UNITED
NATIONS

EP

UNEP/MED WG.463/Inf.3

UNEP

**UNITED NATIONS
ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN**

22 March 2019
Original: English

Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring

Podgorica, Montenegro, 2-3 April 2019

**Agenda Item 3: State of Play of Integrated Monitoring and Assessment Programme (IMAP) Implementation with regards to EO5 and EO9, MEDPOL Monitoring Programme and Way Forward**

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



UNEP/MAP
Athens, 2019

## Note by the Secretariat

The 19th Meeting of the Contracting Parties (COP 19), held in February 2016, adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Sea and Coast and Related Assessment Criteria (Decision IG. 22/7), with a list of regionally agreed good environmental status descriptions, common indicators and targets, with principles and clear timeline for its implementation. Furthermore, 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 were developed, reviewed and agreed by the Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring (CorMon on Pollution Monitoring) held in Marseilles, France, 19-21 October 2016 and the Meeting of the MED POL Focal Points, held in Rome, Italy, 29-31 May 2017, for the Common Indicators to ensure coherent monitoring. The Guidance Factsheets provide concrete guidance to the Contracting Parties supporting implementation of their respective national monitoring programmes aligned with IMAP.

The comments received by the Contracting Parties were considered and approved by the 6$^{th}$ Meeting of the Ecosystem Approach Coordination Group, held in Athens, Greece, 11$^{th}$ September. 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 evolving needs to fill the gaps, in particular related to assessment component of the Guidance Factsheets, the UN Environment/MAP Programme of Work (PoW) adopted at COP 20, under Output 2.4.1 for national pollution and litter monitoring programmes, provides 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 the Ecological Objectives 5 (Eutrophication) and 9 (Contaminants).

## Table of Contents

1. The amendments of the IMAP Guidance Factsheets for Common Indicators 13, 14, 17, 18, 20 and 21 ........ 1
2. Common Indicator 13........ 1
3. Common Indicator 14........ 7
4. Common Indicator 17........ 14
5. Common Indicator 18........ 22
6. Common Indicator 20........ 29
7. Common Indicator 21........ 34

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

1. The Guidance Factsheets update proposed in UNEP/MED WG.463/4 strictly follows the structure of the IMAP Common Indicator Guidance Factsheets as approved by the 6th Meeting of the Ecosystem Approach Coordination Group. The amended Guidance Factsheets follow in particular on an update of the assessment maps in 2019 for the purpose of preparation of the SoED 2019. They are consistent with the Data Standards (DSs) and Data Dictionaries (DDs) of the IMAP (Pilot) Info System currently in development by INFO/RAC under the overall coordination of the Secretariat. The main elements of the update are summarized in UNEP/MED WG.463/4, whilst this document presents the amendments as they are introduced in the Common Indicator IMAP Guidance Factsheets.

## 2. Common Indicator 13

2. The update for Common Indicator 13 (EO5): Concentration of key nutrients in water column[1,2] is presented in bellow table.

| **Indicator Title** | 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.<br>2. Decreasing trend of nutrients concentrations in water column of human impacted areas, statistically defined.<br>3. Reduction of BOD emissions from land based sources.<br>4. Reduction of nutrients emissions from land based sources |
| **Rational** | | |
| **Justification for indicator selection~~or~~**<br><br>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. | | |

[1] 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)

[2] 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** | 13. Concentration of key nutrients in water column (EO5) |
|---|---|

Although, these changes may also occur due to natural processes, the management concern begins when they are attributed to anthropogenic sources.

**Scientific References**


i. Brzezinski M.A., 1985. The Si:C:N ratio of marine diatoms: interspecific variability and the effect of some environmental variables. Journal of Phycology, Vo. 21, pp. 347–357.

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

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 define 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)

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

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**

Concentration of key (inorganic) nutrients in the water column:
Nitrate ($NO_3$-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.

