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Agenda item 7: Further IMAP and MED POL Monitoring Programme Implementation

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

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Note by the Secretariat

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

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

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

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

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

The present document outlines the revision of the Guidance Factsheets for Common Indicators 13, 14, 17, 18, 20 and 21 related to Ecological Objective 5 (Eutrophication) and Ecological Objective 9 (Contaminants) and proposes for the first time Guidance Factsheets for Candidate Indicators 26 and 27 related to Ecological Objective 11 (Energy including underwater noise). These revisions were reviewed and welcomed by the Ecosystem Approach Correspondence Group on Pollution Monitoring (CorMon on Pollution Monitoring) held in Podgorica, Montenegro on 2-3 April 2019, and transmitted to the MED POL Focal Points Meeting for its consideration and approval[1].

[1] All changes made and revisions introduced are marked in bold for easy of reference.

1 Table of Contents

List of Abbreviations / Acronyms

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

1. INTRODUCTION

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

2. The u**pdated** IMAP Guidance Factsheets **for Common Indicators 13, 14, 17, 18, 20 and 21 were considered and welcomed by the Meeting of CorMon on Pollution Monitoring. They** are provided in **Annex I of this document**.

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

2. THE GUIDANCE FACTSHEET FOR THE CANDIDATE INDICATOR 26

4.. The Guidance Factsheet for **Common Indicator 26 (EO11): "**Proportion of days and geographical distribution where loud, low and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animals" is presented in the following tabular form.

Indicator Title	Common indicator 26: Proportion of days and geographical distribution where loud, low and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animals	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Noise from human activities causes no significant impact on marine and coastal ecosystems.	Energy inputs into the marine environment, especially noise from human activities, are minimized	Number of days with impulsive sounds sources, their distribution within the year and spatially within the assessment area, are below thresholds
Rational		
Justification for indicator selection Anthropogenic energy introduced by human activities into the marine environment includes sound, light and other electromagnetic fields, heat and radioactive energy. The most widespread and pervasive is underwater sound (Dekeling et al., 2013a). Sound energy input can occur at varying spatial and temporal scales. Anthropogenic sounds may be of short duration (i.e. impulsive) or be long lasting (i.e. continuous). Lower frequency sounds can be transmitted far (tens to thousands of kilometres), whereas higher frequency sounds transmit less well in the marine environment (hundreds of meters to few kilometres (Urick, 1996). Most common sources of marine noise pollution include ship traffic, geophysical exploration and oil and gas exploitation, military sonar use and underwater detonations, telemetry devices and acoustic modems, scientific research involving the use of active acoustic sources, and offshore and inshore industrial construction works. Such activities are growing throughout the Mediterranean Sea (e.g. DeMicco; OWEMES, 2012; US Energy Information administration, 2013). Marine organisms can be adversely affected both on short and long timescales (and include acute or chronic impact and temporary or permanent effects (Richardson et al, 1995). Adverse effects can be		

subtle (e.g. temporary reduction in hearing sensitivity, stress effects causing reduced immunity, reproduction success or survival), or more obvious (e.g. injury, death). The former may be difficult to observe and evaluate while the latter may in some circumstances be related to acute short-range noise exposures. Concerning noise source-specific impact, it has been demonstrated that naval exercises involving the use of mid-frequency active sonars caused several mass stranding events of Cuvier's beaked whales along the coasts of the Mediterranean Sea and in other sea areas at least during the last 20 years (e.g. Frantzis, 1998; Fernandez et al., 2004; Martin et al., 2004; Agardy et al., 2007; Filadelfo et al., 2009). Further, this correlation is suspected also for the case of geophysical surveys (e.g. Southall et al., 2013; Castellote and Llorens 2013), although definite results are not available yet. Further, displacement and/or acoustic behavioural disruption may occur for Mediterranean fin whales in response to low frequency impulsive noise at very long ranges, reaching more than 200 km (Borsani et al., 2008; Castellote et al., 2012). Finally, sperm whales and beaked whales have been identified to be highly sensitive to mid-frequency impulsive sounds (e.g. Aguilar de Soto et al., 2006; Weir, 2008).

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

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Policy Context and targets

Policy context description

Generalities:

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

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

In parallel, the European Union adopted the same definition of pollution given in the paragraph above in the text of the Marine Strategy Framework Directive (MSFD, 2008/56/EC, adopted in 2008). The MSFD gave a considerable impulse to the undertaking of actions, programs, measures, as well as scientific research to cover the knowledge gaps on underwater noise, and hence develop appropriate guidance on the management of man-made noise in the marine environment.

With regards to the MSFD, underwater noise is addressed by Descriptor 11, and two criteria were selected for monitoring and assessment purposes, one addressing loud impulsive signals produced by several coastal and offshore works (pile driving, explosions, seismic pulses, etc.), the other targeting the contribution of anthropogenic sources, especially shipping, to ambient noise levels. Since the adoption of the MSFD (2008), the European Commission issued two Decisions addressing methodological standards for the monitoring and assessment of underwater noise: Commission Decision 2010/477/EU on criteria and methodological standards on good environmental status of marine waters, and Commission Decision 2017/848/EU laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU.

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

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

With specific regards to impulsive noise:

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

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

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

Targets

The primary activity under common indicator 26 should be the setting up by countries of a database ("a noise register[2]") for the registration of "noise events", where a noise event is the occurrence of loud impulsive signals (in low and mid frequency bands) on a given day and in a given place. Once the register is built, it is possible to obtain an overview of the spatial and temporal distribution of noise-producing activities, as well as set the specific thresholds to achieve defined targets. During the QUIETMED project (DG ENV/MSFD Second Cycle/2016) an interim list was drawn of possible targets addressing especially regulatory and management aspects of underwater noise. Possible target shall deal indeed with (not exhaustive list): increasing the number of mitigation measures applied to activities potentially causing impact, decreasing the number of activities generating loud noise in habitats of sensitive cetacean species, applying time-space closures (set on biological and ecological bases) to the occurrence of activities with the highest potential of causing impact to mention few.

Policy documents

Report of the following Meetings: COP17-18-19

- http://www.unepmap.org/index.php?module=events&action=detail&id=65
- http://rac-spa.org/nfp12/documents/reference/13ig21_9_eng.pdf
- http://195.97.36.231/dbases/MEETING_DOCUMENTS/12IG20_8_Eng.pdf

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

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

DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCILof 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)

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

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

Dekeling, R.P.A., Tasker, M.L., Van der Graaf, A.J., Ainslie, M.A, Andersson, M.H., André, M., Borsani, J.F., Brensing, K., Castellote, M., Cronin, D., Dalen, J., Folegot, T., Leaper, R., Pajala, J., Redman, P., Robinson, S.P., Sigray, P., Sutton, G., Thomsen, F., Werner, S., Wittekind, D., Young, J.V., 2014. Monitoring Guidance for Underwater Noise in European Seas, Part II: Monitoring Guidance Specifications, JRC Scientific and Policy Report EUR 26555 EN, Publications Office of the European Union, Luxembourg, 2014b, doi: 10.2788/27158.

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

Data Confidence and uncertainties

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

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

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

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

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

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

What noise sources should be registered:

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

<u>What information to collect to enter into the register:</u>

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

<u>Minimum thresholds (Source intensity) for including a noise event in the register</u>:
- For low frequency sources: no thresholds, i.e. all sources to be registered
- For mid-frequency sources, table hereafter:
-

Noise source type	**Thresholds for inclusion of noise events in the register**
Explosive	mTNTeq> 8 g
Airgun	SLz-p > 209 dB re 1 µPa m
Low/mid freq sonar	176 dB re 1 µPa m

Low/mid freq acoustic deterrent	176 dB re 1 µPa m
Other pulse	186 dB re 1 µPa² m² s

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

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

Available data sources

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

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

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

For military activities, as a first approach, the *notice to mariners*[3] can be monitored to gather information on possible military activities. Notice to mariners are indeed freely available information for navigation.

Spatial scope guidance and selection of monitoring stations

No monitoring stations needed, only declarative data are required to fill up the noise register. Concerning the spatial scope at large: the monitoring methodology is based on the use of a regular spatial grid to compute pulse-block days. In this sense, a block is a unit of area of a spatial management system, for example a cell of the regular spatial grid. If a noise event lasts several days in the same block (ca. area), the pulse-block day is equal to the number of days of duration of that noise event.

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

Based on the calculation of PBDs, it is possible to derive other quantities such as:

- the extent in km², or the proportion (%) of the assessed area, with impulsive sound sources. Here a country may decide to apply a minimum number of PBDs to account an area (e.g. a grid cell or blocks) in the calculation of the extent or proportion. Example: A conservative choice (ca. risk prevention) would be the proportion (% of grid cells) of the assessed area (total number of grid cell) with at least 1 PBDs.

