientia Marina*, *67*(Suppl. 2), 57–64.
Coppola, L., Raimbault, P., Mortier, L., & Testor, P. (2019). Monitoring the Environment in the Northwestern Mediterranean Sea. *Eos*, *100*. doi: 10.1029/2019EO125951
Cortés, V., Arcos, J. M., & González-Solís, J. (2017). Seabirds and demersal longliners in the northwestern Mediterranean: Factors driving their interactions and bycatch rates. *Marine Ecology Progress Series*, *565*, 1–16.
Cortés, V., & González-Solís, J. (2018). Seabird bycatch mitigation trials in artisanal demersal longliners of the Western Mediterranean. *PLOS ONE*, *13*(5), e0196731. doi: 10.1371/journal.pone.0196731
Costanzo, L. G., Marletta, G., & Alongi, G. (2020). Assessment of Marine Litter in the Coralligenous Habitat of a Marine Protected Area along the Ionian Coast of Sicily (Central Mediterranean). *Journal of Marine Science and Engineering*, *8*(9), 656. doi: 10.3390/jmse8090656
Costanzo, L., Marletta, G., & Alongi, G. (2021). Non-indigenous macroalgal species in coralligenous habitats of the Marine Protected Area Isole Ciclopi (Sicily, Italy). *Italian Botanist*, *11*, 31–44. doi: 10.3897/italianbotanist.11.60474
Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J.-P., Iglesias, A., … Xoplaki, E. (2018). Climate change and interconnected risks to sustainable development in the Mediterranean. *Nature Climate Change*, *8*(11), 972–980. doi: 10.1038/s41558-018-0299-2
Daniel, A., Laës-Huon, A., Barus, C., Beaton, A. D., Blandfort, D., Guigues, N., … Achterberg, E. P. (2020). Toward a Harmonization for Using in situ Nutrient Sensors in the Marine Environment. *Frontiers in Marine Science*, *6*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2019.00773
Darmon, G., Miaud, C., Claro, F., Doremus, G., & Galgani, F. (2017). Risk assessment reveals high exposure of sea turtles to marine debris in French Mediterranean and metropolitan Atlantic waters.

Deep Sea Research Part II: Topical Studies in Oceanography, *141*, 319–328. doi: 10.1016/j.dsr2.2016.07.005
de Araújo Costa, D., Dolbeth, M., Christoffersen, M. L., Zúñiga-Upegui, P. T., Venâncio, M., & de Lucena, R. F. P. (2023). An Overview of Rhodoliths: Ecological Importance and Conservation Emergency. *Life*, *13*(7), 1556. doi: 10.3390/life13071556
De la Vara, A., Parras-Berrocal, I. M., Izquierdo, A., Sein, D. V., & Cabos, W. (2022). Climate change signal in the ocean circulation of the Tyrrhenian Sea. *Earth System Dynamics*, *13*(1), 303–319. doi: 10.5194/esd-13-303-2022
Deidun, A., Marrone, A., Gauci, A., Galdies, J., Lorenti, M., Mangano, M. C., … Sarà, G. (2022). Structure and biodiversity of a Maltese maerl bed: New insight into the associated assemblage 24 years after the first investigation. *Regional Studies in Marine Science*, *52*, 102262. doi: 10.1016/j.rsma.2022.102262
Dekeling, R., Tasker, M., Van, D. G. S., Ainslie, M., Andersson, M., André, M., … Young, J. (2014). *Monitoring Guidance for Underwater Noise in European Seas- Part II: Monitoring Guidance Specifications* (JRC Scientific and Policy Reports No. JRC88045). Luxembourg: Publications Office of the European Union. Retrieved from Publications Office of the European Union website: https://publications.jrc.ec.europa.eu/repository/handle/JRC88045
Del Río, J., Ramos, D. A., Sánchez-Tocino, L., Peñas, J., & Braga, J. C. (2022). The Punta de la Mona Rhodolith Bed: Shallow-Water Mediterranean Rhodoliths (Almuñecar, Granada, Southern Spain). *Frontiers in Earth Science*, *10*. Retrieved from https://www.frontiersin.org/articles/10.3389/feart.2022.884685
Deter, J., Descamp, P., Ballesta, L., Boissery, P., & Holon, F. (2012a). A preliminary study toward an index based on coralligenous assemblages for the ecological status assessment of Mediterranean French coastal waters. *Ecological Indicators*, *20*, 345–352. https://medtrix.fr/wp-content/uploads/2019/09/Deter2012coralligenous-index-CAI.pdf. doi: 10.1016/j.ecolind.2012.03.001
Di Matteo, A., Cañadas, A., Roberts, J., Sparks, L., Panigada, S., Boisseau, O., … Hochscheid, S. (2022). Basin-wide estimates of loggerhead turtle abundance in the Mediterranean Sea derived from line transect surveys. *Frontiers in Marine Science*, *9*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2022.930412
Digka, N., Bray, L., Tsangaris, C., Andreanidou, K., Kasimati, E., Kofidou, E., … Kaberi, H. (2020). Evidence of ingested plastics in stranded loggerhead sea turtles along the Greek coastline, East Mediterranean Sea. *Environmental Pollution*, *263*, 114596. doi: 10.1016/j.envpol.2020.114596
Dimitriadis, C., Karditsa, A., Almpanidou, V., Anastasatou, M., Petrakis, S., Poulos, S., … Mazaris, A. D. (2022). Sea level rise threatens critical nesting sites of charismatic marine turtles in the Mediterranean. *Regional Environmental Change*, *22*(2), 56. doi: 10.1007/s10113-022-01922-2
Dos Santos Fernandes De Araujo, R., & Boschetti, S. (2021). *Marine Strategy Framework Directive Review and analysis of EU Member States' 2018 reports - Descriptor 5: Eutrophication* (JRC Technical Report No. JRC124915). Luxembourg: Publications Office of the European Union. Retrieved from Publications Office of the European Union website: https://publications.jrc.ec.europa.eu/repository/handle/JRC124915
Dos Santos Fernandes De Araujo, R., Somma, F., Aigars, J., Axe, P., Bartolo, A., De, C. K., … Wilkes, R. (2019). *Eutrophication in marine waters: Harmonization of MSFD methodological standards at EU level* (JRC Technical Report No. JRC117109). Publications Office of the European Union. Retrieved from Publications Office of the European Union website: https://publications.jrc.ec.europa.eu/repository/handle/JRC117109
Duncan, E., Botterell, Z., Broderick, A., Galloway, T., Lindeque, P., Nuno, A., & Godley, B. (2017). A global review of marine turtle entanglement in anthropogenic debris: A baseline for further action. *Endangered Species Research*, *34*. doi: 10.3354/esr00865
Duncan, E. M., Arrowsmith, J. A., Bain, C. E., Bowdery, H., Broderick, A. C., Chalmers, T., … Godley, B. J. (2019). Diet-related selectivity of macroplastic ingestion in green turtles (*Chelonia mydas*) in the eastern Mediterranean. *Scientific Reports*, *9*(1), 11581. doi: 10.1038/s41598-019-48086-4
Duncan, E. M., Broderick, A. C., Critchell, K., Galloway, T. S., Hamann, M., Limpus, C. J., … Godley, B. J. (2021). Plastic Pollution and Small Juvenile Marine Turtles: A Potential Evolutionary Trap. *Frontiers in Marine Science*, *8*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2021.699521

El Zrelli, R., Hcine, A., Yacoubi, L., Roa-Ureta, R. H., Gallai, N., Castet, S., … Rabaoui, L. J. (2023). Economic losses related to the reduction of Posidonia ecosystem services in the Gulf of Gabes (Southern Mediterranean Sea). *Marine Pollution Bulletin*, *186*, 114418. doi: 10.1016/j.marpolbul.2022.114418

El Zrelli, R., Rabaoui, L., Roa-Ureta, R. H., Gallai, N., Castet, S., Grégoire, M., … Courjault-Radé, P. (2020). Economic impact of human-induced shrinkage of Posidonia oceanica meadows on coastal fisheries in the Gabes Gulf (Tunisia, Southern Mediterranean Sea). *Marine Pollution Bulletin*, *155*, 111124. doi: 10.1016/j.marpolbul.2020.111124

Elliott, M., Borja, Á., McQuatters-Gollop, A., Mazik, K., Birchenough, S., Andersen, J. H., … Peck, M. (2015). Force majeure: Will climate change affect our ability to attain Good Environmental Status for marine biodiversity? *Marine Pollution Bulletin*, *95*(1), 7–27. doi: 10.1016/j.marpolbul.2015.03.015

El-Sayed, A. A. M., Ibrahim, M. I. A., Shabaka, S., Ghobashy, M. M., Shreadah, M. A., & Abdel Ghani, S. A. (2022). Microplastics contamination in commercial fish from Alexandria City, the Mediterranean Coast of Egypt. *Environmental Pollution (Barking, Essex: 1987)*, *313*, 120044. doi: 10.1016/j.envpol.2022.120044

Enrichetti, F., Bo, M., Morri, C., Montefalcone, M., Toma, M., Bavestrello, G., … Bianchi, C. N. (2019b). Assessing the environmental status of temperate mesophotic reefs: A new, integrated methodological approach. *Ecological Indicators*, *102*, 218–229. doi: 10.1016/j.ecolind.2019.02.028

Étienne, L., Daoud, A., & Beltrando, G. (2017). Evolution of salty surfaces on the Kerkennah archipelago between 1963 and 2010. *Méditerranée. Revue Géographique Des Pays Méditerranéens / Journal of Mediterranean Geography*, (128), 39–44. doi: 10.4000/mediterranee.8559

European Academies Science Advisory Council (Ed.). (2016). *Marine sustainability in an age of changing oceans and seas: Report by the European Academies' Science Advisory Council (EASAC) and the Joint Research Centre (JRC) of the European Commission*. Halle (Saale): EASAC Secretariat, Deutsche Akademie der Naturforscher Leopoldina. doi: 10.2760/787712

European Academies‘ Science Advisory Council (EASAC) & and the Joint Research Centre (JRC) of the European Commission. (2016). *Marine sustainability in an age of changing oceans and seas* (EASAC Policy Report No. 28; p. 60). Retrieved from https://mcc.jrc.ec.europa.eu/main/document.py?code=201605032025&title=Marine%20sustainability%20in%20an%20age%20of%20changing%20oceans%20and%20seas

European Commission. (2019). *Reporting on the 2018 update of articles 8, 9 & 10 for the Marine Strategy Framework Directive. MSFD Guidance Document 14* (p. 72). Bruxelles: DG Environment.

European Commission. (2020). *Background document for the Marine Strategy Framework Directive on the determination of good environmental status and its links to assessments and the setting of environmental targets. Accompanying the Report from the Commission on the European Parliament and the Council on the implementation of the Marine Strategy Framework Directive (Directive 2008/56/EC)*.

European Commission. (2022a). *MSFD CIS Guidance Document No. 19, Article 8 MSFD, May 2022* (p. 193).

European Commission. (2022b). *MSFD Common Implementation Strategy Guidance document N°18, Article 8 MSFD* (MSFD Guidance Document No. 19). Retrieved from https://hal.science/hal-03780306v1/file/MSFDguidance_2022_Art.8Assessment%281%29.pdf

European Commission, Directorate-General for Maritime Affairs and Fisheries (European Commission), & Joint Research Centre (European Commission). (2019). *The EU blue economy report 2019*. LU: Publications Office of the European Union. Retrieved from https://data.europa.eu/doi/10.2771/21854

European Environment Agency. (2018). *Contaminants in Europes seas. Moving towards a clean, non-toxic marine environment* (EEA Report No. N°25/2018; p. 66). European Environment Agency. Retrieved from European Environment Agency website: https://www.eea.europa.eu/publications/contaminants-in-europes-seas

European Environment Agency. (2019). *Marine messages II —Navigating the course towards clean, healthy and productive seas through implementation of an ecosystem-based approach* (EEA Report No. N° 17/2019; p. 77). Retrieved from https://www.eea.europa.eu/publications/marine-messages-2

European Environment Agency, & UNEP/MAP. (2020). *Towards a cleaner Mediterranean: A decade of progress. Monitoring Horizon 2020 regional initiative. Joint EEA-UNEP/MAP Report* (EEA Report No. N°07/2020; p. 56). EEA.

FAO. (2019). *Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries. Methodology for data collection* (FAO Fisheries and Aquaculture Technical Papers N No. N°640). Rome.

FAO. (2022). *The State of Mediterranean and Black Sea Fisheries 2022*. Rome, Italy: FAO. Retrieved from https://www.fao.org/documents/card/en/c/cc3370en

Farahmand, S., Hilmi, N., Cinar, M., Safa, A., Lam, V. W. Y., Djoundourian, S., … Raybaud, V. (2023). Climate change impacts on Mediterranean fisheries: A sensitivity and vulnerability analysis for main commercial species. *Ecological Economics*, *211*, 107889. doi: 10.1016/j.ecolecon.2023.107889

Ferrarin, C., Penna, P., Penna, A., Spada, V., Ricci, F., Bilić, J., … Marini, M. (2021). Modelling the Quality of Bathing Waters in the Adriatic Sea. *Water*, *13*(11), 1525. doi: 10.3390/w13111525

Ferreira, J. G., Andersen, J. H., Borja, A., Bricker, S. B., Camp, J., Silva, M. C. da, … Claussen, U. (2011). Overview of eutrophication indicators to assess environmental status within the European Marine Strategy Framework Directive. *Estuarine, Coastal and Shelf Science*, *93*(2), 117.