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


ii. Piha, H., Zampoucas, N., 2011. Review of Methodological Standards Related to the Marine Strategy Framework Directive Criteria on Good Environmental Status. JRC Scientific and Technical Reports, EUR 24743 EN

iii. UNEP/MAP MED POL (2005). Sampling and Analysis Techniques for the Eutrophication Monitoring Strategy of UNEP/MAP MED POL. MAP Technical Reports Series No. 163. UNEP, Athens. 61pp.

iv. Durairaj, P., Sarangi, R.K., Ramalingam, S. *et al.*Seasonal nitrate algorithms for nitrate retrieval using OCEANSAT-2 and MODIS-AQUA satellite data. Environ Monit 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:

| **Indicator Title** | 13. Concentration of key nutrients in water column (EO5) |
|---|---|

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

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

**Temporal Scope guidance**

Flexibility should be incorporated into the design of the monitoring programme to take account of differences in each marine sub-region/area. At the Mediterranean Sea latitudes, in general terms, the pre-summer and Winter primary production bloom intensity peaks of natural eutrophication will define the strategy for the sampling frequency, although~~year round~~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 scales, 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 take in account the discriminant limit between classes when the nutrient boundaries approach will be widely accepted. Let consider the approach developed for CI14 - Chlorophyll a concentration in water column as an example to be used, as for this CI accepted boundaries exists.

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

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

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

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

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

Based on the above it follows that a particular area can be characterized best if we measure three

| **Indicator Title** | 13. Concentration of key nutrients in water column (EO5) |
|---|---|
| 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 cChl-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:<br>Eutrophic – mesotrophic: monthly,<br>Mmesotrophic – oligotrophic: monthly near the coast, bimonthly in open waters, and<br>Ooligotrophic: 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.<br>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.<br>EXAMPLE: The trophic index (TRIX; Vollenweider*et al.*, 1998) may be used for a preliminary assessment of the trophic status of coastal waters in relation to eutrophication providing that its advantages and shortcomings are taken into account (Primpas and Karydis, 2011). The adopted UNEP/MAP MED POL short-term eutrophication monitoring strategy monitored parameters to support the TRIX. This Index is widely used to synthesize key eutrophication variables into a simple numeric expression to make information comparable over a wide range of trophic situations. For TRIX chlorophyll-a, Oxygen as absolute % deviation from saturation, Dissolved Inorganic Nitrogen, and Total Phosphorus data are required. | |
| **Expected assessments outputs**<br><br>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**<br><br>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.<br>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. | |

| **Indicator Title** | 13. Concentration of key nutrients in water column (EO5) | |
|---|---|---|
| **Contacts and version Date** | | |
| http://www.unepmap.org | | |
| **Version No** | **Date** | **Author** |
| V.1 | 31.~~0~~5.17 | MEDPOL |
| V.2 | 10.1.19 | MEDPOL |

## 3. Common Indicator 14

3. The update for Common Indicator 14 (EO5): Chlorophyll a concentration in water column[3] is presented for in below table.

| **Indicator Title** | 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<br>2. Decreasing trend in chl-*a* concentrations in high risk areas affected by human activities |
| **Rational** | | |
| **Justification for indicator selection**<br><br>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**<br><br>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.<br>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.<br>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** | | |

[3]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 | 14. Chlorophyll *a* concentration in water column (EO5) |
|---|---|

**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 define 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 Marien 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.

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

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

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

**Indicator analysis methods**

**Indicator Definition**

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

**Methodology for indicator calculation**

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.

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

If only limited means are available, determination of those parameters that synthesize the most information should be retained. Chlorophyll *a* determination for example, although not very precise representations of the system, are data which provide a great deal of information. Turbidity may also be a good measure of eutrophication, except near the mouths of rivers where inert suspended solids may be extremely abundant. Dissolved oxygen is one parameter that integrates much information on the processes involved in eutrophication, provided it is measured near the bottom or, at least, below the euphotic zone where an oxycline usually appears.

**Methodology for monitoring, temporal and spatial scope**

**Available Methodologies for Monitoring and Monitoring Protocols**

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

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

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

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.~~from h~~

**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.~~It could be recommended:~~

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

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

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

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

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

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

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

~~Chlorophyll *a*: For coastal stations minimum sampling 4/year, 6-12 /year recommended;~~ 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*
~~Additionally, in order to build a robust sampling frequency scale in future a sounded statistical approach has to be developed that take in account the discriminant limit between classes when the class boundary approach will be widely accepted.~~

**Data analysis and assessment outputs**

**Statistical analysis and basis for aggregation**

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

The classification scheme on chlorophyll *a* concentration developed by MEDGIG as an assessment method easily applicable by all Mediterranean countries based on the indicative thresholds and reference values adopted.