Temporal Scope guidance

Data on noise events can be entered in the register by the responsible institution several times in a year, for example whenever data become available.
Based on the calculation of pulse-block days, it is possible to derive time-based quantities such as:

- the number of PBDs calculated monthly, quarterly, and/or yearly;
- the % of days over a time window with impulsive sound sources (noise events). Here again, a country may decide to apply a minimum # of PBDs to account an area (e.g. a grid cell) in the calculation of the extent or proportion. A conservative version of this indicator would be the following: the proportion (% of days) with at least 1 PBDs in the assessed time window (e.g. 1 month) and area (e.g. a subregion).

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

Basic descriptive statistics are needed to compute the indicator:

- the number of pulse-block days over a time window;
- the % of an assessment area with impulsive sound sources.

Further statistics are the trend analysis that maybe applied on different aggregated periods, for example: year to year; summer to summer, month of year N to month of year N+1 (and N+3, …) or others.

From a regional and sub regional perspective, once the noise register is established by a all countries, such data may be transferred to the ACCOBAMS Nosie Register. This is proposed as the basis for regional and sub regional aggregation of data which can feed regional assessment (QSR) as well as supporting countries in reporting to EcAp EO11.

Expected assessments outputs

The assessment outputs are the following:

- GIS maps showing the spatial and temporal distribution of noise sources over a year, or calculated monthly or quarterly; the value associated to each grid cell (block) in such maps is the total number of *pulse-block days* for a month, a quarter, or a year;
- Noise source coverage values: number of grid cells and % of the total cell number, or extent in km²with number of *pulse-block days*> 0;
- Trend analysis is possible across aggregated time periods (year, seasons, months, etc.).

Known gaps and uncertainties in the Mediterranean

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

Another important issue is the perception that underwater acoustics is too complex and noise monitoring generally too expensive. However, if this might be true if we talk about the science of acoustics (the physics of sound, the engineering behind the hydrophones and recording systems, in-situ recordings, software for analysing measurements, etc.), this Common Indicator was conceived to cut out most of this complexity, and this not only simplifies extremely the way of monitoring, but also minimizes the costs of implementation. Therefore, an emphasis should be put on correctly disseminating the information on how this indicator is built.		
Contacts and version Date		
Key contacts within ACCOBAMS and UN Environment/MAP for further information **SECRETARIAT PERMANENT DE L'ACCOBAMS** JARDIN DE L'UNESCO, LES TERRASSES DE FONTVIEILLE MC-98000, MONACO www.accobams.org **UN Environment/Mediterranean Action Plan** Barcelona Convention Secretariat Vas. Konstantinou 48, Athens 11635, Greece Telephone: +30 210 7273116 jelena.knezevic@unep.org www.unepmap.org		
Version No	**Date**	**Author**
V.1	10/07/2016	ACCOBAMS
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3. THE GUIDANCE FACTSHEET FOR THE CANDIDATE INDICATOR 27

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

Indicator Title	Common Indicator 27. Levels of continuous low frequency sound with the use of models as appropriate	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Noise from human activities causes no significant impact on marine and coastal ecosystems.	Energy inputs into the marine environment, especially noise from human activities, are minimized	Noise levels at monitoring stations are below thresholds; The extent (% or km²) of the assessment area which is above levels causing disturbance to sensitive marine animal is below limits, or such limits are exceeded for a limited amount of time
Rational		
Justification for indicator selector Anthropogenic energy introduced by human activities into the marine environment includes sources of sound, light, heat and others among the electromagnetic field spectrum. The most widespread and pervasive is underwater sound (Dekeling et al., 2013a). Sound energy input can occur at varying spatial and temporal scales. Anthropogenic sounds may be of short duration (i.e. impulsive) or be long lasting (i.e. continuous). Lower frequency sounds can be transmitted far (tens to thousands of kilometres), whereas higher frequency sounds transmit less well in the marine environment (hundreds of meters to few kilometres (Urick, 1996). Most common sources of marine noise pollution include ship traffic, geophysical exploration and oil and gas exploitation, military sonar use and underwater detonations, telemetry devices and acoustic modems, scientific research involving the use of active acoustic sources, and offshore and inshore industrial construction works. Such activities are growing throughout the Mediterranean Sea (e.g. DeMicco; OWEMES, 2012; US Energy Information administration, 2013). Marine organisms can be adversely affected both on short and long timescales and include acute or chronic impact and temporary or permanent effects (Richardson et al, 1995). Adverse effects can be subtle (e.g. temporary reduction in hearing sensitivity, stress effects causing reduced immunity, reproduction success or survival), or more obvious (e.g. injury, death). The former may be difficult to observe and evaluate while the latter may in some circumstances be related to acute short-range noise exposures. This indicator addresses, particularly, the continuous (ca. chronic) low-frequency sound produced by marine activities. The major contributor to this type of ambient ocean noise is produced by maritime traffic. For this reason, it has been pointed as an important factor potentially reducing the acoustic space of marine animals, and particularly cetaceans which are known to communicate over very long ranges through acoustic signals. Many studies also shown negative effects on fish. The potential masking of biological signal due to ship noise is considered indeed as a big issue risk as it may be the cause of many other indirect impacts, such as reduced reproduction, reduced foraging success, and hence a long term degradation of the survival rate of populations(e.g. Blair et al. 2016; Tennessen & Parks 2015; Putland et al. 2017; Aguilar de Soto et al. 2006; Pirotta et al. 2012; Wysocki et al. 2006)		

Scientific References

Aguilar de Soto, N. et al., 2006. Does Intense Ship Noise Disrupt Foraging in Deep-Diving Cuvier'S Beaked Whales (Ziphius Cavirostris)? Marine Mammal Science, 22(3), pp.690–699. Available at: http://doi.wiley.com/10.1111/j.1748-7692.2006.00044.x [Accessed May 22, 2013].

Blair, H.B. et al., 2016. Evidence for ship noise impacts on humpback whale foraging behaviour. Biology Letters, 12(8). Available at: http://rsbl.royalsocietypublishing.org/content/12/8/20160005.abstract.

Dekeling, R.P.A., Tasker, M.L., Van der Graaf, A.J., Ainslie, M.A, Andersson, M.H., André, M., Borsani, J.F., Brensing, K., Castellote, M., Cronin, D., Dalen, J., Folegot, T., Leaper, R., Pajala, J., Redman, P., Robinson, S.P., Sigray, P., Sutton, G., Thomsen, F., Werner, S., Wittekind, D., Young, J.V., 2014. Monitoring Guidance for Underwater Noise in European Seas, Part I: Executive Summary, JRC Scientific and Policy Report EUR 26557 EN, Publications Office of the European Union, Luxembourg, 2014, doi: 10.2788/29293

De Micco P. The prospect of Eastern Mediterranean gas production: An alternative energy supplier for the EU?

OWEMES. 2012. Offshore wind and other marine renewable energies in the Mediterranean and European seas. In Proceedings of the European Seminar OWEMES 2012, Lazzari A, Molinas P (eds). National Agency for New Technologies, Eneregy and Sustainable Economic Development: Rome.

Urick, Robert J. (1996). Principles of underwater sound. pp 444 Peninsula Publishing. 3rd Edition.
Pirotta, E. et al., 2012. Vessel noise affects beaked whale behavior: results of a dedicated acoustic response study. PloS one, 7(8), p.e42535. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3411812&tool=pmcentrez&rendertype=abstract [Accessed October 6, 2012].

Putland, R.L. et al., 2017. Vessel noise cuts down communication space for vocalizing fish and marine mammals. Global Change Biology, (November). Available at: http://doi.wiley.com/10.1111/gcb.13996.
Tennessen, J.B. & Parks, S.E., 2015. Acoustic propagation modeling indicates vocal compensation in noise improves communication range for North Atlantic right whales. Endangered Species Research, 30(1), pp.225–237.

US Energy Information Administration. 2013. Overview of oil and natural gas in the Eastern Mediterranean region. Geology.

Wysocki, L.E., Dittami, J.P. &Ladich, F., 2006. Ship noise and cortisol secretion in European freshwater fishes. Biological Conservation, 128(4), pp.501–508. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0006320705004350 [Accessed January 13, 2014].