Fleet, D., Vlachogianni, T., & Hanke, G. (2021). *A Joint List of Litter Categories for Marine Macrolitter Monitoring* (JRC Scientific and Technical Reports No. EUR 30348; p. 55). Luxembourg: Publications Office of the European Union. doi: 10.2760/127473

Fliedner, A., Rüdel, H., Knopf, B., Lohmann, N., Paulus, M., Jud, M., … Koschorreck, J. (2018). Assessment of seafood contamination under the marine strategy framework directive: Contributions of the German environmental specimen bank. *Environmental Science and Pollution Research*, *25*(27), 26939–26956. doi: 10.1007/s11356-018-2728-1

Fonseca, V. G., Davison, P. I., Creach, V., Stone, D., Bass, D., & Tidbury, H. J. (2023). The Application of eDNA for Monitoring Aquatic Non-Indigenous Species: Practical and Policy Considerations. *Diversity*, *15*(5), 631. doi: 10.3390/d15050631

Ford, H. V., Jones, N. H., Davies, A. J., Godley, B. J., Jambeck, J. R., Napper, I. E., … Koldewey, H. J. (2022). The fundamental links between climate change and marine plastic pollution. *Science of The Total Environment*, *806*, 150392. doi: 10.1016/j.scitotenv.2021.150392

Fortibuoni, T., Amadesi, B., & Vlachogianni, T. (2021). Composition and abundance of macrolitter along the Italian coastline: The first baseline assessment within the european Marine Strategy Framework Directive. *Environmental Pollution*, *268*, 115886. doi: 10.1016/j.envpol.2020.115886

Fraschetti, S., Fabbrizzi, E., Tamburello, L., Uyarra, M. C., Micheli, F., Sala, E., … Borja, A. (2022). An integrated assessment of the Good Environmental Status of Mediterranean Marine Protected Areas. *Journal of Environmental Management*, *305*, 114370. doi: 10.1016/j.jenvman.2021.114370

Friedland, R., Macias, D., Cossarini, G., Daewel, U., Estournel, C., Garcia-Gorriz, E., … Vandenbulcke, L. (2021). Effects of Nutrient Management Scenarios on Marine Eutrophication Indicators: A Pan-European, Multi-Model Assessment in Support of the Marine Strategy Framework Directive. *Frontiers in Marine Science*, *8*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2021.596126

Galanidi, M., Aissi, M., Ali, M., Bakalem, A., Bariche, M., Bartolo, A. G., … Zenetos, A. (2023). Validated Inventories of Non-Indigenous Species (NIS) for the Mediterranean Sea as Tools for Regional Policy and Patterns of NIS Spread. *Diversity*, *15*(9), 962. doi: 10.3390/d15090962

Galanidi, M., & Zenetos, A. (2022). Data-Driven Recommendations for Establishing Threshold Values for the NIS Trend Indicator in the Mediterranean Sea. *Diversity*, *14*(1), 57. doi: 10.3390/d14010057

Galanidi, M., Zenetos, A., & Bacher, S. (2018). Assessing the socio-economic impacts of priority marine invasive fishes in the Mediterranean with the newly proposed SEICAT methodology. *Mediterranean Marine Science*, *19*(1), 107–123. doi: 10.12681/mms.15940

Galili, O., Goffman, O., Roditi-Elasar, M., Mevorach, Y., Bigal, E., Zuriel, Y., … Scheinin, A. (2023). Two Decades of Coastal Dolphin Population Surveys in Israel, Eastern Mediterranean. *Biology*, *12*(2), 328. doi: 10.3390/biology12020328

Galli, M., Baini, M., Panti, C., Giani, D., Caliani, I., Campani, T., … Fossi, M. (2023). Oceanographic and anthropogenic variables driving marine litter distribution in Mediterranean protected areas: Extensive

field data supported by forecasting modelling. *Science of The Total Environment*, *903*, 166266. doi: 10.1016/j.scitotenv.2023.166266
Galparsoro Iza, I., Menchaca, I., Seeger, I., Nurmi, M., McDonald, H., Garmendia, J., … Borja, A. (2022). *Mapping potential environmental impacts of offshore renewable energy* (ETC/ICM Report No. 2/2022). European Environmental Agency.
Garofalo, G., Quattrocchi, F., Bono, G., Di Lorenzo, M., Di Maio, F., Falsone, F., … Fiorentino, F. (2020). What is in our seas? Assessing anthropogenic litter on the seafloor of the central Mediterranean Sea. *Environmental Pollution*, *266*, 115213. doi: 10.1016/j.envpol.2020.115213
Gazeau, F., Alliouane, S., Bock, C., Bramanti, L., López Correa, M., Gentile, M., … Ziveri, P. (2014). Impact of ocean acidification and warming on the Mediterranean mussel (Mytilus galloprovincialis). *Frontiers in Marine Science*, *1*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2014.00062
GEF Adriatic Project. (2021). *Towards a Marine Good Environmental Status (GES) in Albania. Assessment of Marine Litter (EO10)* (p. 40). UNEP/MAP, PAP/RAC, SPA/RAC, , National Agency of Protected Areas of Albania and Ministry of Tourism and Environment of Albania.
Gennaro, P., Piazzi, L., Cecchi, E., Montefalcone, M., Morri, C., & Bianchi, C. N. (Eds.). (2020). *Monitoraggio e valutazione dello stato ecologico dell'habitat acoralligeno. Il coralligeno di parete*. ISPRA.
Genovart, M., Doak, D. F., Igual, J.-M., Sponza, S., Kralj, J., & Oro, D. (2017). Varying demographic impacts of different fisheries on three Mediterranean seabird species. *Global Change Biology*, *23*(8), 3012–3029. doi: 10.1111/gcb.13670
Gervasio, M. P., Soana, E., Granata, T., Colombo, D., & Castaldelli, G. (2022). An unexpected negative feedback between climate change and eutrophication: Higher temperatures increase denitrification and buffer nitrogen loads in the Po River (Northern Italy). *Environmental Research Letters*, *17*(8), 084031. doi: 10.1088/1748-9326/ac8497
Ghanem, R., Kechaou, E. S., Souissi, J. B., & Garrabou, J. (2018). Overview on the distribution of gorgonian species in Tunisian marine coastal waters (central Mediterranean). *Scientia Marina*, *82*(1), 55–66. doi: 10.3989/scimar.04675.07A
Giakoumi, S., Sini, M., Gerovasileiou, V., Mazor, T., Beher, J., Possingham, H. P., … Gucu, A. C. (2013). Ecoregion-based conservation planning in the Mediterranean: Dealing with large-scale heterogeneity. *PloS One*, *8*(10), e76449. (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3796553/).
Giménez, J., Cañadas, A., Ramírez, F., Afán, I., García-Tiscar, S., Fernández-Maldonado, C., … de Stephanis, R. (2018). Living apart together: Niche partitioning among Alboran Sea cetaceans. *Ecological Indicators*, *95*, 32–40. doi: 10.1016/j.ecolind.2018.07.020
Giorgetti, A., Partescano, E., Barth, A., Buga, L., Gatti, J., Giorgi, G., … Wenzer, M. (2018). EMODnet Chemistry Spatial Data Infrastructure for marine observations and related information. *Ocean & Coastal Management*, *166*, 9–17. doi: 10.1016/j.ocecoaman.2018.03.016
Girard, F., Girard, A., Monsinjon, J., Arcangeli, A., Belda, E., Cardona, L., … Claro, F. (2022). Toward a common approach for assessing the conservation status of marine turtle species within the european marine strategy framework directive. *Frontiers in Marine Science*, *9*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2022.790733
Gnone, G., Bellingeri, M., Airoldi, S., Gonzalvo, J., David, L., Di-Méglio, N., … Azzellino, A. (2023). Cetaceans in the Mediterranean Sea: Encounter Rate, Dominant Species, and Diversity Hotspots. *Diversity*, *15*(3), 321. doi: 10.3390/d15030321
Gobler, C. J. (2020). Climate Change and Harmful Algal Blooms: Insights and perspective. *Harmful Algae*, *91*, 101731. doi: 10.1016/j.hal.2019.101731
Gomei, M., Steenbeek, J., Coll, M., & Claudet, J. (2021). *30 by 30: Scenarios to recover biodiversity and rebuild fish stocks in the Mediterranean* (p. 29). Rome, Italy: WWF Mediterranean Marine Initiative. Retrieved from WWF Mediterranean Marine Initiative website: https://www.wwf.eu/?2248641/Scenarios-to-recover-biodiversity-and-rebuild-fish-stocks-in-the-Mediterranean-Sea
Gómez-Gras, D., Linares, C., Dornelas, M., Madin, J. S., Brambilla, V., Ledoux, J.-B., … Garrabou, J. (2021). Climate change transforms the functional identity of Mediterranean coralligenous assemblages. *Ecology Letters*, *24*(5), 1038–1051. doi: 10.1111/ele.13718

Gómez-Gutiérrez, A., Garnacho, E., Bayona, J. M., & Albaigés, J. (2007). Assessment of the Mediterranean sediments contamination by persistent organic pollutants. *Environmental Pollution*, *148*(2), 396–408. doi: 10.1016/j.envpol.2006.12.012

Gómez-Jakobsen, F., Ferrera, I., Yebra, L., & Mercado, J. M. (2022). Two decades of satellite surface chlorophyll a concentration (1998–2019) in the Spanish Mediterranean marine waters (Western Mediterranean Sea): Trends, phenology and eutrophication assessment. *Remote Sensing Applications: Society and Environment*, *28*, 100855. doi: 10.1016/j.rsase.2022.100855

González, D., Coughlan, C., Stips, A., Stolk, C., González Pola, C., Moreno Aranda, I. M., … Krzyminski, W. (2015). *Review of the Commission Decision 2010/477/EU concerning MSFD criteria for assessing Good Environmental Status. Descriptor 7 Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems* (JRC Technical Reports No. JRC97721; p. 32). Retrieved from https://mcc.jrc.ec.europa.eu/main/document.py?code=201603310431&title=Review%20of%20Commission%20Decision%202010/477/EU%20concerning%20MSFD%20criteria%20for%20assessing%20good%20environmental%20status.%20Descriptor%207

Grelaud, M., & Ziveri, P. (2020). The generation of marine litter in Mediterranean island beaches as an effect of tourism and its mitigation. *Scientific Reports*, *10*(1), 20326. doi: 10.1038/s41598-020-77225-5

Grenier, M., Idan, T., Chevaldonné, P., & Pérez, P. (2023). Mediterranean marine keystone species on the brink of extinction. *Global Change Biology*, *29*(7), 1681–1683. doi: 10.1111/gcb.16597

Groombridge, B. (1990). *Marine turtles in the Mediterranean: Distribution, population status, conservation* (p. 99) [A report to the Council of Europe Environment Conservation and Management Division]. Strasbourg.

Guérin, L., & Lizińska, A. (2022). *Analysis of the main elements of the 'Good Environmental Status' from the 1st and 2nd MSFD cycles, reported by the European Member States for the Descriptor 6 (sea floor integrity)—Links with Regional Seas' Conventions and D4 (food webs integrity) and D5 (eutrophication)* (p. 53 pages + 26 pages d'annexes) [Report]. PatriNat (OFB-CNRS-MNHN). doi: 10.13140/RG.2.2.16732.46728

Guerrero-Meseguer, L., Marín, A., & Sanz-Lázaro, C. (2017). Future heat waves due to climate change threaten the survival of *Posidonia oceanica* seedlings. *Environmental Pollution (Barking, Essex: 1987)*, *230*, 40–45. doi: 10.1016/j.envpol.2017.06.039

Guerrini, F., Mari, L., & Casagrandi, R. (2021). The dynamics of microplastics and associated contaminants: Data-driven Lagrangian and Eulerian modelling approaches in the Mediterranean Sea. *Science of The Total Environment*, *777*, 145944. doi: 10.1016/j.scitotenv.2021.145944

Hanke, G., Galgani, F., Werner, S., Oosterbaan, L., Nilsson, P., Fleet, D., … Liebezeit, G. (2014). *Guidance on Monitoring of Marine Litter in European Seas* [JRC Technical Reports]. Retrieved from https://publications.jrc.ec.europa.eu/repository/handle/JRC83985

Hazel, J., Lawler, I., Marsh, H., & Robson, S. (2007). Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research*, *3*, 105–113. doi: 10.3354/esr003105

Hidalgo, M., El-Haweet, A. E., Tsikliras, A. C., Tirasin, E. M., Fortibuoni, T., Ronchi, F., … Vasconcellos, M. (2022). Risks and adaptation options for the Mediterranean fisheries in the face of multiple climate change drivers and impacts. *ICES Journal of Marine Science*, *79*(9), 2473–2488. doi: 10.1093/icesjms/fsac185

Hochscheid, S., Maffucci, F., Abella, E., Bradai, M. N., Camedda, A., Carreras, C., … Tomás, J. (2022). Nesting range expansion of loggerhead turtles in the Mediterranean: Phenology, spatial distribution, and conservation implications. *Global Ecology and Conservation*, *38*, e02194. doi: 10.1016/j.gecco.2022.e02194

Holon, F., Marre, G., Parravicini, V., Mouquet, N., Bockel, T., Descamp, P., … Deter, J. (2018). A predictive model based on multiple coastal anthropogenic pressures explains the degradation status of a marine ecosystem: Implications for management and conservation. *Biological Conservation*, *222*. doi: 10.1016/j.biocon.2018.04.006

Houngnandan, F., Kéfi, S., & Deter, J. (2020). Identifying key-conservation areas for Posidonia oceanica seagrass beds. *Biological Conservation*, *247*, 108546. Archimer. doi: 10.1016/j.biocon.2020.108546