The main statistical analysis is based on the typology criteria and settings derived from the analysis of influence of freshwater inputs as the main nutrient drivers. More information on is presented in document the UNEP(DEPI)/MED WG 417/Inf.15. Tree main types were identified:

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

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

**Table 1.**Major coastal water types in the Mediterranean

| | Type I | Type IIA, IIA Adriatic | Type IIIW | Type IIIE | Type Island-W |
|---|---|---|---|---|---|
| $\sigma_t$ (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 ($\mu g\ L^{-1}$) 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 Chl*a* ($\mu g\ L^{-1}$) | | Boundaries of Chl*a* ($\mu g\ L^{-1}$) for G/M status | |
|---|---|---|---|---|
| | G_mean | 90% percentile | G_mean | 90% percentile |
| Type I | 1,4 | 3,33* - 3,93** | 6,3 | 10* - 17,7** |
| Type II-FR-SP | | 1,9 | | 3,58 |
| Type II-A Adriatic | 0,33 | 0,8 | 1,5 | 4,0 |
| Type II-B Tyrrhenian | 0,32 | 0,77 | 1,2 | 2,9 |
| Type III-W Adriatic | | | 0,64 | 1,7 |
| Type III-W Tyrrhenian | | | 0,48 | 1,17 |
| Type III-W FR-SP | | 0,9 | | 1,80 |
| Type III-E | | 0,1 | | 0,4 |
| Type Island-w | | 0,6 | | 1,2 – 1,22 |

* applicable to Gulf of Lion
** applicable to Adriatic

Further, developments within the European MSFD ~~and OSPAR Comission~~ with regard to eutrophication should also be taken into account.

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

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 ~~develop common~~implement the IMAPassessment methods, in a.

~~EXAMPLE: The trophic index (TRIX, Vollenweider*et al.*, 1998) may be used for a preliminary assessment of the trophic status of coastal waters in relation to eutrophication providing that its advantages and shortcomings are taken into account (Primpas and Karydis, 2011). The adopted UNEP/MAP MED POL short-term eutrophication monitoring strategy monitored parameters to support the TRIX. This Index is widely used to synthesize key eutrophication variables into a simple numeric expression to make information comparable over a wide range of trophic situations.~~
~~For TRIX chlorophyll-a, Oxygen as absolute % deviation from saturation, Dissolved Inorganic Nitrogen, and otal Phosphorus data are required.~~

**Expected assessments outputs**

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

~~2013/480/EU: Commission Decision of 20 September 2013 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 Decision 2008/915/EC~~

**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

| Indicator Title | 14. Chlorophyll *a* concentration in water column (EO5) | |
|---|---|---|
| and oxygen as minimum requirements, where appropriate. This should include quality assurance schemes, as well as data quality control protocols.<br>Further, in order to increase coherency and comparability regarding eutrophication assessment methodologies is recommended that further efforts should be made to harmonize existing tools through workshops, dialogue and comparative exercises at regional/subregional/subdivision levels in Mediterranean with a view to further improve and develop common assessment methods. | | |
| **Contacts and version Date** | | |
| http://www.unepmap.org | | |
| **Version No** | **Date** | **Author** |
| V.1 | 31.05.17 | MEDPOL |
| V.2 | 10.1.19 | MEDPOL |

4. **Common Indicator 17**

4. The update for Common Indicator 17 (EO9): Concentration of key harmful contaminants measured in the relevant matrix[4] is presented in below table.

| Indicator Title | 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<br><br>2. No deterioration trend in contaminants concentrations in sediment and biota from human impacted areas, statistically defined<br><br>3. Reduction of contaminants emissions from land-based sources |
| **Rational** | | |
| **Justification for indicator selectionor**<br><br>Environmental chemical pollution is directly linked with humankind activities in all the earth's ecosystemsand advancements. 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 | | |

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

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

the pressures, state and impact to the environment understand and to decide further management actions for~~discover~~ a growing environmental problem. ~~The monitoring of the spatial and temporal scales of the harmful and noxious substances occurrence determines either a chronic or acute contamination/pollution episode.~~ Currently, new man-made chemicals and emerging pollutants continue to enter the marine environment and interact with the different marine species, habitats and ecosystems (coastal, open ocean, deep-sea areas), increasing the complexity of the chemical pollution threats for the marine environment and their future sustainability to deliver its benefits. The monitoring and assessment of the harmful and noxious substances occurrence, at selected spatial and temporal scales, will determine either a chronic or acute contamination/pollution scenarios.