Policy Context and targets

Policy context description

Shipping activities are regulated by the IMO, the United Nations agency with responsibility for many aspects of shipping, including safety, maritime security, environmental concerns, legal and technical

matters and efficiency. IMO is the source of several legal instruments, and among these the MARPOL Convention was signed with the aim of minimising pollution in oceans and seas. MARPOL includes 6 Annexes, each one addressing a category of pollution produced by ships: oil emissions, noxious liquids, packaged harmful substances, sewage, garbage, air pollution. Unfortunately, MARPOL defines pollution as substance, not energy, contrary to many other regulation bodies including other UN-related bodies such as the UN Convention on the Law of the Sea (UNCLOS). Underwater noise is therefore not addressed by MARPOL. However, in recent years the Marine Environment Protection Committee (MEPC) of the IMO addressed underwater noise produced by shipping. As a result, guidelines were issues on the reduction of noise emission from ships. (IMO 2014; IMO 2013b; IMO 2013a). However, it is worth noting that such guidelines address noise radiated from single ships and the way to mitigate the emissions, while the general rising in ambient ocean noise due to increased shipping (i.e. an ecosystem approach) is not addressed. Given the lack of global regulation of ship radiated noise, the MSFD and EcAp processes provide the first legal instrument for monitoring, assessing and setting targets, at least for their competence areas (the European Union and the Mediterranean region, respectively). All the policy document developed in the framework of such initiatives are therefore a novelty concerning the regulation of emissions of pollutant related to shipping. A closer cooperation with such global regulatory bodies as the IMO and MARPOL is certainly a major asset for the success of initiatives aimed at reducing ship radiated noise, the associated impacts, and therefore deliver good environmental status. Beyond large scale regulation, many interesting initiatives are being proposed to strengthen the implementation of mitigation measures applied to shipping at a local scale. For example, some ports authorities are setting specific rules to foster ships complying with increasingly high environmental standards, including low noise emissions through reduced speed or displacement of ship lanes. One of the most known initiatives appears to be the port authority of Vancouver. Of course, the sum and synergy of increasing numbers of local initiatives has the potential to create a network big enough to produce positive effects at the ecosystem scale.
Targets The early proposition contained in MSFD-related document was to adopt a decreasing trend in average noise levels. However, this appeared hard to implement as a trend could takes decades to be detected by robust statistical analysis, while actions may be taken already today to reduce noise radiated from ships, the contribution of shipping to marine noise, and finally the adverse effects on marine wildlife. An interim list of targets was developed in the framework of the QUIETMED project, subject to further discussion and validation, or adjustments. This list includes operational and environmental targets. The difference between such two types of targets are that operational targets address actions that can be already implemented and for which we are confident that this will help moving towards (or maintaining) GES. On the other hand, environmental targets rather describe the sought characteristics of the environment with respect to the pressure factor (continuous noise from shipping in the case of Common Indicator 27). Therefore, environmental targets are more related to the units of measurements of the indicator (noise levels, spatial extents, etc.). Operational and environmental targets included in QUIETMED Deliverable 2.3 are the following: (operational) promoting the adoption of IMO guidelines on the reduction of ship radiated noise, and promoting other initiatives aimed fostering the emergence of low-noise ships (e.g. labelling, promoting the role of harbour authorities in regulating noise from ships, etc.); (environmental) threshold levels not exceeded > XX days/year; or (environmental) area with levels exceeding thresholds does not exceed XX% of the assessment area.
Policy documents

IMO, 2014. GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE FROM COMMERCIAL SHIPPING TO ADDRESS ADVERSE IMPACTS ON MARINE LIFE. 44(April).
IMO, 2013a. Noise from commercial shipping and its adverse impacts on marine life.66(March).

IMO, 2013b. PROVISIONS FOR REDUCTION OF NOISE FROM COMMERCIAL SHIPPING AND ITS ADVERSE IMPACTS ON MARINE LIFE.

International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78).

Report of the following Meetings: COP17-18-19:

- http://www.unepmap.org/index.php?module=events&action=detail&id=65
- http://rac-spa.org/nfp12/documents/reference/13ig21_9_eng.pdf
- http://195.97.36.231/dbases/MEETING_DOCUMENTS/12IG20_8_Eng.pdf
- Reports of the 4th and 5thEcAp Coordination Unit meeting
- http://195.97.36.231/dbases/MEETING_DOCUMENTS/14WG401_8_ENG.pdf
- Report of the Meeting of the CORMONs, Athens 30 March – 01 April 2015
- Report of the Meeting of MED POL and joint-session MED POL/REMPEC, Malta 16-19, June 2015.
- http://195.97.36.231/dbases/MEETING_DOCUMENTS/15WG417_17_ENG.pdf
-

DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (2010/477/EU).

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

Indicator analysis methods

Indicator Definition

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

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

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

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

Concerning frequencies, they were chosen as follows:

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

Methodology for indicator calculation

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

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

The metrics to employ are the following:

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

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

Indicator units

Sound Pressure Levels expressed in **dB re 1µPa**

List of Guidance documents and protocols available

Dekeling, R.P.A., Tasker, M.L., Van der Graaf, A.J., Ainslie, M.A, Andersson, M.H., André, M., Borsani, J.F., Brensing, K., Castellote, M., Cronin, D., Dalen, J., Folegot, T., Leaper, R., Pajala, J., Redman, P., Robinson, S.P., Sigray, P., Sutton, G., Thomsen, F., Werner, S., Wittekind, D., Young, J.V., 2014. Monitoring Guidance for Underwater Noise in European Seas, Part I: Executive Summary, JRC Scientific and Policy Report EUR 26557 EN, Publications Office of the European Union, Luxembourg, 2014, doi: 10.2788/29293.

Best practice guidelines on acoustic modelling and mapping. 2017/848/EU and ACCOBAMS premises, and generalisation for the EcAp process. Deliverable 3.3, QUIETMED project. DG ENV/MSFD Second Cycle/2016.

Best practices guidelines on signal processing algorithms for the preprocessing of the data and for obtaining the noise indicator. Deliverable 3.2, QUIETMED project. DG ENV/MSFD Second Cycle/2016.

ACCOBAMS, 2015. A basin-wide strategy for underwater noise monitoring in the Mediterranean. Report prepared by Alessio Maglio, Manuel Castellote and Gianni Pavan.

Borsani, J.F., Faulkner, R.C. & Merchant, N.D., 2015. Impacts of noise and use of propagation models to predict the recipient side of noise. Report prepared under contract ENV.D.2/FRA/2012/0025 for the European Commission. Centre for Environment, Fisheries & Aquaculture Science, UK. , (July), p.27. Available at: http://mcc.jrc.ec.europa.eu/document.py?code=201601081529.

Verfuß, U.K., Andersson, M., Folegot, T., Laanearu, J., Matuschek, R., Pajala, J., Sigray, P., Tegowski, J., Tougaard, J. BIAS Standards for noise measurements. Background information, Guidelines and Quality Assurance. Amended version. 2015.

Wang, L.S. et al., 2014. Review of underwater acoustic propagation models (April 2016), p.35.

Data Confidence and uncertainties

Many sources of uncertainty exist concerning both measurements and models: the characteristics of the sound recorder used, the calibration, the mooring conditions and on the location of deployment (near or far from shipping lanes, in shadow areas, etc.), as well as many steps and settings of the data processing. Also, modelling methods contemplate a large number of variability factors often hindering meaningful comparisons among different monitoring programs. Such uncertainty results in well-known shortcomings in the understanding of how anthropogenic noise may affect the environment.

However, despite these sources of uncertainty, many steps forward have been done since the beginning of the implementation of the EcAp process, and considerable effort was done to develop guidance and best practices. Many of these efforts were focussed in northern European waters and the North Atlantic, but recent QUIETMED project produced valuable work in the direction of laying down common methods and shared understanding of the several technical aspects.

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

General monitoring methodology: the combined use of measurements and modelling is recommended. Continuous sound recording should be done at fixed sites through sound recording stations. Acoustic modelling and mapping through appropriate analytical procedures producing estimations to be validated from field measures.

The use of in-situ acoustic measurements is essential for:

- Gathering fundamental field data to establish information on the ambient noise in a given location

- Reducing uncertainty on source levels to be used as the input for modelling;
- Increasing evidence base to improve management decisions.

The use of models is essential for:

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

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

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

Available data sources

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

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

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

Spatial scope guidance and selection of monitoring stations

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

Location of sampling sites:

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

Temporal Scope guidance

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

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

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

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

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

In addition, ACCOBAMS considers that values in percentile appear very useful to convey information about how much time noise levels are maintained, welcoming the advice from different works on

underwater noise monitoring (e.g. Merchant et al., 2013). In this regard, the adoption of the 33% Exceedance Level addresses the potential seasonal rising in ambient noise due to recreational craft, which is suspected to be heavy in many coastal areas of the Mediterranean region. Finally, aggregation could be done through transboundary cooperation at the sub-regional level.
Expected assessments outputs The assessment outputs are the following: - Levels and maps of mean sound pressure level over a year or other suitable temporal windows; - Levels and maps of 33% exceedance level over a year or other suitable temporal windows; Trend analysis across years or other periods (any robust statistical technique able to detect a trend can be used).
Known gaps and uncertainties in the Mediterranean The Mediterranean presents a majority of deep-water environment whose soundscape has been poorly studied, although some fixed deep monitoring observatories (2 stations of the European Multidisciplinary Seafloor Observation/ European Seas Observatory Network of Excellence - EMSO/ESONET network, respectively 1 in the NW Mediterranean and 1 in the Ionian Sea) provide long term acoustic data since many years. Obviously, many other temporary deployments from the ‘90s to date were done and data are available for reviewing levels, results, and more with a view of establishing baselines. However, common shortcomings (lack of standards for calibration, and the many source of variability highlighted above in this factsheet), may prevent from extracting meaningful information from such review concerning the Common Indicator 27. Further, the poor AIS coverage in some parts of the Mediterranean, especially the southern part, may affect the quality of monitoring through modelling techniques. However, the work done in the last 10 years on underwater noise from an ecosystem perspective enabled a better understanding. The Mediterranean present a majority of deep-water environment whose soundscape has been poorly studied, although some fixed deep monitoring observatories (2 stations of the EMSO/ESONET network, 1 in the NW Mediterranean, 1 in the Ionian Sea) provide long term acoustic data since many years. Obviously, many other temporary deployments from the ‘90s to date were done and data are available for reviewing levels, results, and more with a view of establishing baselines. However, common shortcomings (lack of standards for calibration, and the many source of variability highlighted above in this factsheet), may prevent from extracting meaningful information from such review concerning the Common Indicator 27. Further, the poor AIS coverage in some parts of the Mediterranean, especially the southern part, may affect the quality of monitoring through modelling techniques. However, the work done in the last 10 years on underwater noise from an ecosystem perspective enabled a better understanding, and thus a better management and mitigation, of the different sources of uncertainties.