Hüseyinoğlu, M. F., Arda, Y., & Jiménez, C. (2023). *Manual of invasive alien species in the Eastern Mediterranean* (IUCN). Gland, Switerland: IUCN. Retrieved from https://portals.iucn.org/library/node/50729
ICES. (2014a). *Report of the Workshop to develop recommendations for potentially useful Food Web Indicators (WKFooWI), 31 March–3 April 2014, ICES Headquarters* (No. ICES CM 2014\ACOM:48; p. 75). Copenhagen, Denmark.
ICES. (2014b). *Report of the Workshop to draft recommendations for the assessment of Descriptor D3 (WKD3R), 13-17 January 2014* (No. ICES CM 2014/ACOM:50.; p. 153). Copenhagen, Denmark: ICES.
ICES. (2015a). *Report of the Workshop on guidance for the review of MSFD decision descriptor 3 – commercial fish and shellfish II (WKGMSFDD3-II) 10-12 February 2015. ICES Headquarters, Denmark* (No. ICES CM 2015\ACOM:48; p. 36). ICES.
ICES. (2015b). *Report of the Workshop on guidance for the review of MSFD decision descriptor 4 – foodwebs II (WKGMSFDD4-II), 24-25 February 2015, ICES Headquarters* (No. ICES CM 2015\ACOM:49; p. 52). Denmark.
ICES. (2017). *Report of the Workshop on guidance on development of operational methods for the evaluation of the MSFD criterion D3.3 (WKIND3.3ii), 1–4 November 2016, ICES HQ, Copenhagen, Denmark,* (p. 155) [ICES CM 2016/ ACOM: 44].
ICES. (2019a). *EU request to advise on a seafloor assessment process for physical loss (D6C1, D6C4) and physical disturbance (D6C2) on benthic habitats*. Retrieved from https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/Special_Requests/eu.2019.25.pdf
ICES. (2014b). *Introduction and general advice. EU request to ICES for review of the Marine Strategy Framework Directive: Descriptor 6_Seafloor integrity*.
ICES. (2019c). *Workshop on scoping of physical pressure layers causing loss of benthic habitats D6C1– methods to operational data products (WKBEDLOSS).* (ICES Scientific Reports No. 1:15; p. 37). Retrieved from https://archimer.ifremer.fr/doc/00585/69712/
ICES Advisory Committee. (2019b). *Workshop on scoping for benthic pressure layers. D6C2—From methods to operational data product (WKBEDPRES1), 24-26 October 2018* (No. ICES CM 2018/ACOM:59; p. 69). ICES HQ, Copenhagen, Denmark. Retrieved from https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2018/WKBEDPRES%201/WKBEDPRES%201%20Report.pdf#search=seabed
IDEM Project. (2019). *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* (p. 77) [IDEM (Implementation of the MSFD to the Deep Mediterranean Sea) Project]. UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM. Retrieved from UNIVPM, CNR, CSIC, DFMR, ENEA, TAU, UB, UM website: http://www.msfd-idem.eu/?q=system/files/Deliverable%203.3_IDEM%20Project_ALL_0.pdf
Impellitteri, F., Multisanti, C. R., Rusanova, P., Piccione, G., Falco, F., & Faggio, C. (2023). Exploring the Impact of Contaminants of Emerging Concern on Fish and Invertebrates Physiology in the Mediterranean Sea. *Biology*, *12*(6), 767. doi: 10.3390/biology12060767
Indicit II. (2021). *Standard protocol to monitor entanglement of sea turtles and biota in marine litter*.
Interpol. (2007). *Interpol illegal oil discharges from vessels investigative manual*.
Jac, C., Desroy, N., Certain, G., Foveau, A., Labrune, C., & Vaz, S. (2020a). Detecting adverse effect on seabed integrity. Part 1: Generic sensitivity indices to measure the effect of trawling on benthic mega-epifauna. *Ecological Indicators*, *117*. doi: 10.1016/j.ecolind.2020.106631
Jac, C., Desroy, N., Certain, G., Foveau, A., Labrune, C., & Vaz, S. (2020b). Detecting adverse effect on seabed integrity. Part 2: How much of seabed habitats are left in good environmental status by fisheries? *Ecological Indicators*, *117*, 106617. doi: 10.1016/j.ecolind.2020.106617
Jančič, M., Salvemini, P., Holcer, D., Piroli, V., Haxhiu, I., Lazar, B., … Kao, J. (2022). Apparent increasing importance of Adriatic Sea as a developmental habitat for Mediterranean green sea turtles (Chelonia mydas). *Natura Croatica*, *31*, 225–240. doi: 10.20302/NC.2022.31.16
Jardim, V. L., Gauthier, O., Toumi, C., & Grall, J. (2022). Quantifying maerl (rhodolith) habitat complexity along an environmental gradient at regional scale in the Northeast Atlantic. *Marine Environmental Research*, *181*, 105768. doi: 10.1016/j.marenvres.2022.105768

JNCC. (2018a). *Autonomous Underwater Vehicles for use in marine benthic monitoring*. Peterborough. Retrieved from https://data.jncc.gov.uk/data/f52a772a-1d81-4cab-b850-7a9e32d0fef6/JNCC-MMPG-002-FINAL-WEB.pdf
Jozić, S., Baljak, V., Cenov, A., Lušić, D., Galić, D., Glad, M., … Vukić Lušić, D. (2021). Inland and Coastal Bathing Water Quality in the Last Decade (2011–2020): Croatia vs. Region vs. EU. *Water*, *13*(17), 2440. doi: 10.3390/w13172440
Karamanlidis, Aa, Dendrinos, P., & Trillmich, F. (2021). Maternal behavior and early behavioral ontogeny of the Mediterranean monk seal Monachus monachus in Greece. *Endangered Species Research*, *45*, 13–20. doi: 10.3354/esr01114
Karamanlidis, Alexandros, Androukaki, E., Adamantopoulou, S., Chatzispyrou, A., Johnson, W., Kotomatas, S., … Dendrinos, P. (2008). Assessing accidental entanglement as a threat to the Mediterranean monk seal Monachus monachus. *Endangered Species Research*, *5*, 205–213. doi: 10.3354/esr00092
Karamanlidis, Alexandros, Dendrinos, P., Larrinoa, P., Gucu, A. C., Johnson, W., Kıraç, C., & Pires, R. (2015). The Mediterranean monk seal *Monachus monachus*: Status, biology, threats, and conservation priorities. *Mammal Review*, *46*. doi: 10.1111/mam.12053
Karamitros, G., Gkafas, G. A., Giantsis, I. A., Martsikalis, P., Kavouras, M., & Exadactylos, A. (2020). Model-Based Distribution and Abundance of Three Delphinidae in the Mediterranean. *Animals : An Open Access Journal from MDPI*, *10*(2), 260. doi: 10.3390/ani10020260
Kassis, D., & Varlas, G. (2021). Hydrographic effects of an intense “medicane” over the central-eastern Mediterranean Sea in 2018. *Dynamics of Atmospheres and Oceans*, *93*, 101185. doi: 10.1016/j.dynatmoce.2020.101185
Katsanevakis, S., Olenin, S., Puntila-Dodd, R., Rilov, G., Stæhr, P. A. U., Teixeira, H., … Tidbury, H. J. (2023). Marine invasive alien species in Europe: 9 years after the IAS Regulation. *Frontiers in Marine Science*, *10*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2023.1271755
Katsanevakis, S., Tempera, F., & Teixeira, H. (2016). Mapping the impact of alien species on marine ecosystems: The Mediterranean Sea case study. *Diversity and Distributions*, *22*(6), 694–707. doi: 10.1111/ddi.12429
Katsanevakis, S., Tsirintanis, K., Sini, M., Gerovasileiou, V., & Koukourouvli, N. (2020). Aliens in the Aegean – a sea under siege (ALAS). *Research Ideas and Outcomes*, *6*, e53057. doi: 10.3897/rio.6.e53057
Keramidas, I., Tsikliras, A. C., Zenetos, A., & Karachle, P. K. (2023). Risk assessment of Golani’s round herring (Etrumeus golanii) in the Greek seas (northeastern Mediterranean Sea). *Frontiers in Marine Science*, *10*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2023.1220318
Kibria, G., Nugegoda, D., Rose, G., & Haroon, A. K. Y. (2021). Climate change impacts on pollutants mobilization and interactive effects of climate change and pollutants on toxicity and bioaccumulation of pollutants in estuarine and marine biota and linkage to seafood security. *Marine Pollution Bulletin*, *167*, 112364. doi: 10.1016/j.marpolbul.2021.112364
Kleitou, P., Hall-Spencer, J. M., Savva, I., Kletou, D., Hadjistylli, M., Azzurro, E., … Rees, S. E. (2021). The Case of Lionfish (Pterois miles) in the Mediterranean Sea Demonstrates Limitations in EU Legislation to Address Marine Biological Invasions. *Journal of Marine Science and Engineering*, *9*(3), 325. doi: 10.3390/jmse9030325
Komi, A., Petropoulos, A., Evelpidou, N., Poulos, S., & Kapsimalis, V. (2022). Coastal Vulnerability Assessment for Future Sea Level Rise and a Comparative Study of Two Pocket Beaches in Seasonal Scale, Ios Island, Cyclades, Greece. *Journal of Marine Science and Engineering*, *10*(11), 1673. doi: 10.3390/jmse10111673
Kuplulu, O., Cil, G. I., Korkmaz, S. D., Aykut, O., & Ozansoy, G. (2018). Determination of Metal Contamination in Seafood from the Black, Marmara, Aegean and Mediterranean Sea Metal Contamination in Seafood. *Journal of the Hellenic Veterinary Medical Society*, *69*(1), 749–758. doi: 10.12681/jhvms.16400
Kurt, M., & Gücü, A.-C. (2021). Demography and population structure of Northeastern Mediterranean monk seal population. *Mediterranean Marine Science*, *22*(1), 79_87. doi: http://dx.doi.org/10.12681/mms.21913

Laloë, J.-O., Cozens, J., Renom, B., Taxonera, A., & Hays, G. C. (2017). Climate change and temperature-linked hatchling mortality at a globally important sea turtle nesting site. *Global Change Biology*, *23*(11), 4922–4931. doi: 10.1111/gcb.13765
Lambert, C., Authier, M., Dorémus, G., Laran, S., Panigada, S., Spitz, J., … Ridoux, V. (2020). Setting the scene for Mediterranean litterscape management: The first basin-scale quantification and mapping of floating marine debris. *Environmental Pollution*, *263*, 114430. doi: 10.1016/j.envpol.2020.114430
Langhans, S. D., Reichert, P., & Schuwirth, N. (2014). The method matters: A guide for indicator aggregation in ecological assessments. *Ecological Indicators*, (45), 494–507.
Le Bris, N., & Levin, L. (2020). *Climate change cumulative impacts on deep-sea ecosystems*. doi: 10.1093/oso/9780198841654.003.0009
Lefebvre, A., & Devreker, D. (2020). First Comprehensive Quantitative Multi-Parameter Assessment of the Eutrophication Status from Coastal to Marine French Waters in the English Channel, the Celtic Sea, the Bay of Biscay, and the Mediterranean Sea. *Journal of Marine Science and Engineering*, *8*(8), 561. doi: 10.3390/jmse8080561
Lejeusne, C., Chevaldonné, P., Pergent-Martini, C., Boudouresque, C. F., & Pérez, T. (2010). Climate change effects on a miniature ocean: The highly diverse, highly impacted Mediterranean Sea. *Trends in Ecology & Evolution*, *25*(4), 250–260. doi: https://doi.org/10.1016/j.tree.2009.10.009
Lincoln, S., Andrews, B., Birchenough, S. N. R., Chowdhury, P., Engelhard, G. H., Harrod, O., … Townhill, B. L. (2022). Marine litter and climate change: Inextricably connected threats to the world's oceans. *Science of The Total Environment*, *837*, 155709. doi: 10.1016/j.scitotenv.2022.155709
Lionetto, M. G., Caricato, R., & Giordano, M. E. (2021). Pollution Biomarkers in the Framework of Marine Biodiversity Conservation: State of Art and Perspectives. *Water*, *13*(13), 1847. doi: 10.3390/w13131847
Llabrés, E., Blanco-Magadán, A., Sales, M., & Sintes, T. (2023). Effect of global warming on Western Mediterranean seagrasses: A preliminary agent-based modelling approach. *Marine Ecology Progress Series*, *710*, 43–56. doi: 10.3354/meps14298
Machado, I., Moura, T., Figueiredo, I., Chaves, C., Costa, J., & Cabral, H. (2020). Effects of scale on the assessment of fish biodiversity in the marine strategy framework directive context. *Ecological Indicators*, *117*, 106546. doi: 10.1016/j.ecolind.2020.106546
Macias, D., Cózar, A., Garcia-Gorriz, E., González-Fernández, D., & Stips, A. (2019). Surface water circulation develops seasonally changing patterns of floating litter accumulation in the Mediterranean Sea. A modelling approach. *Marine Pollution Bulletin*, *149*, 110619. doi: 10.1016/j.marpolbul.2019.110619
Maggio, T., Perzia, P., Pazzini, A., Campagnuolo, S., Falautano, M., Mannino, A. M., … Castriota, L. (2022). Sneaking into a Hotspot of Biodiversity: Coverage and Integrity of a Rhodolith Bed in the Strait of Sicily (Central Mediterranean Sea). *Journal of Marine Science and Engineering*, *10*(12), 1808. doi: 10.3390/jmse10121808
Magliozzi, C., Druon, J.-N., Boschetti, S., & Palialexis, A. (2021). *Marine Strategy Framework Directive - Review and analysis of EU Member States' 2018 reports - Descriptor 1: Pelagic habitats*. doi: 10.2760/09511
Magliozzi, C., Druon, J.-N., Palialexis, A., Aguzzi, L., Alexande, B., Antoniadis, K., … Zervoudaki, S. (2021). *Pelagic habitats under the MSFD D1: Scientific advice of policy relevance*. doi: 10.2760/081368
Magliozzi, C., Druon, J.-N., Palialexis, A., Artigas, L. F., Boicenco, L., González-Quirós, R., … Varkitzi, I. (2021). *Pelagic habitats under MSFD D1: Current approaches and priorities*. doi: 10.2760/942589
Magliozzi, C., Palma, M., Druon, J.-N., Palialexis, A., Mcquatters-Gollop, A., Varkitzi, I., … Artigas, L. F. (2023). *Status of pelagic habitats within the EU-Marine Strategy Framework Directive: Proposals for improving consistency and representativeness of the assessment*. doi: 10.1016/j.marpol.2022.105467
Magliozzi, C., Van, H. N., Živana, N. G., & Cardoso, A.-C. (2023). *Establishing thresholds: Workshop on the MSFD Newly Introduced NIS (D2C1)* (JRC Conference and Workshop Report No. JRC132962.). Luxembourg: Publications Office of the European Union. doi: 10.2760/631257
Malagó, A., Bouraoui, F., Grizzetti, B., & De Roo, A. (2019). Modelling nutrient fluxes into the Mediterranean Sea. *Journal of Hydrology: Regional Studies*, *22*, 100592. doi: 10.1016/j.ejrh.2019.01.004