**Scientific References**


i. Clark, R.B., 1986. Marine Pollution, Oxford University Press.

ii. Neff, J.M., 1979. Polycyclic aromatic hydrocarbons in the aquatic environment. Sources, fates and biological effects. Applied Science Publishers, Ltd., London.

iii. Goldberg, E. D., 1975. The Musssel Watch - a first step in global marine monitoring. *Mar.Poll.Bull.*, 6, 111.

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

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 ~~ecosystem~~ compartments are undertaken in response to the UNEP/MAP Barcelona Convention (~~1975~~1976) and its Land-Based Protocol, through the coordination of the UNEP/MAP MED POL Monitoring Program. For Mediterranean EU countries, ~~as well as international~~the ~~,~~ European legislation on the Marine Environment also applies (e.g. EU WFD and ~~or~~ EU MSFD), as well as ~~or~~ 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 ~~from~~ 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~~its~~ policy and practical framework built in the Mediterranean Sea.

**Targets**

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

Initial ~~targets of~~ 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 ~~targets~~ monitoring of these targets will be based upon data of a relatively small number of ~~both~~ primarily legacy ~~and ‘traditional’ chemicals~~pollutants, reflecting the scope of current programmes and the availability of suitable agreed assessment criteria for them, despitethe measurement of other chemicals remains open and is necessary.~~.~~ The inclusion of contemporary and emerging chemicals ~~compounds~~ of new environmental concern and their targets for GES, within IMAP Common Indicator 17, will be implemented as the scientific knowledge ~~develops~~advances.

**Policy documents**

**General Policy documents**

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

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

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

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

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.

~~v.~~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**

~~v.~~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.

~~vi.~~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.

~~vii.~~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.

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

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

~~x.~~xii. EEA, 2003. Hazarous 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

~~i.~~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

~~i.~~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~~component~~ pressure indicator):

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

The l~~L~~ipid content and ~~,~~ flesh fresh/dry weight ratio ~~for normalisation purposes~~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 A~~a~~romatic H~~h~~ydrocarbons (PAHs)

The a~~A~~luminium (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 ~~for environmental~~and assessment of contaminants in seawater samples collected in coastal, marine and open-sea areas ~~purposes and the determination of contaminants in seawater~~ presents specific challenges and higher costs. For the mid/long-term monitoring programes, 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.

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

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**

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 are subject to internal Quality Assurance ~~Protocols~~ through National Laboratories QA/QC Protocols and Laboratory accreditations, as well as external Quality Assurance by performing ~~and~~ regional interlaboratory QA/QC exercises organized by the~~:~~ ~~QA/QC through~~ UNEP/MAP MED POL/IAEA MESL.
~~, National QA/QC Procedures~~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**

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

**Available Methodologies for Monitoring and Monitoring Protocols**

~~With regard~~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~~in the sea~~, 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 ~~in pollutant concentrations~~and levels and their comparability overtime and across spatial scales.

**Available data sources**

i. UNEP(DEPI)/MED WG.365/Inf.5. Analysis of the trend monitoring activities and data for the MED POL Phase III and IV (1999-2010). Consultation Meeting to Review MED POL Monitoring Activities. Athens, 22-23 November 2011.
ii. UNEP(DEPI)/MED WG. 365/Inf.8. Development of assessment criteria for hazardous substances in the Mediterranean. Consultation Meeting to Review MED POL Monitoring Activities. Athens, 22-23 November 2011.
iii. UNEP(DEPI)/MED WG. 427/Inf.3. Background to the Assessment Criteria for Hazardous Substances and Biological Markers in the Mediterranean Sea Basin and its Regional Scales.
~~ii.~~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 ~~of risks~~ and the long-term monitoring purposes~~ (long term)~~. The selection of the sampling sites for the monitoring of contaminants in the marine environment should consider:

• Risk a~~A~~reas of concern identified on the basis of the review of the existing information.
• Vulnerable a~~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~~S~~ites representative ~~in monitoring~~ of other sources, such as ~~sea-based (~~shipping~~)~~ and atmospheric ~~sources~~inputs.
•Reference monitoring sites: to establish scale-based ~~For~~ reference values and background concentrations.
• Monitoring sites r~~R~~epresenting ~~ative of~~ sensitive pollution sites/areas at national and sub regional scale.
• Monitoring sites in d~~D~~eep-sea sites, offshore stations (sediments) and ~~/~~areas of potential particular concern.