Contacts and version Date		
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Version No	**Date**	**Author**
V.1	10/07/2016	ACCOBAMS
V.2	25/01/2019	ACCOBAMS in consultations with UN Environment/MAP

Annex I

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

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

1.1 Common Indicator 13

1. The update for **Common Indicator 13 (EO5)**: Concentration of key nutrients in water column[4,5] is presented in bellow table.

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

[4]Note that this builds upon a previous indicator factsheet developed under Horizon 2020. H2020 Indicators Fact Sheets. Regional meeting on PRTR and Pollution indicators, Ankara (Turkey), 16-17 June 2014. (UNEP(DEPI)/MED WG. 399/4)

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

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

ii. Conley D.J., Schelske C.L., Stoermer E. F., 1993. Modification of the biogeochemical cycle of silica with eutrophication. Mar. Ecol. Prog. Ser. 101, 179-192.

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

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

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

Policy Context and targets

Policy context description

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

Targets

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

Policy documents

General Policy documents

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

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

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

Indicator Title	Common Indicator 13. Concentration of key nutrients in water column (EO5)
iv. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy(Marine Strategy Framework Directive). **Nutrient/Eutrophication related Policy documents** v. UNEP/MAP MED POL (2003). Eutrophication Monitoring Strategy of UNEP/MAP MED POL. UNEP(DEPI)/MED WG.231/14. UNEP, Athens. vi. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. vii. UNEP/FAO/WHO (1996). ‘Assessment of the state of eutrophication in the Mediterranean Sea’. MAP Technical Reports Series No 106. UNEP, Athens, 211 pp. viii. UNEP/MAP MED POL (1990a). Activity IV: Research on the effects of pollutants on Marine Organisms and their Populations (UNEP/MAP MED POL Phase I, 1975-1981). ix. UNEP/MAP MED POL (1990b). Activity V: Research on the effects of pollutants on Marine Communities and Ecosystems (UNEP/MAP MED POL Phase I, 1975-1981).	
Indicator analysis methods	
Indicator Definition Concentration of key (inorganic) nutrients in the water column: **Nítrate** (NO_3-N) Nitrite (NO_2-N) Ammonium (NH_4-N) Total Nitrogen (TN) Orthophosphate (PO_4-P) Total Phosphorus (TP) Orthosilicate (SiO_4-Si) Sub-Indicators: Nutrient ratios (molar) of silica, nitrogen and phosphorus where appropriate: Si:N, N:P, Si:P	
Methodology for indicator calculation All: Spectrophotometry (manually or automated methods and instrumentation)	
Indicator units All: micromol per liter, that is micromolar concentration (μmol/L =μM) Ratios: adimensional (simple mathematical derivation of ratios from nutrient concentrations)	
List of Guidance documents and protocols available i. OSPAR, 2012. OSPAR MSFD Advice Document on Eutrophication. Approaches to determining good environmental status, setting of environmental targets and selecting indicators for Marine Strategy Framework Directive descriptor 5. ii. Piha, H., Zampoucas, N., 2011. Review of Methodological Standards Related to the Marine Strategy Framework Directive Criteria on Good Environmental Status. JRC Scientific and Technical Reports, EUR 24743 EN	

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

iii. UNEP/MAP MED POL (2005). Sampling and Analysis Techniques for the Eutrophication Monitoring Strategy of UNEP/MAP MED POL. MAP Technical Reports Series No. 163. UNEP, Athens. 61pp.
iv. Durairaj, P., Sarangi, R.K., Ramalingam, S. *et al.* Seasonal nitrate algorithms for nitrate retrieval using OCEANSAT-2 and MODIS-AQUA satellite data. Environ Monitoring Assess (2015) 187: 176.
v. See also UNEP/MAP website (http://web.unep.org/unepmap)

Data Confidence and uncertainties

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

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

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

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

Available data sources
MED POL Database.

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

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

Spatial scope guidance and selection of monitoring stations

The first factor promoting eutrophication is nutrient enrichment. This explains why the main eutrophic areas are to be found primarily not far from the coast, mainly in areas receiving high nutrient loads, despite some natural symptoms of eutrophication can also be found, such as in upwelling areas. Additionally, the risk of eutrophication is linked to the capacity of the marine environment to confine growing algae in the well-lighted surface layer. The geographical extent of potentially eutrophic waters may vary widely, depending on:
(i) the extent of shallow areas, i.e. with depth $\leq$ 20 m;

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

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

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

Temporal Scope guidance

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

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

Mainly, in order to build a robust sampling frequency scale in future a sounded statistical approach has to be developed that takes into account the discriminant limit between classes when the nutrient boundaries approach will be widely accepted. **Let consider the approach developed for CI14 - Chlorophyll a concentration in water column as an example to be used, as for this CI accepted boundaries exists.**

Sampling frequency is determined by the variability of the measured parameters and is usually determined by how many samples are needed to reliably assess the differences between two neighbouring mean values.

Discriminant limit (ie power of applied test), depends on sample size:

Discriminant limit dM = sd * t(α/2; N1+N2-2) * √ 2; N1+N2-2) 0

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

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

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

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

Data analysis and assessment outputs

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

Expected assessments outputs

As suggested by the on line expert group on eutrophication established by the Contracting parties it is recommended that with regard to nutrient concentrations, until commonly agreed thresholds have been determined and agreed upon, GES may be determined on a levels and trend monitoring basis.

Known gaps and uncertainties in the Mediterranean

For a complete assessment of eutrophication and GES achievement, GES thresholds and reference conditions (natural background concentrations) are needed not only for chlorophyll *a*, but such values must be set in the near future, through dedicated workshops and exercises also for nutrients, transparency and oxygen as minimum requirements (see also related Common Indicator 14). This should include quality assurance schemes, as well as data quality control protocols.
Nutrient, transparency and oxygen thresholds and reference values may not be identical for all areas, since is recognized that area-specific environmental conditions must define threshold values. GES could be defined on a sub-regional level, or on a sub-division of the sub-region (such as the Northern Adriatic), due to local specificities in relation to the trophic level and the morphology of the area.

Contacts and version Date

http://www.unepmap.org

Version No	**Date**	**Author**
V.1	31.5.17	MEDPOL
V.2	10.1.19	MEDPOL

1.2 Common Indicator 14

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

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Natural levels of algal biomass, water transparency and oxygen concentrations in line with prevailing physiographic, geographic and weather conditions	Direct and indirect effects of nutrient over-enrichment are prevented	1. Chlorophyll *a* concentrations in high-risk areas below thresholds 2. Decreasing trend in chl-*a* concentrations in high risk areas affected by human activities
Rational		
Justification for indicator selection Eutrophication is a process driven by enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of nutrients causing changes to the balance of organisms; and water quality degradation. The consequences of eutrophication are undesirable if they appreciably degrade ecosystem health and/or the sustainable provision of goods and services, such as excessive algal blooms, dissolved oxygen deficiency, declines in sea-grasses, mortality of benthic organisms and/or fish. Altough, these changes may also occur due to natural processes, the management concern begins when they are attributed to anthropogenic sources.		
Scientific References i. Boyer J.N. Kelble C.R., Ortner P.B., Rudnick D.T., 2009. Phytoplankton bloom status: Chlorophyll *a* biomass as an indicator of water quality condition in the southern estuaries of Florida, USA. Ecological Indicators 9s:s56- s67. ii. Primpas I., Karydis M., 2011. Scaling the trophic index (TRIX) in oligotrophic marine environments. Environmental Monitoring and Assessment July 2011, Volume 178, Issue 1-4, pp 257-269. iii. Vollenweider, R.A., Giovanardi F., Montanari, G., Rinaldi A., 1998. Characterization of the trophic conditions of marine coastal waters, with special reference to the NW Adriatic Sea: proposal for a trophic scale, turbidity and generalized water quality index. Environmetrics, 9, 329-357.		
Policy Context and targets		
Policy context description In the Mediterranean, the UNEP/MAP MED POL Monitoring programme included from its inception the study of eutrophication as part of its seven pilot projects approved by the Contracting Parties at the Barcelona meeting in 1975 (UNEP MAP, 1990a,b). The issue of a consistent monitoring strategy and assessment of eutrophication was first raised at the UNEP/MAP MED POL National Coordinators Meeting in 2001 (Venice, Italy) which recommended to the Secretariat to elaborate a draft programme for monitoring of eutrophication in the Mediterranean coastal waters (UNEP/MAP MED POL, 2003).		