Mandić, M., Gvozdenović, S., De Vito, D., Alfonso, G., Daja, S., Ago, B., … Piraino, S. (2022). Setting thresholds is not enough: Beach litter as indicator of poor environmental status in the southern Adriatic Sea. *Marine Pollution Bulletin*, *177*, 113551. doi: 10.1016/j.marpolbul.2022.113551
Manini, E., Baldrighi, E., Ricci, F., Grilli, F., Giovannelli, D., Casabianca, S., … Penna, A. (2022). Assessment of Spatio-Temporal Variability of Faecal Pollution along Coastal Waters during and after Rainfall Events. *Water*, *14*, 502. doi: 10.3390/w14030502
Mannino, A. M., Balistreri, P., Mancuso, F. P., Bozzeda, F., & Pinna, M. (2023). Searching for the competitive ability of the alien seagrass *Halophila stipulacea* with the autochthonous species *Cymodocea nodosa*. *NeoBiota*, *83*, 155–177. doi: 10.3897/neobiota.83.99508
Mannino, A. M., Bertolino, F., Deidun, A., & Balistreri, P. (2018). *Effects of NIS on Mediterranean marine ecosystems: The case study of Egadi Island MPA (Sicily, Tyrrhenian Sea)*. 16858.
Mannocci, L., Roberts, J. J., Halpin, P. N., Authier, M., Boisseau, O., Bradai, M. N., … Vella, J. (2018). Assessing cetacean surveys throughout the Mediterranean Sea: A gap analysis in environmental space. *Scientific Reports*, *8*(1), 3126. doi: 10.1038/s41598-018-19842-9
Marampouti, C., Buma, A. G. J., & de Boer, M. K. (2021). Mediterranean alien harmful algal blooms: Origins and impacts. *Environmental Science and Pollution Research*, *28*(4), 3837–3851. doi: 10.1007/s11356-020-10383-1
Marbà, N., & Duarte, C. M. (2010). Mediterranean warming triggers seagrass (Posidonia oceanica) shoot mortality. *Global Change Biology*, *16*(8), 2366–2375. doi: 10.1111/j.1365-2486.2009.02130.x
Marbà, N., Jorda, G., Agusti, S., Girard, C., & Duarte, C. M. (2015). Footprints of climate change on Mediterranean Sea biota. *Frontiers in Marine Science*, *2*. doi: 10.3389/fmars.2015.00056
Marchessaux, G., Gjoni, V., & Sarà, G. (2023). Environmental drivers of size-based population structure, sexual maturity and fecundity: A study of the invasive blue crab *Callinectes sapidus* (Rathbun, 1896) in the Mediterranean Sea. *PLOS ONE*, *18*(8), e0289611. doi: 10.1371/journal.pone.0289611
Martin, C. S., Giannoulaki, M., De Leo, F., Scardi, M., Salomidi, M., Knittweis, L., … Fraschetti, S. (2014). Coralligenous and maërl habitats: Predictive modelling to identify their spatial distributions across the Mediterranean Sea. *Scientific Reports*, *4*(1), 5073. doi: 10.1038/srep05073
Martin, S., & Hall-Spencer, J. (2017). Effects of Ocean Warming and Acidification on Rhodolith/Maërl Beds. In R. Riosmena-Rodriguez, W. Nelson, & J. Aguirre (Eds.), *Rhodolith/Maërl Beds: A Global Perspective* (pp. 55–85). Springer. doi: 10.1007/978-3-319-29315-8_3
Martins, S., Patino−Martinez, J., Abella, E., de Santos Loureiro, N., Clarke, L. J., & Marco, A. (2022). Potential impacts of sea level rise and beach flooding on reproduction of sea turtles. *Climate Change Ecology*, *3*, 100053. doi: 10.1016/j.ecochg.2022.100053
Mauffret, A., Bajt, O., Bellas, J., Chalkiadaki, O., Dassenakis, M., Giannoudi, L., … Zeri, C. (2019). *Report on the approaches implemented in the Mediterranean countries for GES descriptor 8 Proposition of a road map for a better harmonization* (p. 72). MEDCIS project (Support Mediterranean Member States towards coherent and Coordinated Implementation of the second phase of the MSFD). Retrieved from MEDCIS project (Support Mediterranean Member States towards coherent and Coordinated Implementation of the second phase of the MSFD) website: https://archimer.ifremer.fr/doc/00620/73249/72463.pdf
McIvor, A. J., Pires, R., Lopes, C., Raimundo, J., Campos, P. F., Pais, M. P., … Dinis, A. (2023). Assessing microplastic exposure of the Critically Endangered Mediterranean monk seal (*Monachus monachus*) on a remote oceanic island. *Science of The Total Environment*, *856*, 159077. doi: 10.1016/j.scitotenv.2022.159077
McKenzie, L. J., Nordlund, L. M., Jones, B. L., Cullen-Unsworth, L. C., Roelfsema, C., & Unsworth, R. K. F. (2020). The global distribution of seagrass meadows. *Environmental Research Letters*, *15*(7), 074041. doi: 10.1088/1748-9326/ab7d06
MedECC. (2020). *Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report* (W. Cramer & J. Guiot, Eds.). Marseille: Union for the Mediterranean, Plan Bleu, UNEP/ MAP. Retrieved from https://www.medecc.org/medecc-reports/climate-and-environmental-change-in-the-mediterranean-basin-current-situation-and-risks-for-the-future-1st-mediterranean-assessment-report/

Merchant, N. D., Putland, R. L., André, M., Baudin, E., Felli, M., Slabbekoorn, H., & Dekeling, R. (2022). A decade of underwater noise research in support of the European Marine Strategy Framework Directive. *Ocean & Coastal Management*, *228*, 106299. doi: 10.1016/j.ocecoaman.2022.106299

Merhaby, D., Rabodonirina, S., Net, S., Ouddane, B., & Halwani, J. (2019). Overview of sediments pollution by PAHs and PCBs in mediterranean basin: Transport, fate, occurrence, and distribution. *Marine Pollution Bulletin*, *149*, 110646. doi: 10.1016/j.marpolbul.2019.110646

Merino, F., & Prats, M. A. (2022). Are blue flags a good indicator of the quality of sea water on beaches? An empirical analysis of the Western Mediterranean basin. *Journal of Cleaner Production*, *330*, 129865. doi: 10.1016/j.jclepro.2021.129865

Mili, S., Ennouri, R., Zarrouk, H., & Fatnassi, M. (2021). Development of the fishing and commercialization of the blue crabs in Bizerta and Ghar EL Melh lagoons: A case study of promotion opportunities of blue growth in Tunisia. *Journal of Aquaculture & Marine Biology*, *Volume 10*(Issue 2), 66–74. doi: 10.15406/jamb.2021.10.00308

Militão, T., Sanz-Aguilar, A., Rotger, A., & Ramos, R. (2022). Non-breeding distribution and at-sea activity patterns of the smallest European seabird, the European Storm Petrel (Hydrobates pelagicus). *Ibis*, *164*(4), 1160–1179. doi: 10.1111/ibi.13068

Mitrić, M., & Ramšak, A. (2021). Sampling Site Specific Biomarker Responses in Mediterranean Mussels from the Adriatic Sea. *Bulletin of Environmental Contamination and Toxicology*, *106*(2), 310–317. doi: 10.1007/s00128-020-03083-6

Montefalcone, M., Tunesi, L., & Ouerghi, A. (2021). A review of the classification systems for marine benthic habitats and the new updated Barcelona Convention classification for the Mediterranean. *Marine Environmental Research*, *169*, 105387. doi: 10.1016/j.marenvres.2021.105387

Moullec, F., Barrier, N., Guilhaumon, F., Peck, M. A., Ulses, C., & Shin, Y.-J. (2023). Rebuilding Mediterranean marine resources under climate change. *Marine Ecology Progress Series*, *708*, 1–20. doi: 10.3354/meps14269

MSFD Technical Group on Marine Litter. (2013). *Guidance on Monitoring of Marine Litter in European Seas. A guidance document within the Common Implementation Strategy for the Marine Strategy Framework Directive* (JRC Scientific and Policy Reports No. EUR 26113 EN; p. 128). Luxembourg: European Commission.

Nicolaou, H., Dendrinos, P., Marcou, M., Michaelides, S., & Karamanlidis, A. A. (2021). Re-establishment of the Mediterranean monk seal Monachus monachus in Cyprus: Priorities for conservation. *Oryx*, *55*(4), 526–528. doi: 10.1017/S0030605319000759

Nin, C. J., & Rodgher, S. (2021). Effect of a temperature rise on metal toxicity for the aquatic biota: A systematic review. *Brazilian Journal of Environmental Sciences (RBCIAMB)*, *56*(4), 710–720. doi: 10.5327/Z217694781010

NOAA. (2017). *Mediterranean Monk Seal (Monachus monachus) 5-Year Review: Summary and Evaluation* (p. 31). National Marine Fisheries Service Office of Protected Ressources.

Nwankwegu, A. S., Li, Y., Huang, Y., Wei, J., Norgbey, E., Sarpong, L., … Wang, K. (2019). Harmful algal blooms under changing climate and constantly increasing anthropogenic actions: The review of management implications. *3 Biotech*, *9*(12), 449. doi: 10.1007/s13205-019-1976-1

Orthodoxou, D. L., Loizidou, X. I., Baldwin, C., Kocareis, C., Karonias, A., & Ateş, M. A. (2022). Seasonal and geographic variations of marine litter: A comprehensive study from the island of Cyprus. *Marine Pollution Bulletin*, *177*, 113495. doi: 10.1016/j.marpolbul.2022.113495

Osterhaus, A., van de Bildt, M., Vedder, L., Martina, B., Niesters, H., Vos, J., … Barham, M. E. O. (1998). Monk seal mortality: Virus or toxin? *Vaccine*, *16*(9), 979–981. doi: 10.1016/S0264-410X(98)00006-1

Otero, M. M., Serena, F., Gerovasileiou, V., Barone, M., Bo, M., Arcos, J. M., … Xavier, J. (2019). *Identification guide of vulnerable species incidentally caught in Mediterranean fisheries* (p. 204) [IUCN, Malaga, Espagne].

Öztürk, B. (2021). *Non-indigenous species in the Mediterranean and the Black Sea*. Rome, Italy: FAO. doi: 10.4060/cb5949en

Pace, D. S., Ferri, S., Giacomini, G., Di Marco, C., Papale, E., Silvestri, M., … Ardizzone, G. (2022). Resources and population traits modulate the association patterns in the common bottlenose dolphin living nearby the Tiber River estuary (Mediterranean Sea). *Frontiers in Marine Science*, *9*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2022.935235