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

The selected sites should allow the collection of a realistic number of samples over the years (e.g. to be suitable for sediment sampling, to allow sampling a sufficient number of biota for the selected species during the duration of the programme). It is essential that the monitoring strategies are being coordinated at regional and/or sub regional level. The c~~C~~oordination 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 ~~by the purpose and the status~~ of the national marine monitoring.

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

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

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

**Data analysis and assessment outputs**

**Statistical analysis and basis for aggregation**

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

**Expected assessments outputs**

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

**Known gaps and uncertainties in the Mediterranean**

| **Indicator Title** | 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9) | |
|---|---|---|
| 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 s, 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. in monitoring programmes. Through these,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.<br>It has been recognized that the open and deep sea is much less covered by monitoring efforts than coastal areas. There is a need to include within monitoring programmes also areas beyond the coastal areas in a representative and efficient way (, where risks warrant coverage). | | |
| **Contacts and version Date** | | |
| **http://www.unepmap.org** | | |
| **Version No** | **Date** | **Author** |
| V.2 | 31.05.17 | MEDPOL |
| V.3 | 11.09.17 | MEDPOL |
| V.4 | 12.12.18 | MEDPOL |

## 5. **Common Indicator 18**

5. The update for Common Indicator 18 (EO9): Level of pollution effects of key contaminants where a cause and effect relationship has been established[5] is presented in below table.

| **Indicator Title** | 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<br>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 indicator 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
v. Scarpato, R., L. Migliore, G. Alfinito-Cognetti and R. Barale (1990), Induction of

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

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

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 ~~ecosystem~~ compartments are undertaken in response to the UNEP/MAP Barcelona Convention (1976~~5~~) and its Land-Based Protocol, through the coordination of the UNEP/MAP MED POL Monitoring Program. For Mediterranean EU countries,~~ as well as international,~~theEuropeanlegislation on the Marine Environment also applies (e.g. EU WFD and ~~or~~ EU MSFD), as well as ~~or~~ 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 ~~from~~ 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, ~~occurrence, distributions, levels and trends~~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 ~~its~~ 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

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

(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 (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, ~~comet assay,~~ 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 biomarkers 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)

| **Indicator Title** | 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9) |
|---|---|
| and data on temperature, salinity and oxygen dissolved. | |
| **Indicator units**<br><br>(retention) minutes - Lysosomal Membrane Stability (LMS)<br>nmol/min mg protein in gills (bivalves) - Acetylcholinesterase (AChE) assay<br>Number of cases, ‰ in haemocytes - Micronucleus assay | |
| **List of Guidance documents and protocols available**<br><br>i. European Commission, 2014. Technical report on effect-based monitoring tools. Technical Report 2014 – 077. European Commission, 2014.<br>ii. UNEP/RAMOGE: Manual on the Biomarkers Recommended for the UNEP/MAP MED POL Biomonitoring Programme. UNEP, Athens, 1999.<br>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.<br>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**<br><br>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**<br><br>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 ~~in the sea~~, and (6) the use of existing time series as the basis of monitoring against a "no deterioration" target. The availability of quality assured data is of importance for the assessment of levels and trends, and thus, their comparability overtime and across spatial scales. Therefore, based on the work already carried out, the results of the intercalibration exercises and the scientific and technical publications within the UNEP/MAP MED POL programme on biological effects monitoring, there is a network of laboratories in the Mediterranean region with the capacity to carry out biological effects monitoring activities, in | |