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

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

Targets

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

Policy documents

General Policy documents

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

Nutrient/Eutrophication related Policy documents

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

Indicator analysis methods

Indicator Definition

Chlorophyll *a* concentration in the water column (State, Impact Indicator);

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)
Sub-Indicators: Water Transparency (State, Impact Indicator) and Dissolved oxygen (State, Impact Indicator)	
Methodology for indicator calculation Chlorophyll *a*: Spectrophotometry. ISO 10260 (1992) on spectrometric determination of the chlorophyll *a* concentration provides a standard method for quantification of chlorophyll *a*. Water transparency: measured as Secchi disk depth or according to ISO 7027:1999 Water Quality-Determination of Turbidity Dissolved Oxygen: Chemical methods, Oxygen sensors, etc. measured near the bottom (under the euphotic layer/oxycline)	
Indicator units microgram per liter (µg/L) - Chlorophyll *a* meters – Secchi disk depth; NTU Turbidity Scale (Nephelometric Turbidity Units) – Water transparency milligram per liter (mg/L) and % Saturation (if temperature and salinity is known) – Dissolved Oxygen	
List of Guidance documents and protocols available i. OSPAR, 2012. OSPAR MSFD Advice Document on Eutrophication. Approaches to determining good environmental status, setting of environmental targets and selecting indicators for Marine Strategy Framework Directive descriptor 5 ii. Piha, H., Zampoucas, N., 2011. Review of Methodological Standards Related to the Marine Strategy Framework Directive Criteria on Good Environmental Status. JRC Scientific and Technical Reports, EUR 24743 EN iii. UNEP/MAP MED POL, 2005. Sampling and Analysis Techniques for the Eutrophication Monitoring Strategy of UNEP/MAP MED POL. MAP Technical Reports Series No. 163. UNEP, Athens. 61pp.	
Data Confidence and uncertainties Despite the great variability born by the water layers subject to active hydrodynamic processes, monitoring the characteristics of the seawater is still the most direct way of assessing eutrophication. A number of parameters have been identified as providing most information relative to eutrophication e.g. chlorophyll *a*, dissolved oxygen, inorganic nutrients, organic matter, suspended solids, light penetration, aquatic macro-phytes, zoo benthos, etc. They all may be determined either at the surface or at various depths. If only limited means are available, determination of those parameters that synthesize the most information should be retained. Chlorophyll *a* determination for example, although not very precise representations of the system, are data which provide a great deal of information. Turbidity may also be a good measure of eutrophication, except near the mouths of rivers where inert suspended solids may be extremely abundant. Dissolved oxygen is one parameter that integrates much information on the processes involved in eutrophication, provided it is measured near the bottom or, at least, below the euphotic zone where an oxycline usually appears.	
Methodology for monitoring, temporal and spatial scope	
Available Methodologies for Monitoring and Monitoring Protocols Traditional methods for eutrophication monitoring in coastal waters involve *in situ* sampling/measurements of commonly measured parameters such as nutrients concentration, chlorophyll	

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)
a concentration, phytoplankton abundance and composition, transparency and dissolved oxygen concentration. Concerning available methods for *in situ* measurements, ships provide flexible platforms for eutrophication monitoring, while remote sensing provides opportunities for a synoptic view over regions or sub-regions. Besides traditional ship measurements, ferry-boxes and other autonomous measuring devices have been developed that allow high frequency and continuous measurements. Modelling and remote sensing should also be considered as area integrating in addition to *in situ* measurements, depending on the requirements with respect to data. In general, *in situ* measurements always remain necessary to validate and calibrate the models and data calculated from satellite measurements. However, satellite data need to be supported by ground truth data. A good strategy appears to be a combination of remote sensing and scanning of the area known or suspected to be affected with automatic measuring instruments such as thermo-salinometer, dissolved oxygen sensors and *in vivo*fluorometer and/or nephelometer. Sampling for the determination of *in vitro* fluorescence and nutrient analysis may be carried out with relatively little effort if a proper pump and hose are mounted on the ship. The measurements may be done at the surface or just below it with a water intake on the hull of the vessel or at fixed or varying depths with a towed "fish" and pumping system.	
Available data sources **MED POL Database.** **EMODNET Chemistry:** **http://www.emodnet-chemistry.eu/data_access.html** **EEA Waterbase - Transitional, coastal and marine waters:** **http://www.eea.europa.eu/data-and-maps/data/waterbase-transitional-coastal-and-marine-waters-11** Satellite databases such as in EMIS http://mcc.jrc.ec.europa.eu/emis/	
Spatial scope guidance and selection of monitoring stations The extent of eutrophication shows spatial variation, for instance coastal regions versus the open sea. The frequency and spatial resolution of the monitoring programme should reflect this spatial variation in eutrophication status and pressures following a risk based approach and the precautionary principle. The geographical extent of potentially eutrophic waters may vary widely, depending on: (i) the extent of shallow areas, i.e. with depth ≤ 20 m; (ii) the extent of stratified river plumes, which can create a shallow surface layer separated by a halocline from the bottom layer, whatever its depth (iii) extended water residence times in enclosed seas leading to blooms triggered to a large degree by internal and external nutrient pools; and (iv) upwelling phenomena leading to autochthonous nutrient supply and high nutrient concentrations from deep water nutrient pools, which can be of natural or human origin. Therefore, the geographical scale of monitoring for the assessment of GES for eutrophication will depend on the hydrological and morphological conditions of an area, particularly the freshwater inputs from rivers, the salinity, the general circulation, upwelling and stratification. The spatial distribution of the monitoring stations should, prior to the establishment of the eutrophication status of the marine sub-region/area, be risk-based and proportionate to the anticipated extent of eutrophication in the sub-region under consideration as well as its hydrographic characteristics aiming for the determination of spatially homogeneous areas. The eutrophication monitoring programmes should pursue to assess the	

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

eutrophication phenomena, based on the differentiation of the scale and time dependant signals from human induced versus natural eutrophication.

Temporal Scope guidance

The current national eutrophication monitoring programme implemented so far by the Contracting Parties in the framework of the UNEP/MAP MED POL programme should be used as a sound basis for monitoring under the EcAp.
Sampling frequency has to be determined by the variability of the measured parameters and is usually determined by how many samples are needed to reliably assess the differences between two neighbouring mean values.
Discriminant limit (i.e. power of applied test), depends on sample size:

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

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

N = 12 t = 2.074 $\sqrt{(2/12)}$ **= 0.408 dM > |0.25|**
N = 24 t = 2.013 $\sqrt{(2/24)}$ **= 0.289 dM > |0.17|**
N = 52 t = 1,983 $\sqrt{(2/52)}$ **= 0.196 dM > |0.12|**

Based on the above it follows that a particular area can be characterized best if we measure three relevant depths (typically 0, 5 and 10 m) at one station at least monthly or at three stations one depth (0 m). It is at annual base 36 samples which discriminates around 0.15 chla log10 unit for mesotrophic - eutrophic area that is slightly less than half difference between two classes (0.37 as log10 unit). Due to smaller standard deviation for an oligotrophic area we achieve the same with half the frequency. The next measurement frequency is proposed:
Eutrophic – mesotrophic: monthly,
mesotrophic – oligotrophic: monthly near the coast, bimonthly in open waters, and
oligotrophic: bimonthly near the coast, seasonally in open waters.
For open waters sampling frequency to be determined on a sub-regional level following a risk-based approach
Water transparency: *id.* Chlorophyll *a*
Dissolved Oxygen: *id.* Chlorophyll *a*

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

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

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

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

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

Table 1. Major coastal water types in the Mediterranean

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

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

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

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

***	applicable to Gulf of Lion**
****	applicable to Adriatic**

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

Expected assessments outputs

GES thresholds and trends are recommended to be used in a combined way, according to data availability and agreement on GES threshold levels. In the framework of UNEP/MAP MED POL