Palialexis, A., & Boschetti, S. (2021). *Marine Strategy Framework Directive - Review and analysis of Member States' 2018 reports Descriptor 1: Species biological diversity*. doi: 10.2760/27700
Palialexis, A., Boschetti, S., Vasilakopoulos, P., & Somma, F. (2020). *Alignment of the Marine Strategy Framework Directive and the Habitats Directive: Current state and future perspectives*. doi: 10.2760/581087
Palialexis, A., Connor, D., Damalas, D., Gonzalvo, J., Micu, D., Mitchel, I., … Somma, F. (2019). *Indicators for status assessment of species, relevant to MSFD Biodiversity Descriptor: Identifying methods to set thresholds for the GES assessment* (JRC Technical Reports No. EUR 29820 EN; p. 66). Luxembourg. Retrieved from doi:10.2760/282667, JRC117126
Palialexis, A., De, J. C. A., & Somma, F. (2018). *JRC's reference lists of MSFD species and habitats: MSFD reporting for Descriptors 1 and 6*. doi: 10.2760/794186
Palialexis, A., Korpinen, S., Rees, A., Mitchell, I., Micu, D., Gonzalvo, J., … Tuaty-Guerra, M. (2021a). *Species thresholds: Review of methods to support the EU Marine Strategy Framework Directive MSFD Descriptor 1 biological diversity* (JRC Technical Report No. EUR 30680 EN.). doi: 10.2760/52931
Palialexis, A., Kousteni, V., Boicenco, L., Enserink, L., Pagou, K., Zweifel, U. L., … Connor, D. (2021b). Monitoring biodiversity for the EU Marine Strategy Framework Directive: Lessons learnt from evaluating the official reports. *Marine Policy*, *128*, 104473. doi: 10.1016/j.marpol.2021.104473
Panayotidis, P., Papathanasiou, V., Gerakaris, V., Fakiris, E., Orfanidis, S., Papatheodorou, G., … Loukaidi, V. (2022). *Seagrass meadows in the Greek Seas* [Data set]. SEANOE. doi: https://doi.org/10.17882/87740
Panigada, S., Lauriano, G., Donovan, G., Pierantonio, N., Cañadas, A., Vázquez, J. A., & Burt, L. (2017). Estimating cetacean density and abundance in the Central and Western Mediterranean Sea through aerial surveys: Implications for management. *Deep Sea Research Part II: Topical Studies in Oceanography*, *141*, 41–58. doi: 10.1016/j.dsr2.2017.04.018
Panou, A., Giannoulaki, M., Varda, D., Lazaj, L., Pojana, G., & Bundone, L. (2023). Towards a strategy for the recovering of the Mediterranean monk seal in the Adriatic-Ionian Basin. *Frontiers in Marine Science*, *10*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2023.1034124
PAP/RAC. (2023). *2023 Quality Status Report (QSR) Content on IMAP Ecological Objectives (EO) 7 and 8. Contribution to the 2023 Med QSR for the cluster on Coast and Hydrography* (p. 37). Split: PAP/RAC.
PAP/RAC, UNEP/MAP, & SPA/RAC. (2021). *Towards a Marine Good Environmental Status (GES) in Montenegro. Assessment of Hydrography (EO7)*. GEF Adriatic Project.
Paracuellos, M., & Nevado, J. C. (2003). Nesting seabirds in SE Spain: Distribution, numbers and trends in the province of Almería. *Scientia Marina*, *67*(Suppl.2), 125–128.
Parras-Berrocal, I. M., Vazquez, R., Cabos, W., Sein, D., Mañanes, R., Perez-Sanz, J., & Izquierdo, A. (2020). The climate change signal in the Mediterranean Sea in a regionally coupled atmosphere–ocean model. *Ocean Science*, *16*(3), 743–765. doi: 10.5194/os-16-743-2020
Patricio, A., Hawkes, L., Monsinjon, J., Godley, B., & Fuentes, M. (2021). Climate change and marine turtles: Recent advances and future directions. *Endangered Species Research*. doi: 10.3354/esr01110
Pedrotti, M. L., Lombard, F., Baudena, A., Galgani, F., Elineau, A., Petit, S., … Gorsky, G. (2022). An integrative assessment of the plastic debris load in the Mediterranean Sea. *Science of The Total Environment*, *838*, 155958. doi: 10.1016/j.scitotenv.2022.155958
Perroca, J., Giarrizzo, T., Azzurro, E., Rodrigues-Filho, J. L., da Silva, C., Arcifa, M., & Azevedo-Santos, V. (2022). Negative effects of ghost nets on Mediterranean biodiversity. *Aquatic Ecology*. doi: 10.1007/s10452-022-09985-3
Pettex, E., David, L., Authier, M., Blanck, A., Dorémus, G., Falchetto, H., … Ridoux, V. (2017). Using large scale surveys to investigate seasonal variations in seabird distribution and abundance. Part I: The North Western Mediterranean Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, *141*, 74–85. doi: 10.1016/j.dsr2.2016.11.008
Phillips, G., Kelly, M., Teixeira, H., Salas, H. M. F., Free, G., Leujak, W., … Poikane, S. (2018). *Best practice for establishing nutrient concentrations to support good ecological status* (JRC Science for Policy Report No. JRC112667). Publications Office of the European Union. Retrieved from

Publications Office of the European Union website: https://publications.jrc.ec.europa.eu/repository/handle/JRC112667
Piazzi, L., Cecchi, E., Cinti, M. F., & Ceccherelli, G. (2021). Extreme events and conservation of subtidal habitats: Effects of a rainfall flood on coralligenous reefs. *Marine Pollution Bulletin*, *165*, 112106. doi: 10.1016/j.marpolbul.2021.112106
Pierdomenico, M., Bonifazi, A., Argenti, L., Ingrassia, M., Casalbore, D., Aguzzi, L., … Chiocci, F. L. (2021). Geomorphological characterization, spatial distribution and environmental status assessment of coralligenous reefs along the Latium continental shelf. *Ecological Indicators*, *131*, 108219. doi: 10.1016/j.ecolind.2021.108219
Pietroluongo, G., Quintana Martín-Montalvo, B., Ashok, K., Miliou, A., Fosberry, J., Antichi, S., … Azzolin, M. (2022). Combining Monitoring Approaches as a Tool to Assess the Occurrence of the Mediterranean Monk Seal in Samos Island, Greece. *Hydrobiology*, *1*, 440–450. doi: 10.3390/hydrobiology1040026
Piroddi, C., Teixeira, H., Lynam, C. P., Smith, C., Alvarez, M. C., Mazik, K., … Uyarra, M. C. (2015). Using ecological models to assess ecosystem status in support of the European Marine Strategy Framework Directive. *Ecological Indicators*, *58*, 175–191. doi: 10.1016/j.ecolind.2015.05.037
Pitacco, V., Mistri, M., Granata, T., Moruzzi, L., Meloni Maria, L., Massara, F., … Munari, C. (2021). Sediment Contamination by Heavy Metals and PAH in the Piombino Channel (Tyrrhenian Sea). *Water*, *13*(11), 1487. doi: 10.3390/w13111487
Plan Bleu. (2019). *Science-Policy Interface (SPI) to support monitoring implementation plans as well as sub-regional and regional policy- developments regarding EcAp clusters on pollution, contaminants and eutrophication, marine biodiversity and fisheries, coast and hydrography* (Technical Paper No. 18). Retrieved from https://planbleu.org/wp-content/uploads/2019/11/Cahier18_EN_SPI.pdf
Polimene, L., Parn, O., Garcia, G. E., Macias, M. D., Stips, A., Duteil, O., … Serpetti, N. (2023). Should we reconsider how to assess eutrophication? *Journal of Plankton Research*, *45*(3), 413–420. doi: https://doi.org/10.1093/plankt/fbad022
Polinov, S., Bookman, R., & Levin, N. (2021). Spatial and temporal assessment of oil spills in the Mediterranean Sea. *Marine Pollution Bulletin*, *167*, 112338. doi: 10.1016/j.marpolbul.2021.112338
Powley, H. R., Krom, M. D., & Van Cappellen, P. (2018). Phosphorus and nitrogen trajectories in the Mediterranean Sea (1950–2030): Diagnosing basin-wide anthropogenic nutrient enrichment. *Progress in Oceanography*, *162*, 257–270. doi: 10.1016/j.pocean.2018.03.003
Prins, T. C., Borja, A., Simboura, N., Tsangaris, C., Van der Meulen, M. D., Boon, A. R., … Gilbert, A. J. (2014). *Coherent geographic scales and aggregation rules for environmental status assessment within the Marine Strategy Framework Directive. Towards a draft guidance.* (No. Report 1207879-000-ZKS-0014 to the European Commission). Deltares/AZTI/HCMR.
Probst, W. Nikolaus. (2023). An approach to assess exploited fish stocks compliant to the requirements of the Marine Strategy Framework Directive (MSFD) including criterion D3C3. *Ecological Indicators*, *146*, 109899. doi: 10.1016/j.ecolind.2023.109899
Probst, W. Nikolaus, & Lynam, C. P. (2016). Integrated assessment results depend on aggregation method and framework structure – A case study within the European Marine Strategy Framework Directive. *Ecological Indicators*, *61*, 871–881. doi: 10.1016/j.ecolind.2015.10.040
Probst, Wolfgang Nikolaus, Kempf, A., Taylor, M., Martinez, I., & Miller, D. (2021). Six steps to produce stock assessments for the Marine Strategy Framework Directive compliant with Descriptor 3. *ICES Journal of Marine Science*, *78*(4), 1229–1240. doi: 10.1093/icesjms/fsaa244
Quemmerais-Amice, F., Barrere, J., La Rivière, M., Contin, G., & Bailly, D. (2020). A Methodology and Tool for Mapping the Risk of Cumulative Effects on Benthic Habitats. *Frontiers in Marine Science*, *7*. Retrieved from https://www.frontiersin.org/article/10.3389/fmars.2020.569205
RAC/SPA - UNEP/MAP. (2015). *A guide on environmental monitoring of rocky seabeds in Mediterranean marine protected areas and surrounding zones* (RAC/SPA-MedMPAnet Project). Tunis. Retrieved from http://www.rac-spa.org/sites/default/files/doc_medmpanet/final_docs_regional/78.guide_suivi_amp_med_en.pdf
RAC/SPA-UNEP/MAP. (2014). *Monitoring protocol for coralligenous community. Case study—Croatia* (RAC/SPA-MedMPAnet Project). Tunis. Retrieved from http://www.rac-spa.org/sites/default/files/doc_medmpanet/monitoring_protocol_coralligenous_croatia.pdf

RAGES. (2021). *Developing a Risk-based Approach to Good Environmental Status. RAGES Deliverable 2.3.* [GRANT AGREEMENT Nº 110661/2018/794607/SUB/ ENV.C.2: Risk Based Approaches to Good Environmental Status Project.].

Ragkousis, M., Sini, M., Koukourouvli, N., Zenetos, A., & Katsanevakis, S. (2023). Invading the Greek Seas: Spatiotemporal Patterns of Marine Impactful Alien and Cryptogenic Species. *Diversity*, *15*(3), 353. doi: 10.3390/d15030353

Ramírez, F., Coll, M., Navarro, J., Bustamante, J., & Green, A. J. (2018). Spatial congruence between multiple stressors in the Mediterranean Sea may reduce its resilience to climate impacts. *Scientific Reports*, *8*(1), 14871. doi: 10.1038/s41598-018-33237-w

Ramon, D., Morick, D., Croot, P., Berzak, R., Scheinin, A., Tchernov, D., … Britzi, M. (2021). A survey of arsenic, mercury, cadmium, and lead residues in seafood (fish, crustaceans, and cephalopods) from the south-eastern Mediterranean Sea. *Journal of Food Science*, *86*(3), 1153–1161. doi: 10.1111/1750-3841.15627

Range, P., Teodósio Chícharo, M., Ben-Hamadou, R., Piló, D., Fernández-Reiriz, M.-J., Labarta, U., … Chícharo, L. (2013). Impacts of CO2-induced seawater acidification on coastal Mediterranean bivalves and interactions with other climatic stressors. *Regional Environmental Change*, 1–12. doi: 10.1007/s10113-013-0478-7

Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea. (2021). *Study on trends and outlook of marine pollution from ships and activities and of maritime traffic and offshore activities in the Mediterranean* (p. 182). Floriana: REMPEC. Retrieved from REMPEC website: https://www.rempec.org/en/news-media/rempec-news/study-trends-and-outlook-of-marine-pollution

REMPEC. (2022). *Best Practices Review of Descriptor 8 (D08C03, D08C04) of the Marine Strategy Framework Directive (MSFD) (REMPEC/WG.56/INF.6)* [Fifteenth Meeting of the Focal Points of the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) Kappara, Malta, 13-15 June 2023]. UNEP/MAP, REMPEC, IMO.

Rendina, F., Kaleb, S., Caragnano, A., Ferrigno, F., Appolloni, L., Donnarumma, L., … Falace, A. (2020). Distribution and Characterization of Deep Rhodolith Beds off the Campania coast (SW Italy, Mediterranean Sea). *Plants*, *9*(8), 985. doi: 10.3390/plants9080985

Rice, J., Arvanitidis, C., Borja, A., Frid, C., Hiddink, J. G., Krause, J., … Norkko, A. (2012). Indicators for Sea-floor Integrity under the European Marine Strategy Framework Directive. *Ecological Indicators*, *12*(1), 174–184. doi: 10.1016/j.ecolind.2011.03.021

Rodrigues, C., & Cunha, M. Â. (2017). Assessment of the microbiological quality of recreational waters: Indicators and methods. *Euro-Mediterranean Journal for Environmental Integration*, *2*(1), 25. doi: 10.1007/s41207-017-0035-8

Rotter, A., Klun, K., Francé, J., Mozetič, P., & Orlando-Bonaca, M. (2020). Non-indigenous Species in the Mediterranean Sea: Turning From Pest to Source by Developing the 8Rs Model, a New Paradigm in Pollution Mitigation. *Frontiers in Marine Science*, *7*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2020.00178

Ruiz, O. S. P. L., Tornero, A. M. V., Boschetti, S., & Hanke, G. (2021). *Marine Strategy Framework Directive - Review and analysis of EU Member States' 2018 reports - Descriptor 10: Marine litter*. doi: 10.2760/238367

Sakellari, A., Karavoltsos, S., Moutafis, I., Koukoulakis, K., Dassenakis, M., & Bakeas, E. (2021). Occurrence and Distribution of Polycyclic Aromatic Hydrocarbons in the Marine Surface Microlayer of an Industrialized Coastal Area in the Eastern Mediterranean. *Water*, *13*(22), 3174. doi: 10.3390/w13223174

Sala, B., Giménez, J., Fernández-Arribas, J., Bravo, C., Lloret-Lloret, E., Esteban, A., … Eljarrat, E. (2022). Organophosphate ester plasticizers in edible fish from the Mediterranean Sea: Marine pollution and human exposure. *Environmental Pollution*, *292*, 118377. doi: 10.1016/j.envpol.2021.118377

Saladié, Ò., & Bustamante, E. (2021). Abundance and Composition of Marine Litter on the Seafloor of the Gulf of Sant Jordi (Western Mediterranean Sea). *Environments*, *8*(10), 106. doi: 10.3390/environments8100106

Salas Herrero, Maria Fuensanta, Dos Santos Fernandes De Araujo, R., Claussen, U., Leujak, W., Boughaba, J., Dellsae, J., … Poikane, S. (2020). *Physico-chemical supporting elements in coastal waters: Links between Water and Marine Framework Directives and Regional Sea Conventions* (JRC Technical