| Indicator Title | 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9) |
|---|---|
| line with the new 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**<br><br>i. MED POL Database.<br>ii. UNEP/RAMOGE: Manual on the Biomarkers Recommended for the UNEP/MAP MED POL Biomonitoring Programme. UNEP, Athens, 1999.<br>ii.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**<br><br>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  of risks and the long-term monitoring purpose (long term). The selection of the sampling sites for the monitoring of biological effects in the marine environment should consider:<br><br>• Risk aAreas of concern identified on the basis of the review of the existing information.<br>• Vulnerable aAreas of known past and/or present release of chemical contaminants.<br>• Offshore areas where risk warrants coverage (aquaculture, offshore oil and gas activity, dredging, mining, dumping at sea and others).<br>• Monitoring sSites representative in monitoring of other sources, such as sea-based (shipping) and atmospheric inputssources.<br>• Reference monitoring sites: to establish scale-based For reference values and background concentrations.<br>• Monitoring sites rRepresenting ative sensitive pollution sites/areas at national and sub regional scale.<br>• Monitoring sites in dDeep-sea sitessites/areas, offshore stations (sediments)and areas of potential particular concern<br><br>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**<br><br>Sampling frequencies will be determined according the by the purpose and the current status of the pilots and national marine monitoring programmes:.<br><br>INITIAL PHASE MONITORING (PILOT): , if required to identify monitoring stations to collect and can include: BIOTA (bivalves, such as *Mytilus galloprovincialis*, mussel yearly) on a yearly basis (or higher frequencies if the environmental variability study needs to be carried | |

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

out), and in the same manner as for chemical monitoring, focusing on few locations such as ~~(~~hotspots and reference stations~~) if biological effects will be determined for both~~.
ADVANCED PHASE MONITORING: when ~~(~~fully completed and reported MED POL Phase ~~III~~ IV datasets, including biological effects is achieved, then, at~~): 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 ~~previous~~ the experiences from developing pilot monitoring activities (Initial Phase).

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

**Data analysis and assessment outputs**

**Statistical analysis and basis for aggregation**

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

**Expected assessments outputs**

For biological effects, trends analysis and distribution levels could be carried out on sub-regional level, provided appropriate quality assured datasets are available. For the integrated assessment of GES, it would be carried out using Mediterranean data from the MEDPOL database and applying a twolevel 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.

**Contacts and version Date**

http://www.unepmap,org

| **Version No** | **Date** | **Author** |
|---|---|---|
| V.2 | 31.05.17 | MEDPOL |

| **Indicator Title** | 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9) | |
|---|---|---|
| V.3 | 12.12.18 | MEDPOL |

## 6. Common Indicator 20

6. The update for Common Indicator 20 (EO9): Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood[6] is presented in below table.

| **Indicator Title** | 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9) | |
|---|---|---|
| **Relevant GES definition** | **Related Operational Objective** | **Proposed Target(s)** |
| Concentrations of contaminants are within the regulatory limits for consumption by humans. | Levels of known harmful contaminants in major types of seafood do not exceed established standards | 1. Concentrations of contaminants are within the regulatory limits set by legislation. |

**Rational**

**Justification for indicator selection**

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

**Scientific References**

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

[6]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** | 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9) |
|---|---|

International, 77, 116-131.
viii. Dellate, E. *et al.* 2014. Individual methylmercury intake estimates from local seafood of the Mediterranean Sea, in Italy. Regulatory Toxicology and Pharmacology, 69, 105-112.
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 ( and FAO), are also national and international authorities with regard seafood safety, respectively.

**Targets**

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

**Policy documents**

**General Policy documents**

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

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

**Contaminants related Policy documents**

vi. EU 1881/2006. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. European Commission.

vii. US FDA http://www.fda.gov/Food/FoodborneIllnessContaminants/Metals/ucm115644.htm

viii. Joint FAO/WHO Expert consultation on the risk and benefits of fish consumption. FAO Fisheries and Aquaculture Report No. 978. ISSN 2070-6987. Rome, January, 2010.

ix. List of maximum levels for contaminants in foods set by the FAO/WHO Codex Alimentarius Commission can be found at ftp://ftp.fao.org/codex/Meetings/cccf/cccf7/cf07_INFe.pdf

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

**Indicator analysis methods**

**Indicator Definition**

Number of detected regulated contaminants* in commercial species.

Number of detected regulated contaminants* exceeding regulatory limits.

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

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

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

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

**Methodology for indicator calculation**

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

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

**Indicator units**

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

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

**List of Guidance documents and protocols available**

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

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.