Indicator Title	Common Indicator 14. Chlorophyll *a* concentration in water column (EO5)
there is experience with regard to using quantitative thresholds. It is proposed that for the Mediterranean region, quantitative thresholds between "good" (GES) and "moderate" (non GES) conditions for coastal waters could be based as appropriate on the work carried out in the framework of the MEDGIG intercalibration process of the EU Water Framework Directive (WFD). The Contracting Parties are recommended to rely on the classification scheme on chlorophyll a concentration (μg/L) in coastal waters as a parameter easily applicable by all Mediterranean countries based on the indicative thresholds and reference values of chlorophyll a in Mediterranean coastal water types (according to 2013/480/EU, see reference below), recalling on reference conditions and boundaries of good/moderate status (G/M). **In this context regarding the definition of sub-regional thresholds for chlorophyll a water typology is very important for further development of classification schemes of a certain area. Within the MEDGIG exercise the recommended water types for applying eutrophication assessment is based on hydrological parameters characterizing a certain area dynamics and circulation.** **COMMISSION DECISION (EU) 2018/229 of 12 February 2018 establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, the values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Commission Decision 2013/480/EU.**	
Known gaps and uncertainties in the Mediterranean For a complete assessment of eutrophication and GES achievement, GES thresholds and reference conditions (natural background concentrations) are needed not only for chlorophyll *a*, but such values must be set, in the near future, through dedicated workshops and exercises also, water transparency and oxygen as minimum requirements, where appropriate. This should include quality assurance schemes, as well as data quality control protocols. Further, in order to increase coherency and comparability regarding eutrophication assessment methodologies is recommended that further efforts should be made to harmonize existing tools through workshops, dialogue and comparative exercises at regional/subregional/subdivision levels in Mediterranean with a view to further improve and develop common assessment methods.	
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Version No	**Date**	**Author**
V.1	31.5.17	MEDPOL
V.2	10.1.19	MEDPOL

1.3 Common Indicator 17

3. **The update for Common Indicator 17 (EO9)**: Concentration of key harmful contaminants measured in the relevant matrix[7] is presented in below table.

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

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

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

iv. Bricker, S., Lauenstein, G., Maruya, K., 2014. NOAA's Mussel Watch Program: Incorporating contaminants of emerging concern (CECs) into a long-term monitoring program. *Mar.Poll.Bull.*, 81, 289–290.

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

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

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

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

Policy Context and targets

Policy context description

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

Targets

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

Policy documents

General Policy documents

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

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

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

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

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

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

vi. COMMISSION DECISION (EU) 2017/848 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU.

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

Contaminants related Policy documents

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

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

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

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

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

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

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

Indicator analysis methods

Indicator Definition

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

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

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

Organochlorinated compounds (PCBs, Hexachlorobenzene, Lindane and ΣDDTs)
Polycyclic Aromatic Hydrocarbons **(PAHs)**

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

MARINE SEDIMENTS: In coastal **and marine areas, continental** platform and offshore, sediments **should be collected by mechanical means and processed at the laboratory** (< 2 mm particle size fraction). **Further the following hazardous substances should be measured:**
Trace/Heavy Metals: Total mercury (HgT), Cadmium (Cd) and Lead (Pb)
Organochlorinated compounds (PCBs (at least, congeners 28, 52, 101, 118, 138, 153, 180, 105 and 156) , aldrin, dieldrin, Hexachlorobenzene, Lindane and ΣDDTs)
Polycyclic Aromatic Hydrocarbons **(PAHs)**

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

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

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

The chemical compounds above are being used to develop the IMAP Info System and those are included in the list of contaminants of concern which accompanies the Data Dictionaries (DDs) and Data Standards (DSs) for CI17.

Methodology for indicator calculation

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

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

TOC: Elemental Analyser

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

Additional parameters to be recorded: biometrics (size/length, age), biological parameters such as condition index (mussels), condition factor **according established protocols and scientific knowledge.**

Indicator units

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

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

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

TOC: Elemental Analyser (as %)

Particle fractions (as %)

List of Guidance documents and protocols available

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

Data Confidence and uncertainties

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

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

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

Available data sources

i. UNEP(DEPI)/MED WG.365/Inf.5. Analysis of the trend monitoring activities and data for the MED POL Phase III and IV (1999-2010). Consultation Meeting to Review MED POL Monitoring Activities. Athens, 22-23 November 2011.

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

ii. UNEP(DEPI)/MED WG. 365/Inf.8. Development of assessment criteria for hazardous substances in the Mediterranean. Consultation Meeting to Review MED POL Monitoring Activities. Athens, 22-23 November 2011.

iii. UNEP(DEPI)/MED WG. 427/Inf.3. Background to the Assessment Criteria for Hazardous Substances and Biological Markers in the Mediterranean Sea Basin and its Regional Scales.

iv. **Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring Marseille, France, 19-21 October 2016.**

Spatial scope guidance and selection of monitoring stations

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

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

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

Temporal Scope guidance

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

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

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

<table>
<tr><td>Indicator Title</td><td colspan="2">Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)</td></tr>
<tr><td colspan="3">The temporal scope may range from seasonally variable parameters up to large time scales, e.g. sediment core monitoring (years to decades). For temporal trend determinations the sampling frequencies will depend on the ability to detect trends considering the environmental and the analytical variability (ca. total uncertainty). It can be possible to decrease the sampling frequencies and target chemicals in cases where established time trends and levels show concentrations well below levels of concern, and without any upward trend over a number of years (including the stations/sites where recurrently exhibit non-detected contaminants value; that is below detection and quantification limits).</td></tr>
<tr><td colspan="3">Data analysis and assessment outputs</td></tr>
<tr><td colspan="3">Statistical analysis and basis for aggregation

Monitoring should allow the necessary statistical data treatments and long-term time-trend data analysis.</td></tr>
<tr><td colspan="3">Expected assessments outputs

For chemical contaminants, trends analysis and distribution levels for the assessment could be carried out on sub-regional and/or regional level, provided appropriate quality control assured datasets are available. For the assessment of GES, it would be carried out using Mediterranean data from the MEDPOL database and applying a two-level threshold classification (Background Assessment Criteria-BACs and Environmental Assessment Criteria-EACs), such as the OSPAR methodology. However, the revised Mediterranean BACs and EACs for chemical contaminants, such as trace metals (mercury, cadmium and lead) and organic contaminants (chlorinated compounds and PAHs) in sediments and biota in the Mediterranean Sea should be applied.</td></tr>
<tr><td colspan="3">Known gaps and uncertainties in the Mediterranean

Important development areas in the Mediterranean Sea over the next few years will include harmonization of monitoring targets (determinants and matrices) within assessment at sub-regions scales, development of suites of assessment criteria, integrated chemical and biological assessment method developments, and review of the scope of the national monitoring programmes to ensure that those contaminants which are considered to be important within each assessment area are included.. Through these and other actions, it will be possible to develop targeted and effective monitoring programmes tailored to meet the needs and conditions within each GES assessment sub-region.It has been recognized that the open and deep sea is much less covered by monitoring efforts than coastal areas. There is a need to include within monitoring programmes also areas beyond the coastal areas in a representative and efficient way (where risks warrant coverage).</td></tr>
<tr><td colspan="3">Contacts and version Date</td></tr>
<tr><td colspan="3">http://www.unepmap.org</td></tr>
<tr><td>Version No</td><td>Date</td><td>Author</td></tr>
<tr><td>V.2</td><td>31.05.17</td><td>MEDPOL</td></tr>
<tr><td>V.3</td><td>11.09.17</td><td>MEDPOL</td></tr>
<tr><td>V.4</td><td>12.12.18</td><td>MEDPOL</td></tr>
</table>

1.4 Common Indicator 18

4. The update for **Common Indicator 18 (EO9)**: Level of pollution effects of key contaminants where a cause and effect relationship has been established8 is presented in below table.