Report No. JRC121759). Luxembourg: Publications Office of the European Union. Retrieved from Publications Office of the European Union website: https://publications.jrc.ec.europa.eu/repository/handle/JRC121759
Salas Herrero, M.F., Dos Santos Fernandes De Araujo, R., Leujak, W., & Poikane, S. (2022). *Physico-chemical supporting elements in coastal waters: WFD-MSFD-RSC Links* (JRC Technical Report No. JRC128107). Publications Office of the European Union. Retrieved from Publications Office of the European Union website: https://publications.jrc.ec.europa.eu/repository/handle/JRC128107
Saydam, E., & Güçlüsoy, H. (2023). Revealing the Mediterranean Monk Seal (*Monachus monachus*)'s Cave Preference in Gökova Bay on the Southwest Coast of Türkiye. *Sustainability*, *15*, 12017. doi: 10.3390/su151512017
Sigray, P., Andersson, M., Andre, M., Azzellino, A., Borsani, J. F., Bou, M., … Weilgart, L. (2023). *Setting EU Threshold Values for impulsive underwater sound* (No. JRC133477). Luxembourg: Publications Office of the European Union. doi: 10.2760/60215
Simmonds, J., Bitetto, I., Cikes Kec, V., Guijarro, B., Isajlovic, I., Ligas, A., … Tsikliras, A. (2021). *Methods for supporting stock assessment in the Mediterranean (STECF-21-02).* [Report]. Publications Office of the European Union. Retrieved from Publications Office of the European Union website: https://repository.oceanbestpractices.org/handle/11329/1801
Smiraglia, D., Cavalli, A., Giuliani, C., & Assennato, F. (2023). The Increasing Coastal Urbanization in the Mediterranean Environment: The State of the Art in Italy. *Land*, *12*(5), 1017. doi: 10.3390/land12051017
Somot, S., Jorda, G., Harzallah, A., & Darmaraki, S. (2018). Sub-chapter 1.2.3. The Mediterranean Sea in the future climate projections. In J.-P. Moatti & S. Thiébault (Eds.), *The Mediterranean region under climate change: A scientific update* (pp. 93–104). Marseille: IRD Éditions. doi: 10.4000/books.irdeditions.23100
Spanier, E., & Zviely, D. (2023). Key Environmental Impacts along the Mediterranean Coast of Israel in the Last 100 Years. *Journal of Marine Science and Engineering*, *11*(1), 2. doi: 10.3390/jmse11010002
Spedicato, M. T., Zupa, W., Carbonara, P., Fiorentino, F., Follesa, M., Galgani, F., … Thasitis, I. (2019). Spatial distribution of marine macro-litter on the seafloor in the northern Mediterranean Sea: The MEDITS initiative. *Scientia Marina*, *83*. doi: 10.3989/scimar.04987.14A
Spisla, C., Taucher, J., Bach, L. T., Haunost, M., Boxhammer, T., King, A. L., … Riebesell, U. (2021). Extreme Levels of Ocean Acidification Restructure the Plankton Community and Biogeochemistry of a Temperate Coastal Ecosystem: A Mesocosm Study. *Frontiers in Marine Science*, *7*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2020.611157
Spiteri, C. (2015). *Guidance document on how to reflect changes in hydrographical conditions in relevant assessments* (p. 38). UNEP/MAP PAP/RAC.
Squadrone, S., Pederiva, S., Bezzo, T., Sartor, R. M., Battuello, M., Nurra, N., … Abete, M. C. (2022). Microplastics as vectors of metals contamination in Mediterranean Sea. *Environmental Science and Pollution Research International*, *29*(20), 29529–29534. doi: 10.1007/s11356-021-13662-7
Stein, D. U., Korpinen, S., Nurmi, M., Laamanen, L., Klančnik, K., Zupančič, G., … Vaughan, D. (2019). *Multiple Pressures and their Combined Effects in Europe's Seas* (ETC/ICM Technical Report No. 4/2019; p. 164). European Environment Agency. Retrieved from European Environment Agency website: https://www.ecologic.eu/17220
Stips, A., Macias, M. D., Garcia, G. E., & Miladinova-Marinova, S. (2016). *Alternative assessments of large scale Eutrophication using ecosystem simulations: Hind-casting and scenario modelling* (JRC Technical Reports No. EUR 27904). Luxembourg. Retrieved from https://publications.jrc.ec.europa.eu/repository/handle/JRC101277
Sweetman, A. K., Thurber, A. R., Smith, C. R., Levin, L. A., Mora, C., Wei, C.-L., … Roberts, J. M. (2017). Major impacts of climate change on deep-sea benthic ecosystems. *Elementa: Science of the Anthropocene*, *5*, 4. doi: 10.1525/elementa.203
Tam, J. C., Link, J. S., Rossberg, A. G., Rogers, S. I., Levin, P. S., Rochet, M.-J., … Rindorf, A. (2017). Towards ecosystem-based management: Identifying operational food-web indicators for marine ecosystems. *ICES Journal of Marine Science*, *74*(7), 2040–2052. doi: 10.1093/icesjms/fsw230
Tamburini, M., Keppel, E., Marchini, A., Repetto, M. F., Ruiz, G. M., Ferrario, J., & Occhipinti-Ambrogi, A. (2021). Monitoring Non-indigenous Species in Port Habitats: First Application of a Standardized

North American Protocol in the Mediterranean Sea. *Frontiers in Marine Science*, *8*. Retrieved from https://www.frontiersin.org/article/10.3389/fmars.2021.700730

Tarchouna, M. K. (2019). Palm Trees in Kerkena Archipelago (Tunisia) Natural Heritage in Degradation. *Earth Sciences*, *8*(3), 132. doi: 10.11648/j.earth.20190803.12

Telesca, L., Belluscio, A., Criscoli, A., Ardizzone, G., Apostolaki, E. T., Fraschetti, S., … Salomidi, M. (2015). Seagrass meadows (*Posidonia oceanica*) distribution and trajectories of change. *Scientific Reports*, *5*(1), 12505. doi: 10.1038/srep12505

Temino-Boes, R., García-Bartual, R., Romero, I., & Romero-Lopez, R. (2021). Future trends of dissolved inorganic nitrogen concentrations in Northwestern Mediterranean coastal waters under climate change. *Journal of Environmental Management*, *282*, 111739. doi: 10.1016/j.jenvman.2020.111739

Tempesti, J., Mangano, M. C., Langeneck, J., Lardicci, C., Maltagliati, F., & Castelli, A. (2020). Non-indigenous species in Mediterranean ports: A knowledge baseline. *Marine Environmental Research*, *161*, 105056. doi: 10.1016/j.marenvres.2020.105056

Topouzelis, K., Bernardini, A., Ferraro, G., Meyer-Roux, S., & Tarchi, D. (2006). *Satellite mapping of oil spills in the Mediterranean Sea*. *15*, 1014.

Tornero Alvarez, M. V., Hanke, G., Haber, A., Kuenitzer, A., Mauffret, A., Munch, C. A., … Leon, V. (2021). *Guidance on potential exclusion of certain WFD priority substances from MSFD monitoring beyond coastal and territorial waters* (JRC Technical Report No. JRC124593). Luxembourg: Publications Office of the European Union. Retrieved from Publications Office of the European Union website: https://publications.jrc.ec.europa.eu/repository/handle/JRC124593

Tornero Alvarez, M. V., Palma, M., Boschetti, S., Cardoso, A. C., Druon, J.-N., Kotta, M., … Hanke, G. (2023). *Marine Strategy Framework Directive—Review and analysis of EU Member States' 2020 reports on Monitoring Programmes*. Retrieved from https://publications.jrc.ec.europa.eu/repository/handle/JRC129363

Torreblanca, E., Báez, J.-C., Real, R., Macías, D., García-Barcelona, S., Ferri-Yañez, F., & Camiñas, J.-A. (2022). Factors associated with the differential distribution of cetaceans linked with deep habitats in the Western Mediterranean Sea. *Scientific Reports*, *12*(1), 12918. doi: 10.1038/s41598-022-14369-6

Traganos, D., Lee, C. B., Blume, A., Poursanidis, D., Čižmek, H., Deter, J., … Reinartz, P. (2022). Spatially Explicit Seagrass Extent Mapping Across the Entire Mediterranean. *Frontiers in Marine Science*, *9*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2022.871799

Travers-Trolet, M., Bourdaud, P., Genu, M., Velez, L., & Vermard, Y. (2020). The Risky Decrease of Fishing Reference Points Under Climate Change. *Frontiers in Marine Science*, *7*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2020.568232

Tselemponis, A., Stefanis, C., Giorgi, E., Kalmpourtzi, A., Olmpasalis, I., Tselemponis, A., … Constantinidis, T. C. (2023). Coastal Water Quality Modelling Using E. coli, Meteorological Parameters and Machine Learning Algorithms. *International Journal of Environmental Research and Public Health*, *20*(13), 6216. doi: 10.3390/ijerph20136216

Tsiamis, K., Boschetti, S., Palialexis, A., Somma, F., & De, J. C. A. (2021a). *Marine Strategy Framework Directive – Review and analysis of EU Member States' 2018 reports – Descriptor 2: Non-Indigenous Species*. doi: 10.2760/7897

Tsiamis, K., Palialexis, A., Connor, D., Antoniadis, S., Bartilotti, C., Bartolo, A. G., … De, J. C. A. (2021b). *Marine Strategy Framework Directive – Descriptor 2, Non-Indigenous Species. Delivering solid recommendations for setting threshold values for non-indigenous species pressure on European seas* (JRC Science for Policy Report No. JRC124136). Luxembourg: Publications Office of the European Union. doi: 10.2760/035071

Tsiamis, K., Palialexis, A., Stefanova, K., Gladan, Ž. N., Skejić, S., Despalatović, M., … Cardoso, A. C. (2019). Non-indigenous species refined national baseline inventories: A synthesis in the context of the European Union's Marine Strategy Framework Directive. *Marine Pollution Bulletin*, *145*, 429–435. doi: 10.1016/j.marpolbul.2019.06.012

Tsikliras, A., & Froese, R. (2018). Maximum Sustainable Yield. In *Reference Module in Earth Systems and Environmental Sciences*. doi: 10.1016/B978-0-12-409548-9.10601-3

Tsikoti, C., & Genitsaris, S. (2021). Review of Harmful Algal Blooms in the Coastal Mediterranean Sea, with a Focus on Greek Waters. *Diversity*, *13*(8), 396. doi: 10.3390/d13080396

UNEP/MAP. (2015). *Adriatic Sea: Status and conservation of Seabirds (UNEP(DEPI)/MED WG.408/Inf.12)*.
UNEP/MAP. (2017a). *Draft guidelines for the preparation of the country specific EcAp monitoring programme for biodiversity and NIS (UNEP(DEPI)/MED WG.444/Inf.14)* (p. 41) [6th Meeting of the Ecosystem Approach Coordination Group].
UNEP/MAP. (2017b). *IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries) (UNEP(DEPI)/MED WG.444/6/REV.1)*.
UNEP/MAP. (2017c). *Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria* (p. 52) [UN Environment/MAP]. Athens, Greece. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/17012/imap_2017_eng.pdf?sequence=5&isAllowed=y
UNEP/MAP. (2017d). *Mediterranean 2017 Quality Status Report*. Retrieved from https://www.medqsr.org/sites/default/files/inline-files/2017MedQSR_Online_0.pdf
UNEP/MAP. (2020). *Updated Baseline Values and Proposal for Threshold Values for IMAP Common Indicator 22 (UNEP/MED WG.482/23)*. UNEP/MAP MED POL.
UNEP/MAP. (2021). *Updated Baseline Values and Proposal for Threshold Values for IMAP Common Indicator 22 (UNEP/MED WG.514/7)* (p. 29) [8th Meeting of the Ecosystem Approach Coordination Group].
UNEP/MAP. (2023). *Updated Baseline Values (BV) and Threshold Values (TV) for IMAP Common Indicator 23 (Seafloor macro-litter, Floating microplastics) (UNEP/MED WG.555/3)* [Meeting of the Ecosystem Approach Correspondence Group on Marine Litter Monitoring]. UNEP/MAP-MED POL.
UNEP/MAP. (2017c). *Defining the Most Representative Species for IMAP Candidate Indicator 24 (UNEP(DEPI)/MED WG.444/Inf.11)* (p. 38) [6th Meeting of the Ecosystem Approach Coordination Group].
UNEP/MAP. (2017a). *IMAP Common Indicator Guidance Facts Sheets (Pollution and Marine Litter) (UNEP(DEPI)/MED WG.439/12)* (p. 75) [Meeting of the MED POL Focal Points]. UNEP/MAP-MED POL.
UNEP/MAP. (2016a). *Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria*. Athens: UNEP/MAP. Retrieved from https://wedocs.unep.org/rest/bitstreams/45233/retrieve
UNEP/MAP. (2017b). *Pollution Assessment Criteria and Thresholds (UNEP(DEPI)/MED WG.444/12)* (p. 22) [6th Meeting of the Ecosystem Approach Coordination Group]. UNEP/MAP.
UNEP/MAP - PAP/RAC. (2019). *Indicator guidance factsheets for EO7 and EO8 Coast and Hydrography Common Indicators 15, 16 and 25 (UNEP/MED WG.467/6)* (p. 32) [7th Meeting of the Ecosystem Approach Coordination Group].
UNEP/MAP - PAP/RAC. (2023a). *Definition of GES for the CI 16 "Length of coastline subject to physical disturbance due to the influence of human-made structures". Assessment criteria and the Guiding document for application of assessment criteria for the IMAP Common Indicator 16 (UNEP/MAP WG.549/6)* (p. 27) [Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Coast and Hydrography].
UNEP/MAP - PAP/RAC. (2023b). *Upgraded Guidance Factsheet for Candidate Common Indicator 25 "Land cover change" – Rationale and background (UNEP/MAP WG.549/Inf.3)* (p. 34) [Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Coast and Hydrography]. Split: UNEP/MAP PAP/RAC.
UNEP/MAP - RAC/SPA. (2019). *Monitoring Protocols for IMAP Common Indicators related to Biodiversity and Non-Indigenous species (UNEP/MAP WG.467/16)*.
UNEP-MAP RAC/SPA. (2006). *Guidelines for reducing the presence of sensitive chondrichthyan species within by-catch. By Melendez, M.J. & D. Macias, IEO* (p. 21). Tunis: RAC/SPA.
UNEP/MAP RAC/SPA. (2007). *Guidelines for Management and Monitoring Threatened Population of Marine and Coastal Bird Species and their Important Areas in the Mediterranean. By Joe Sultana* (RAC/SPA). Tunis.
UNEP/MAP RAC/SPA. (2013). *Seabirds in the Gulf of Lions shelf and slope area. By Carboneras, C.* (RAC/SPA). Tunis.