Indicator Title	Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Concentrations of contaminants are not giving rise to acute pollution events	Effects of released contaminants are minimized	Contaminants effects below threshold Decreasing trend in the operational releases of oil and other contaminants from coastal, maritime and off-shore activities.
Rational		
Justification for indicator selection Upon exposure to certain dose of harmful contaminants, marine organisms start manifesting a number of symptoms that are indicative of biological damage, the first ones appearing after a short while at the sub-cellular level. These ’sub lethal’ effects, when integrated, often converge to visible harm for the organisms and possibly to the whole population at a later stage, when it will be too late to limit the extent of biological damage resulting from environmental chemical exposure and ecosystems deterioration. Most of these symptoms have been reproducibly obtained in the laboratory (at high dose) and the various biological mechanisms of response to major xenobiotics are now sufficiently well documented. In the latest decades, scientific research has been intensified towards these alternative cellular and sub-cellular methods for integrated pollution monitoring, despite it revealed a more complex panorama with samples exposed to environmental concentrations, which includes a number of confounding factors hindering the cost-effective and reliable determination of biological effects at cellular and sub-cellular levels. As a consequence, most of these methods (biomarkers), based on the chemical exposure to biological effects cause relationships, are envisaged to monitor hotpots stations, dredging materials assessments and local damage evaluations rather than for continuous long-term environmental monitoring (surveillance). Ongoing research (biomarkers, bioassays) and future research trends, such as ‘omics’ developments, will further define the indicators and the methodologies for these common indicators for toxicological effects.		
Scientific References i. European Commission, 2014. Technical report on aquatic effect-based monitoring tools. Technical Report - 2014 – 077. ii. Davies, I. M. And Vethaak, A.D., 2012. Integrated marine environmental monitoring of chemicals and their effects. ICES Cooperative Research Report N). iii. Moore, M.N. (1985), Cellular responses to pollutants. *Mar.Pollut.Bull.*, 16:134-139 iv. Moore, M.N. (1990), Lysosomal cytochemistry in marine environmental monitoring. *Histochem J.*, 22:187-191		

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

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

v. Scarpato, R., L. Migliore, G. Alfinito-Cognetti and R. Barale (1990), Induction of micronuclei in gill tissue of *Mytilusgalloprovincialis*exposed to polluted marine waters *Mar.Pollut.Bull.*, 21:74-80

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

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

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

Policy Context and targets

Policy context description

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

Targets

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

Policy documents

General Policy documents

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

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

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

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

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

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

Contaminants related Policy documents

vi. UNEP (1997), The MED POL Biomonitoring Programme Concerning the Effects of Pollutants on Marine Organisms Along the Mediterranean Coasts. UNEP(OCA)/MED WG.132/3, Athens, 15 p.

vii. UNEP (1997), Report of the Meeting of Experts to Review the MED POL Biomonitoring Programme. UNEP(OCA)/MED WG.132/7, Athens, 19 p.

viii. Targets: UNEP(DEPI)/MED WG.421/Inf.9. Integrated Monitoring and Assessment Guidance. Agenda item 5.7: Draft Decision on Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria. Meeting of the MAP Focal Points. Athens, Greece, 13-16 October 2015.

Indicator analysis methods

Indicator Definition

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

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

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

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

Methodology for indicator calculation

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

Acetylcholinesterase (AChE) assay: Biochemical techniques, including spectrophotometry

Micronucleus assay: Biochemical techniques, including microscopy

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

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

Indicator units

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

List of Guidance documents and protocols available

i. European Commission, 2014. Technical report on effect-based monitoring tools. Technical Report 2014 – 077. European Commission, 2014.
ii. UNEP/RAMOGE: Manual on the Biomarkers Recommended for the UNEP/MAP MED POL Biomonitoring Programme. UNEP, Athens, 1999.
iii. UNEP/MAP, 2005. Fact sheets on Marine Pollution Indicators. Meeting of the UNEP/MAP MED POL National Coordinators. Barcelona, Spain, 24-27 May 2005. UNEP(DEC)/MED/ WG.264/ Inf.14. UNEP, Athens.
iv. ICES Cooperative Research Report. No.315. Integrated marine environmental monitoring of chemicals and their effects. I.M. Davies and D. Vethaak Eds., November 2012.

Data Confidence and uncertainties

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

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

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

Available data sources

i. MED POL Database.

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

ii. UNEP/RAMOGE: Manual on the Biomarkers Recommended for the UNEP/MAP MED POL Biomonitoring Programme. UNEP, Athens, 1999.

iii. **ICES Cooperative Research Report, No 315, November 2012. Integrated marine environmental monitoring of chemicals and their effects. Ed. Ian M. Davis and Dick Vethaack.**

Spatial scope guidance and selection of monitoring stations

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

• **Risk a**reas of concern identified on the basis of the review of the existing information.
• **Vulnerable a**reas of known past and/or present release of chemical contaminants.
• Offshore areas where risk warrants coverage (aquaculture, offshore oil and gas activity, dredging, mining, dumping at sea **and others**).
• **Monitoring s**ites representative of other **sources, such as** shipping and atmospheric inputs.
• Reference **monitoring** sites: **to establish scale-based** reference values and background concentrations.
• **Monitoring sites r**epresenting sensitive pollution sites/areas at **national and** sub regional scale.
• **Monitoring sites in d**eep-sea **sites**, **offshore stations (sediments)and areas** of potential particular concern

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

Temporal Scope guidance

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

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

For trend determinations the sampling frequencies will depend on the ability to detect trends considering the environmental and the analytical variability (ca. total uncertainty). It can be possible to decrease the sampling frequencies in cases where established time trends and levels

Indicator Title	Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)
show concentrations well below levels of concern, and without any upward trend over a number of years.	
Data analysis and assessment outputs	
Statistical analysis and basis for aggregation Monitoring should allow the necessary statistical data treatments and long-term time-trend analysis.	
Expected assessments outputs For biological effects, trends analysis and distribution levels could be carried out on sub-regional level, provided appropriate quality assured datasets are available. For the integrated assessment of GES, it would be carried out using Mediterranean data from the MEDPOL database and applying a two-level threshold classification (such as the OSPAR methodology). Assessing biomarker responses against Background Assessment Criteria (BACs) and Environmental Assessment Criteria (EACs) allows establishing if the responses measured are at levels that are not causing deleterious biological effects, at levels where deleterious biological effects are possible or at levels where deleterious biological effects are likely in the long-term. In the case of biomarkers of exposure, only BAC can be estimated, whereas for biomarkers of effects both BAC and EAC can be established.	
Known gaps and uncertainties in the Mediterranean Important development areas in the Mediterranean Sea over the next few years will include harmonization of monitoring targets (determinants and matrices) within assessment sub-regions, development of suites of assessment criteria integrated chemical and biological assessment methods, and review of the scope of the monitoring programmes to ensure that those contaminants which are considered to be important within each assessment area are included in monitoring programmes. Through these and other actions, it will be possible to develop targeted and effective monitoring programmes tailored to meet the needs and conditions within each GES assessment sub-region. It has been recognized that the open and deep sea is much less covered by monitoring efforts than coastal areas. There is a need to include within monitoring programmes also areas beyond the coastal areas in a representative and efficient way, where risks warrant coverage.	
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1.5 Common Indicator 20

5. The update for **Common Indicator 20 (EO9):** Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood9 is presented in below table.

<table>
<tr><td>Indicator Title</td><td colspan="2">Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9)</td></tr>
<tr><td>Relevant GES definition</td><td>Related Operational Objective</td><td>Proposed Target(s)</td></tr>
<tr><td>Concentrations of contaminants are within the regulatory limits for consumption by humans.</td><td>Levels of known harmful contaminants in major types of seafood do not exceed established standards</td><td>1. Concentrations of contaminants are within the regulatory limits set by legislation.</td></tr>
<tr><td colspan="3">Rational</td></tr>
<tr><td colspan="3">Justification for indicator selection

One of the potential risks associated with the occurrence of harmful substances (chemicals, nanoparticles, microplastics, toxins) in the marine environment is the human exposure through commercial fish and shellfish species (primarily, from wild fisheries and aquaculture). These organisms are exposed to environmental contaminants which enter their organism through different mechanisms and pathways according their thropic level, which include from filter feeding to predatory strategies (crustaceans, bivalves, fish). Consequently, there exist both bioaccumulation and biomagnification processes of these chemicals released in the marine environment. Common examples are the well-known bioaccumulation of metals and organic compounds in commercial bivalve species (such as the Mytillusgalloprovincialis in the Mediterranean Sea) or alkyl mercury compounds (methylmercury) in tuna fish, which should be increased by new and emerging contaminants in the near future.</td></tr>
<tr><td colspan="3">Scientific References

i. Vandermeersch, G. et al. 2015. Environmental contaminants of emerging concern in seafood – European database on contaminant levels. Environmental Research, 143B, 29-45.
ii. Maulvault, A.M. et al. 2015. Toxic elements and speciation in seafood samples from different contaminated sites in Europe. Environmental Research, 143B, 72-81.
iii. Molin, M. et al., 2015. Arsenic in the human food chain, biotransformation and toxicology – Review focusing on seafood arsenic. Journal of Trace Elements in Medicine and Biology, 31, 249-259.
iv. Bacchiocchi, S. et al. 2015. Two-year study of lipophilic marine toxin profile in mussels of the North-central Adriatic Sea: First report of azaspiracids in Mediterranean seafood. Toxicon, 108, 115-125.
v. Perello, G. et al., 2015. Human exposure to PCDD/Fs and PCBs through consumption of fish and seafood in Catalonia (Spain): Temporal trend. Food and Chemical Toxicology, 81, 28-33.
vi. Zaza, S. et al. 2015. Human exposure in Italy to lead, cadmium and mercury through fish and seafood product consumption from Eastern Central Atlantic Fishing Area. Journal of Food Composition and Analysis, 40, 148-153.
vii. Cruz, R. Brominated flame retardants and seafood safety: A review. Environment International, 77, 116-131.</td></tr>
</table>

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

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

viii. Dellate, E. *et al*. 2014. Individual methylmercury intake estimates from local seafood of the Mediterranean Sea, in Italy. Regulatory Toxicology and Pharmacology, 69, 105-112.
ix. Spada, L. *et al*. 2014. Mercury and methylmercury concentrations in Mediterranean seafood and surface sediments, intake evaluation and risk for consumers. International Journal of Hygiene and Environmental Health, 215, 418-42.

Policy Context and targets

Policy context description

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

Targets

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

Policy documents

General Policy documents

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

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

Contaminants related Policy documents

v. EU 1881/2006. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. European Commission.
vi. US FDA http://www.fda.gov/Food/FoodborneIllnessContaminants/Metals/ucm115644.htm

<table>
<tr><td>Indicator Title</td><td>Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9)</td></tr>
<tr><td colspan="2">vii. Joint FAO/WHO Expert consultation on the risk and benefits of fish consumption. FAO Fisheries and Aquaculture Report No. 978. ISSN 2070-6987. Rome, January, 2010.
viii. List of maximum levels for contaminants in foods set by the FAO/WHO Codex Alimentarius Commission can be found at ftp://ftp.fao.org/codex/Meetings/cccf/cccf7/cf07_INFe.pdf
ix. Global Legally Binding Treaty (Minamata Convention on Mercury) http://www.mercuryconvention.org/</td></tr>
<tr><td colspan="2">Indicator analysis methods</td></tr>
<tr><td colspan="2">Indicator Definition

Number of detected regulated contaminants* in commercial species.

Number of detected regulated contaminants* exceeding regulatory limits.

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

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

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

The chemical compounds list, as in the case of CI17, accompanies the development of the IMAP Info System along Data Dictionaries (DDs) and Data Standards (DSs) for CI20.</td></tr>
<tr><td colspan="2">Methodology for indicator calculation

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

Number of detected contaminants exceeding regulatory limits: monitoring by national regulatory and inspection bodies through statistics and databases</td></tr>
<tr><td colspan="2">Indicator units

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

(Frequencies, %) - Number of detected contaminants exceeding regulatory limits in appropriate units, for example, mg/kg fresh weight (parts per million, ppm, and fresh weight) or µg/g fresh weight (part per billion, ppb, fresh weight).</td></tr>
<tr><td colspan="2">List of Guidance documents and protocols available

Refer to UNEP Methods and Protocols for Marine Pollution, as well as from other regional conventions for the determination of contaminants in marine organisms (Note, pre-treatment of samples from marine organisms might differ between sample preparation and analytical methods and care should be taken when comparing the different reference values.</td></tr>
</table>

Indicator Title	Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9)
Data Confidence and uncertainties The data confidence is directly related to the number of available tests performed to commercial species and their regularity, beyond the analytical quality assurance (QA/QC) related to the determination of contaminants in fish	
Methodology for monitoring, temporal and spatial scope	
Available Methodologies for Monitoring and Monitoring Protocols There are no directly-applicable monitoring protocols in order to fulfil the requirement of this Common Indicator. Risk-based public health methodologies to define the monitoring are recommended.	
Available data sources At present national databases (if available), research papers and environmental databases (the MED POL Database)	
Spatial scope guidance and selection of monitoring stations Risk-based methodologies to define monitoring are recommended. Guidance for monitoring stations: environmental monitoring, fish markets, aboard fishing fleets, sampling at regular inspections by national authorities	
Temporal Scope guidance Risk-based methodologies to define monitoring are recommended. The temporal scope is highly linked to the data confidence and uncertainty of the indicator. Yearly statistics would be the basic time period.	
Data analysis and assessment outputs	
Statistical analysis and basis for aggregation Monitoring should allow the necessary statistical data treatments and long-term time-trend evaluations. Geographic reporting scales (within IMAP implementation) should be also considered in terms of indictor aggregation: (1) Whole region (i.e. Mediterranean Sea); (2) Mediterranean sub-regions, as presented in the Initial Assessment of the Mediterranean Sea, UNEP(DEPI)/MED IG.20/Inf.8; (3) Coastal waters and other marine waters; (4) Subdivisions of coastal waters provided by Contracting Parties	
Expected assessments outputs Assessment outputs would be based on trend analysis and annual statistics	
Known gaps and uncertainties in the Mediterranean As this is a new Common Indicator within the context of marine environmental protection policy (*ca*. Ecosystem Approach and IMAP implementation) its applicability beyond food consumer protection and public health would need to be determined, although intuitively reflects the health status of the marine environment in terms of their delivery of benefits (e.g. fisheries industry). Thus, monitoring protocols,	

Indicator Title	Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9)	
risk-based approaches, analytical testing and assessment methodologies would need to be further examined between Contracting Parties national food safety authorities, research organisations and/or environmental agencies.		
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1.6 Common Indicator 21

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

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

Justification for indicator selection

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

Scientific References

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

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

US EPA RWQC 2012. Recreational Water Quality Criteria. OFFICE OF WATER 820-F-12-058. Scientific document.

Policy Context and targets

Policy context description

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

Targets

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

Policy documents

General Policy documents

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

Contaminants related Policy documents

vi. UNEP(DEPI)/MED IG 20/8. Decision IG.20/9. Criteria and Standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol. COP17, Paris, 2012.

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

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

Indicator analysis methods

Indicator Definition

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

Methodology for indicator calculation

A methodology has been proposed by Directive 2006/7/EC with the following specification:
Based upon percentile evaluation of the log10 normal probability density function of microbiological data acquired from the particular bathing water, the **90^{th} and 95^{th}**percentile values **are** derived as follows:
1) Take the log10 value of all bacterial enumerations in the data sequence to be evaluated. (If a zero value is obtained, take the log10 value of the minimum detection limit of the analytical method used instead)
2) Calculate the arithmetic mean of the log10 values (μ).
3) Calculate the standard deviation of the log10 values (σ).
The upper 90-percentile point of the data probability density function is derived from the following equation: upper 90-percentile = antilog (μ + 1,282 σ). The upper 95-percentile point of the data probability density function is derived from the following equation: upper 95-percentile = antilog (μ + 1,65 σ).

Indicator units

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

List of Guidance documents and protocols available

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

Data Confidence and uncertainties

As in the case of analytical chemistry, the data confidence originates in the maintenance of internal QA/QC programmes by national laboratories, as well as regular interlaboratory or proficiency testing exercises. It should be mentioned that the level of uncertainty in measurements could be considered low, provided the above is fulfilled. On the other hand, the ISO 7899-2 **methodology**

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

describes the isolation of intestinal enterococci (*Enterococcus faecalis, E. faecium, E. durans*and *E. hirae*), **pointing out that,** other Enterococcus species and some species of the genus Streptococcus (namely *S. bovis*and *S. equinus*) may occasionally be detected. These Streptococcus species do not survive long in water and are probably not enumerated quantitatively. Further, for purposes of water examination, *enterococci sp.* can be regarded as indicators of faecal pollution, despite it should be mentioned that some enterococci found in water can occasionally also originate from other habitats.

Methodology for monitoring, temporal and spatial scope

Available Methodologies for Monitoring and Monitoring Protocols

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

Available data sources

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

Spatial scope guidance and selection of monitoring stations

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

Temporal Scope guidance

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

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

Data analysis and assessment outputs

Statistical analysis and basis for aggregation

<table>
<tr><td>Indicator Title</td><td colspan="2">Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)</td></tr>
<tr><td colspan="3">Monitoring should allow the necessary statistical data treatments, as well as time-trend evaluations. In order to comply with the stated Common Indicator within IMAP, the geographic reporting scales (nested approach) should be taken into account. However, the balance between data, locations and spatial resolution should be carefully considered for coherence in areas (1) and (2), as this Common Indicator is largely (if not entirely) evaluated in coastal waters (3) and (4):

(1) Whole region (i.e. Mediterranean Sea);
(2) Mediterranean sub-regions, as presented in the Initial Assessment of the Mediterranean Sea, UNEP(DEPI)/MED IG.20/Inf.8;
(3) Coastal waters and other marine waters;
(4) Subdivisions of coastal waters provided by Contracting Parties</td></tr>
<tr><td colspan="3">Expected assessments outputs

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

Distribution maps and temporal trend assessment (short periods) are also envisaged.</td></tr>
<tr><td colspan="3">Known gaps and uncertainties in the Mediterranean

Within the context of Ecosystem Approach and IMAP implementation its applicability beyond bathing waters (recreational waters) protection and management would need to be determined, although intuitively reflects the health status of the coastal environment in terms of their delivery of benefits (e.g. tourism).</td></tr>
<tr><td colspan="3">Contacts and version Date</td></tr>
<tr><td colspan="3">http://www.unepmap.org</td></tr>
<tr><td>Version No</td><td>Date</td><td>Author</td></tr>
<tr><td>V.2</td><td>31.05.17</td><td>MED POL</td></tr>
<tr><td>V.3</td><td>12.12.18</td><td>MED POL</td></tr>
<tr><td>V.4</td><td>29.04.19</td><td>MED POL</td></tr>
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