UNEP/MAP RAC/SPA. (2015a). *Alboran Sea: Status and conservation of seabirds. By Arcos, J.M.* (D. Cebrian & S. Requena, Eds.). Tunis.

UNEP/MAP RAC/SPA. (2015b). *Sicily Channel/Tunisian Plateau: Status and conservation of Seabirds. By Carboneras, C.* (RAC/SPA; Daniel Cebrian & S. Requena Moreno, Eds.). Tunis.

UNEP/MAP, REMPEC, & IMO. (2021). *IMAP Guidance Fact Sheets: Common Indicators 6 and 19 (REMPEC/WG.51/9/1)* (p. 26) [Fourteenth Meeting of the Focal Points of the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC)].

UNEP/MAP-MED POL. (2019). *IMAP Guidance Factsheets: Update for Common Indicators 13, 14, 17, 18, 20 and 21; New proposal for Candidate Indicators 26 and 27* (Meeting Report No. UNEP/MED WG.473/7; p. 62).

UNEP/MAP-MED POL. (2021c). *Assessment Criteria Methodology for IMAP Common Indicator 13: Pilot Application in Adriatic Sub-region* (Meeting Report No. UNEP/MED WG.509/13; p. 21).

UNEP/MAP-MED POL. (2021a). *Monitoring Guideline for Reporting Monitoring Data for IMAP Common Indicators 13, 14, 17, 18 and 20* (Meeting Report No. UNEP/MED WG.509/33; p. 77).

UNEP/MAP-MED POL. (2021b). *Monitoring Guidelines/Protocols for Analytical Quality Assurance for IMAP Common Indicators 13, 14, 17, 18 and 20* (Meeting Report No. UNEP/MED WG.509/32; p. 21).

UNEP/MAP-PAP/RAC. (2015). *Pilot project in the Adriatic on testing the candidate common indicator 'Land use change' in the Mediterranean* (p. 70).

UNEP/MAP-RAC/SPA. (2009). *Guidelines for reducing by catch of seabirds in the Mediterranean region. By Carles Carboneras* (p. 49). Tunis: RAC/SPA.

UNEP/MAP-RAC/SPA. (2015). *Guidelines for the standardization of mapping and monitoring methods of marine magnoliophyta in the Mediterranean* (p. 55). Tunis: RAC/SPA.

UNEP/MAP-SPA/RAC. (2006). *Report of the international conference on monk seal conservation. Antalya—Turkey, 17-19 September 2006* (p. 69).

UNEP/MAP-SPA/RAC. (2017). *Guidelines for the long term Monitoring programmes for marine turtles nesting beaches and standardized monitoring methods for nesting beaches, feeding and wintering areas (UNEP(DEPI)/MED WG.431/ Inf.4)* (p. 60). Tunis.

UNEP/MAP-SPA/RAC. (2019). *Monitoring protocols of the Ecosystem Approach Common Indicators 1 and 2 related to marine benthic habitats* (Meeting Report No. UNEP/MED WG.474/3; p. 171). Tunis. Retrieved from http://www.rac-spa.org/cormon1/docs/wg.474_3_en.pdf

UNEP/MAP-SPA/RAC. (2021a). *Comparative Analysis undertaken with regard to IMAP and the European Commission GES Decision 2017/848/EU for Biodiversity (UNEP MED WG.502/Inf.10)*.

UNEP-MAP/SPA-RAC. (2021). *First elements to elaborate the List of Reference of Pelagic Habitat Types in the Mediterranean Sea (UNEP/MED WG.502/7)* (p. 13). Retrieved from https://www.rac-spa.org/meetings/nfp15/nfp_docs/wg502_07_en.pdf

UNEP/MAP-SPA/RAC. (2021b). *Guidelines for the assessment of environmental impact on coralligenous and maërl assemblages (UNEP/MED WG.502/Inf.3)* (p. 58). Tunis: SPA/RAC.

UNEP/MAP-SPA/RAC. (2021c). *Interpretation Manual of Marine Habitat Types in the Mediterranean Sea (UNEP/MED WG.502/Inf.4)* (p. 426). Tunis.

UNEP/MPA-SPA/RAC. (2016). *Integrated Monitoring and Assessment Guidance* (Meeting Report No. UNEP(DEPI)/MED IG.22/Inf.7; p. 282). Athens. Retrieved from https://www.rac-spa.org/sites/default/files/ecap/ig22_inf7.pdf

Valente, T., Scacco, U., & Matiddi, M. (2020). Macro-litter ingestion in deep-water habitats: Is an underestimation occurring? *Environmental Research*, *186*, 109556. doi: 10.1016/j.envres.2020.109556

Van Loon, W., Hanke, G., Fleet, D., Werner, S., Barry, J., Strand, J., … Walvoort, D. (2020). *A European threshold value and assessment method for macro litter on the coastlines: Guidance developed within the Common Implementation strategy for the Marine Strategy Framework Directive MSFD Technical Group on Marine Litter* (JRC Technical Reports No. JRC121707). Luxembourg: Publications Office of the European Union. Retrieved from Publications Office of the European Union website: https://data.europa.eu/doi/10.2760/54369

Vandarakis, D., Panagiotopoulos, I. P., Loukaidi, V., Hatiris, G.-A., Drakopoulou, P., Kikaki, A., … Kapsimalis, V. (2021). Assessment of the Coastal Vulnerability to the Ongoing Sea Level Rise for the Exquisite Rhodes Island (SE Aegean Sea, Greece). *Water*, *13*(16), 2169. doi: 10.3390/w13162169

Vasilakopoulos, Paraskevas, Konrad, C., Palialexis, A., & Boschetti, S. (2021). *Marine Strategy Framework Directive - Review and analysis of EU Member States' 2018 reports - Descriptor 3: Commercial species*. doi: 10.2760/40557

Vasilakopoulos, Paris, Palialexis, A., Boschetti, S., Cardoso, A.-C., Druon, J.-N., Konrad, C., … Hanke, G. (2022a). *Marine Strategy Framework Directive - Thresholds for MSFD criteria: State of play and next steps*. doi: 10.2760/640026

Vasilakopoulos, Paris, Palialexis, A., Boschetti, S., Cardoso, A.-C., Druon, J.-N., Konrad, C., … Hanke, G. (2022b). *Marine Strategy Framework Directive - Thresholds for MSFD criteria: State of play and next steps*. doi: 10.2760/640026

Verling, E., Bartilotti, C., Hollatz, C., Tuaty-Guerra, M., Lobo-Arteaga, J., & O'Higgins, T. (2023). Applying risk-based approaches to implementation of the Marine Strategy Framework Directive in the North-East Atlantic: Learning lessons and moving forward. *Marine Policy*, *153*, 105667. doi: 10.1016/j.marpol.2023.105667

Vighi, M., Boschetti, S., & Hanke, G. (2021). *Marine Strategy Framework Directive - Review and analysis of EU Member States' 2018 reports - Descriptor 11: Underwater Noise and Energy*. doi: 10.2760/20326

Vighi, M., Ruiz-Orejón, L. F., Hanke, G., & MSFD Technical Group on Marine Litter. (2022). *Monitoring of Floating Marine Macro Litter. State of the art and literature overview* (JRC Technical Reports No. JRC129261). Luxembourg: Publications Office of the European Union.

Vitelletti, M. L., Manea, E., Bongiorni, L., Ricchi, A., Sangelantoni, L., & Bonaldo, D. (2023). Modelling distribution and fate of coralligenous habitat in the Northern Adriatic Sea under a severe climate change scenario. *Frontiers in Marine Science*, *10*. Retrieved from https://www.frontiersin.org/articles/10.3389/fmars.2023.1050293

Vlachogianni, Th. (2019). *Assessing marine litter on Mediterranean beaches. Filling in the knowledge gaps via a participatory-science initiative.* (p. 42). IO-ECSDE.

Vlachogianni, Th., & Kalampokis, V. (2014). *Methodology for Monitoring Marine Litter on the Seafloor (Shallow coastal waters (0–20m) Visual surveys with SCUBA/snorkeling* (p. 10) [DeFishGear]. MIO-ECSDE.

Walvoort, D., Loon, W. M. G. M., Schulz, M., & André, S. (2021). *Modelling and forecasting of beach litter assessment values*. doi: 10.18174/10.18174/546866

Werner, S., Fischer, E., Fleet, D., Galgani, F., Hanke, G., Kinsey, S., & Mattidi, M. (2020). *Threshold values for marine litter. General discussion paper on defining threshold values for marine litter* (JRC Technical Reports No. EUR 30018 EN; p. 27). Luxembourg. Retrieved from https://mcc.jrc.ec.europa.eu/main/dev.py?N=41&O=453

World Health Organization. (2021). *Guidelines on recreational water quality: Volume 1 Coastal and fresh waters* (WHO). Geneva. Retrieved from https://www.who.int/publications-detail-redirect/9789240031302

Zampoukas, N., Palialexis, A., Duffek, A., Graveland, J., Giorgi, G., Hagebro, C., … Zevenboom, W. (2014). *Technical guidance on monitoring for the Marine Stategy Framework Directive* (p. 175) [JRC Scientific and policy reports]. European Commission. pdf. Retrieved from European Commission website: https://publications.jrc.ec.europa.eu/repository/handle/JRC88073

Zenetos, A., Albano, P. G., Garcia, E. L., Stern, N., Tsiamis, K., & Galanidi, M. (2022a). Established non-indigenous species increased by 40% in 11 years in the Mediterranean Sea. *Mediterranean Marine Science*, *23*(1). doi: 10.12681/mms.29106

Zenetos, A., & Galanidi, M. (2020a). Mediterranean non indigenous species at the start of the 2020s: Recent changes. *Marine Biodiversity Records*, *13*(1), 10. doi: 10.1186/s41200-020-00191-4

Zenetos, A., & Galanidi, M. (2020b). Mediterranean non indigenous species at the start of the 2020s: Recent changes. *Marine Biodiversity Records*, *13*(1), 10. doi: 10.1186/s41200-020-00191-4

Zenetos, A., Tsiamis, K., Galanidi, M., Carvalho, N., Bartilotti, C., Canning-Clode, J., … Outinen, O. (2022b). Status and Trends in the Rate of Introduction of Marine Non-Indigenous Species in European Seas. *Diversity*, *14*(12), 1077. doi: 10.3390/d14121077

Zentner, Y., Rovira, G., Margarit, N., Ortega, J., Casals, D., Medrano, A., … Linares, C. (2023). Marine protected areas in a changing ocean: Adaptive management can mitigate the synergistic effects of local

and climate change impacts. *Biological Conservation*, *282*, 110048. doi: 10.1016/j.biocon.2023.110048
Zgouridou, A., Tripidaki, E., Giantsis, I. A., Theodorou, J. A., Kalaitzidou, M., Raitsos, D. E., … Michaelidis, B. (2022a). The current situation and potential effects of climate change on the microbial load of marine bivalves of the Greek coastlines: An integrative review. *Environmental Microbiology*, *24*(3), 1012–1034. doi: 10.1111/1462-2920.15765
Zgouridou, A., Tripidaki, E., Giantsis, I. A., Theodorou, J. A., Kalaitzidou, M., Raitsos, D. E., … Michaelidis, B. (2022b). The current situation and potential effects of climate change on the microbial load of marine bivalves of the Greek coastlines: An integrative review. *Environmental Microbiology*, *24*(3), 1012–1034. doi: 10.1111/1462-2920.15765
Zorita, I., Apraiz, I., Ortiz-Zarragoitia, M., Orbea, A., Cancio, I., Soto, M., … Cajaraville, M. P. (2007). Assessment of biological effects of environmental pollution along the NW Mediterranean Sea using mussels as sentinel organisms. *Environmental Pollution (Barking, Essex: 1987)*, *148*(1), 236–250. doi: 10.1016/j.envpol.2006.10.022
Zunino, S., Canu, D. M., Zupo, V., & Solidoro, C. (2019). Direct and indirect impacts of marine acidification on the ecosystem services provided by coralligenous reefs and seagrass systems. *Global Ecology and Conservation*, *18*, e00625. doi: 10.1016/j.gecco.2019.e00625

Annex A: Data Dictionaries/Data Standards, Assessment Criteria, Threshold Values, Baseline Values, Guidance Factsheets, Guidelines and Monitoring Protocols available or in progress for each IMAP Common Indicator (CI) or Candidate Common Indicator (CCI).

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
EO 1	**1**	UNEP/MED WG.467/9					UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16; UNEP/MED WG.482/20 (updated for marine veg. And other calcareous bioconstructions); UNEP/MED WG.500/3 (benthic habitats review); UNEP/MED WG.502/Inf.4 (Interpretation Manual of Marine Habitat Types in the Mediterranean Sea)
	2	UNEP/MED WG.467/9					UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16; UNEP/MED WG.500/3 (benthic habitats review);

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
								UNEP/MED WG.502/Inf.3 (Guidelines for the assessment of environmental impact on coralligenous and maërl assemblages); UNEP/MED WG.502/Inf.4 (Interpretation Manual of Marine Habitat Types in the Mediterranean Sea)
	3 marine mammals	UNEP/MED WG.482/22; UNEP/MED WG.520/6 (updated)	UNEP/MED WG.500/4; UNEP/MED WG.514/Inf.1	UNEP/MED WG.500/4; UNEP/MED WG.514/Inf.1	UNEP/MED WG.500/4; UNEP/MED WG.514/Inf.1	UNEP/MED WG.500/4; UNEP/MED WG.514/Inf.1	UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16
	3 marine birds	UNEP/MED WG.482/22; UNEP/MED WG.520/8 (updated)	UNEP/MED WG.521/Inf.7	UNEP/MED WG.521/Inf.7	UNEP/MED WG.521/Inf.7	UNEP/MED WG.521/Inf.7	UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
	3 marine reptiles	UNEP/MED WG.482/22; UNEP/MED WG.520/7 (updated)	UNEP/MED WG.500/5; UNEP/MED WG.514/Inf.12	UNEP/MED WG.500/5; UNEP/MED WG.514/Inf.12	UNEP/MED WG.500/5; UNEP/MED WG.514/Inf.12	UNEP/MED WG.500/5; UNEP/MED WG.514/Inf.12	UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16
EO 1	**4** marine mammals	UNEP/MED WG.482/22; UNEP/MED WG.520/6 (updated)	UNEP/MED WG.500/4; UNEP/MED WG.502/16 Appendix B	UNEP/MED WG.500/4; UNEP/MED WG.502/16 Appendix B	UNEP/MED WG.500/4; UNEP/MED WG.502/16 Appendix B	UNEP/MED WG.500/4; UNEP/MED WG.502/16 Appendix B	UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16
	4 marine birds	UNEP/MED WG.482/22; UNEP/MED WG.520/8 (updated)	UNEP/MED WG.467/16; UNEP/MED WG.520/4	UNEP/MED WG.520/4	UNEP/MED WG.520/4	UNEP/MED WG.520/4	UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16
	4 marine reptiles	UNEP/MED WG.482/22; UNEP/MED WG.520/7 (updated)	UNEP/MED WG.500/5; UNEP/MED WG.502/16 Rev.1.Appendix C. Rev.1 (Refinement)	UNEP/MED WG.500/5; UNEP/MED WG.502/16 Rev.1.Appendix C. Rev.1 (Refinement)	UNEP/MED WG.500/5; UNEP/MED WG.502/16 Rev.1.Appendix C. Rev.1 (Refinement)	UNEP/MED WG.500/5; UNEP/MED WG.502/16 Rev.1.Appendix C. Rev.1 (Refinement)	UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
	5 marine mammals	UNEP/MED WG.482/22 (DD/DS); UNEP/MED WG.520/6 (updated)	UNEP/MED WG.467/16; UNEP/MED WG.500/4; UNEP/MED WG.502/16 Appendix B	UNEP/MED WG.500/4; UNEP/MED WG.502/16 Appendix B	UNEP/MED WG.500/4; UNEP/MED WG.502/16 Appendix B	UNEP/MED WG.500/4; UNEP/MED WG.502/16 Appendix B	UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16
	5 marine birds	UNEP/MED WG.482/22; UNEP/MED WG.520/8 (updated)	UNEP/MED WG.520/4	UNEP/MED WG.520/4	UNEP/MED WG.520/4	UNEP/MED WG.520/4	UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16
	5 marine reptiles	UNEP/MED WG.482/22; UNEP/MED WG.520/7 (updated)	UNEP/MED WG.500/5 (Refinement); UNEP/MED WG.502/16 Rev.1.Appendix C. Rev.1 (Refinement)	UNEP/MED WG.500/5 (Refinement); UNEP/MED WG.502/16 Rev.1.Appendix C. Rev.1 (Refinement)	UNEP/MED WG.500/5 (Refinement); UNEP/MED WG.502/16 Rev.1.Appendix C. Rev.1 (Refinement)	UNEP/MED WG.500/5 (Refinement); UNEP/MED WG.502/16 Rev.1.Appendix C. Rev.1 (Refinement)	UNEP(DEPI)/MED WG.444/6/Rev.1	UNEP/MED WG.467/16

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
EO 2	**6**	UNEP/MED WG.467/9	UNEP/MED WG.500/7; UNEP/MED WG.502/16.Appendix E; UNEP/MED WG.520/Inf.3	UNEP/MED WG.500/7; UNEP/MED WG.502/16.Appendix E; UNEP/MED WG.520/Inf.3	UNEP/MED WG.500/7; UNEP/MED WG.502/16.Appendix E; UNEP/MED WG.520/Inf.3	UNEP/MED WG.500/8; UNEP/MED WG.520/6; UNEP/MED WG.520/Inf.3 Also see Baseline for the IMAP CI 6 UNEP/MED WG.521/Inf.8	UNEP(DEPI)/MED WG.444/6/Rev.1 ; UNEP/MED WG.482/21; UNEP/MED WG.500/6 (revised); UNEP/MED WG.514/10	UNEP/MED WG.467/16
EO 3	**7**						UNEP(DEPI)/MED WG.444/6/Rev.1	
	8						UNEP(DEPI)/MED WG.444/6/Rev.1	
	9						UNEP(DEPI)/MED WG.444/6/Rev.1	
	10						UNEP(DEPI)/MED WG.444/6/Rev.1	
	11						UNEP(DEPI)/MED WG.444/6/Rev.1	

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
	12						UNEP(DEPI)/MED WG.444/6/Rev.1	
EO 4								
EO 5	**13**	UNEP/MED WG.467/8; UNEP/MED WG.473/8		UNEP/MED WG.492/Inf.9 ; UNEP/MED WG.533/4 (for Adriatic sub-region)	UNEP/MED WG.533/4 (for Adriatic sub-region)		UNEP(DEPI)/MED WG.439/12; UNEP(DEPI)/MED WG.444/5; UNEP/MED WG.463/04; UNEP/MED WG.467/5; UNEP/MED WG.473/07 (updated);	UNEP/MED WG.463/6; UNEP/MED WG.482/06 (physical); UNEP/MED WG.482/07 (chemical); UNEP/MED WG.482/05 (sampling); UNEP/MED WG.482/08 (key nutrients in seawater-Nitrogen compounds); UNEP/MED WG.482/09 (Phosphorus and silica compounds); UNEP/MED WG.509/32 and

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
								UNEP/MED WG.509/33
	14	UNEP/MED WG.467/8; UNEP/MED WG.473/8		UNEP/MED WG.492/Inf.9			UNEP(DEPI)/MED WG.439/12; UNEP(DEPI)/MED WG.444/5; UNEP/MED WG.463/04; UNEP/MED WG.467/5; UNEP/MED WG.473/07 (updated)	UNEP/MED WG.463/6; UNEP/MED WG.482/05 (sampling); UNEP/MED WG.482/10 (Chlorophyll a in seawater); UNEP/MED WG.509/32 and UNEP/MED WG.509/33
EO 6								

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
EO 7	**15**	UNEP/MED WG.467/10		Guidance document on how to reflect changes in hydrographical conditions in relevant assessments			UNEP(DEPI)/MED WG.444/07; UNEP/MED WG.467/6	Guidance document on how to reflect changes in hydrographical conditions in relevant assessments
EO 8	**16**	UNEP/MED WG.467/10		Assessment Criteria and Guiding document for application of assessment criteria for the IMAP Common Indicator 16 on coastline			UNEP(DEPI)/MED WG.444/07; UNEP/MED WG.467/6	Assessment Criteria and Guiding document for application of assessment criteria for the IMAP Common Indicator 16 on coastline
EO 9	**17** sediment	UNEP/MED WG.467/8; UNEP/MED WG.473/8		UNEP/MED WG.492/Inf.9, UNEP/MED WG.533/3 (BC/BAC/EAC)	UNEP/MED WG.533/5 (proposition for Adriatic subregion and use of NEAT approach); UNEP/MED WG.533/6		UNEP(DEPI)/MED WG.439/12; UNEP(DEPI)/MED WG.444/5; UNEP/MED WG.463/04; UNEP/MED WG.467/5;	UNEP/MED WG.463/6; UNEP/MED WG.482/11 (sampling); UNEP/MED WG.482/12 (sample prep. and analysis); UNEP/MED

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
					(proposition for Levantine basin using CHASE+ and traffic light approach)		UNEP/MED WG.473/07 (updated)	WG.509/32 and UNEP/MED WG.509/33
	17 marine biota	UNEP/MED WG.467/8; UNEP/MED WG.473/8		UNEP/MED WG.492/Inf.9, UNEP/MED WG.533/3 (BC/BAC/EAC)	UNEP/MED WG.533/5 (proposition for Adriatic subregion and use of NEAT approach); UNEP/MED WG.533/6 (proposition for Levantine basin using CHASE+ and traffic light approach)		UNEP(DEPI)/MED WG.439/12; UNEP(DEPI)/MED WG.444/5; UNEP/MED WG.463/04; UNEP/MED WG.467/5; UNEP/MED WG.473/07 (updated)	UNEP/MED WG.482/13 (sampling); UNEP/MED WG.482/14 (sample prep. and analysis); UNEP/MED WG.509/32 and UNEP/MED WG.509/33
	17 seawater	UNEP/MED WG.467/8; UNEP/MED WG.473/8		UNEP/MED WG.492/Inf.9, UNEP/MED WG.533/3 (BC/BAC/EAC)			UNEP(DEPI)/MED WG.439/12; UNEP(DEPI)/MED WG.444/5; UNEP/MED WG.463/04; UNEP/MED	UNEP/MED WG.463/6; UNEP/MED WG.482/15 (sampling); UNEP/MED WG.482/16 (sampling

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
							WG.467/5; UNEP/MED WG.473/07 (updated)	prep. and analysis); UNEP/MED WG.509/32 and UNEP/MED WG.509/33
	18	UNEP/MED WG.533/7		UNEP/MED WG.492/Inf.9, UNEP/MED WG.533/3 (EAC)			UNEP(DEPI)/MED WG.439/12; UNEP(DEPI)/MED WG.444/5; UNEP/MED WG.463/04; UNEP/MED WG.467/5; UNEP/MED WG.473/07 (updated)	UNEP/MED WG.463/6, UNEP/MED WG. 492/6 (Biomonitoring) ; UNEP/MED WG.509/28 and UNEP/MED WG.509/29 (for biomarkers); UNEP/MED WG.509/32 and UNEP/MED WG.509/33
	19			UNEP/MED WG.492/Inf.9			UNEP(DEPI)/MED WG.439/12; UNEP(DEPI)/MED WG.444/5; UNEP/MED WG.482/21 (revision)	UNEP/MED WG.463/6

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
EO 9	**20**	UNEP/MED WG.533/7		UNEP/MED WG.492/Inf.9, UNEP/MED WG.533/3 (EAC)			UNEP(DEPI)/MED WG.439/12; UNEP(DEPI)/MED WG.444/5; UNEP/MED WG.463/04; UNEP/MED WG.467/5; UNEP/MED WG.473/07 (updated)	UNEP/MED WG.463/6; UNEP/MED WG.482/17 (sampling); UNEP/MED WG.482/18 (analysis); UNEP/MED WG.509/30 and UNEP/MED WG.509/31 for sampling and sampling analysis; UNEP/MED WG.509/32 and UNEP/MED WG.509/33
	21	UNEP/MED WG.467/8, UNEP/MED WG.473/8		UNEP/MED WG.492/Inf.9			UNEP(DEPI)/MED WG.439/12; UNEP(DEPI)/MED WG.444/5; UNEP/MED WG.463/04; UNEP/MED WG.467/5; UNEP/MED WG.473/07 (updated)	UNEP/MED WG.463/6

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
EO 10	**22**	UNEP/MED WG.467/8; UNEP/MED WG.473/8		UNEP/MED WG.492/Inf.9	UNEP/MED WG.482/23 (proposals), UNEP/MED IG. 25/27 Annex IV, UNEP/MED WG.514/7 (proposal)	UNEP/MED WG.482/23 (updated), UNEP/MED IG. 25/27 Annex IV, UNEP/MED WG.514/7 (updated)	UNEP(DEPI)/MED WG.444/5	
	23 A. seafloor Marine litter	UNEP/MED WG.467/8; UNEP/MED WG.473/8		UNEP/MED WG.492/Inf.9			UNEP(DEPI)/MED WG.444/5	
	23 B. Floating Marine litter	UNEP/MED WG.467/8; UNEP/MED WG.473/8, UNEP/MED WG.490/6 (Addendum)		UNEP/MED WG.492/Inf.9			UNEP(DEPI)/MED WG.444/5	UNEP/MED WG.482/19 (microplastics); UNEP/MED WG.509/34
	CCI 24						UNEP(DEPI)/MED WG.444/5	UNEP/MED WG.461/8

EO	Common Indicators and CCIs	Data Dictionaries/ Data standards	Monitoring and Assessment Scales	Assessment Criteria	Thresholds Values	Baseline Values	Guidance Factsheets	Guidelines and Monitoring Protocols
EO 8	**CCI 25**		Monitoring and Assessment Methodological Guidance on Land Use Change				UNEP(DEPI)/MED WG.444/07; UNEP/MED WG.467/6	Pilot project tested Pilot project in the Adriatic on testing the candidate common indicator "Land use change" in the Mediterranean
EO 11	**CCI 26**						UNEP/MED WG.463/04 (proposal); UNEP/MED WG.467/5 (proposal), UNEP/MED WG.473/07 (proposal)	
	CCI 27						UNEP/MED WG.463/04 (proposal); UNEP/MED WG.467/5 (proposal), UNEP/MED WG.473/07 (proposal)	