**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 recommend.

**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**

| **Indicator Title** | 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9) | |
|---|---|---|
| Assessment outputs would be based on trend analysis and annual statistics | | |
| **Known gaps and uncertainties in the Mediterranean**<br><br>As this is a new Common Indicator within the context of marine environmental protection policy (*ca*. Ecosystem Approach and IMAP implementation) its applicability beyond food consumer protection and public health would need to be determined, although intuitively reflects the health status of the marine environment in terms of their delivery of benefits (e.g. fisheries industry). Thus, monitoring protocols, risk-based approaches, analytical testing and assessment methodologies would need to be further examined between Contracting Parties national food safety authorities, research orgnisations and/or environmental agencies. | | |
| **Contacts and version Date** | | |
| **http://www.unepmap.org** | | |
| **Version No** | **Date** | **Author** |
| V.2 | 31.05.17 | MEDPOL |
| V.3 | 12.12.18 | MEDPOL |

## 7. **Common Indicator 21**

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

| **Indicator Title** | 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~~or~~**<br><br>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.~~due to non-treated discharges into the marine environment and cause human infections~~. Therefore, intestinal enterococci concentrations are frequently used as a faecal indicator bacteria proxy~~,~~ or general indicators of faecal contamination in the marine environment,.~~Particularly, *E. faecalis* and *E.faecium* species are related to urinary tract infections, endocarditis, bacteriema, neonatal infections, central nervous system, abdominal and pelvic infections. It has been also shown a correlation between elevated levels of enterococci and the risks of human gastroenteritis.~~ 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.~~The abundance in human and animal feces and the simplicity of the analytical methods for their measurements has favoured the use of entorococci as a surrogate of polluted recreational waters, and therefore, as a Common Indicator for GES~~ | | |
| **Scientific References**<br><br>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.<br>~~i.~~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<br>~~ii.~~iii. Byappanahalli, MN. *et al*., 2012. Enterococci in the environment. Microbiol. Mol. Biol.Rev., 76, 685-706 | | |

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

~~iii. Moellering RC Jr. 1992. Emergence of Enterococcus as a significant pathogen. Clin. Infect. Dis., 15, 58–62~~
~~iv. Mote BL, Turner JW, Lipp EK. 2012. Persistence and growth of the faecal indicator bacteria enterococci in detritus and natural estuarine plankton communities. Appl. Environ. Microbiol.,78, 2569–2577~~
~~v. Sadowsky MJ, Whitman RL (Ed). 2010. The faecal bacteria. ASM Press, Washington, DC.~~
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
~~vi.~~v. Kay D, *et al*. 1994. Predicting likelihood of gastroenteritis from sea bathing: results from randomised exposure. Lancet, 344, 905–909
vi. Prüss A. 1998. Review of epidemiological studies on health effects from exposure to recreational water. Int. J. Epidemiol., 27, 1–9
~~vii.~~ US EPA RWQC 2012. Recreational Water Quality Criteria. OFFICE OF WATER 820-F-12-058. Scientific document.

**Policy Context and targets**

**Policy context description**

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

**Targets**

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) quality categories for the “last assessment”; which means~~,~~ the last four years (see documents below~~, Directive 2006/7/EC~~)

**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** | 21. Percentage of intestinal enterococci concentration measurements within established standards (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 (Marine Strategy Framework Directive).
v. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

**Contaminants related Policy documents**

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

**Indicator analysis methods**

**Indicator Definition**

~~Percentage of intestinal enterococci concentration measurements within established standards.~~

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

**Methodology for indicator calculation**

A~~n ISO~~ 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 ~~is~~ 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 Title** | 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9) |
|---|---|

**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.~~Percentage of intestinal enterococci (as %)~~

~~CFU (Colony Forming Units)/100 mL sample – Concentration of intestinal enterococci~~

**List of Guidance documents and protocols available**

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

**Data Confidence and uncertainties**

As in the case of analytical chemistry, the data confidence originates in the maintenance of internal QA/QC programmes by national laboratories, as well as regular interlaboratory or proficiency testing exercises. It should be mentioned that the level of uncertainty in measurements could be considered low, provided the above is fulfilled. On the other hand, the ISO 7899-2 methodology describes the isolation of intestinal enterococci (*Enterococcus faecalis*, *E. faecium*, *E. durans*and *E. hirae*), pointing out that, ~~. In addition,~~ 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, f~~F~~or 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 ~~Mediterranen~~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

~~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~~

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

**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**

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

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

**Expected assessments outputs**

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

| **Indicator Title** | 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9) | |
|---|---|---|
| Distribution maps and temporal trend assessment (short periods) are also envisaged. | | |
| **Known gaps and uncertainties in the Mediterranean**<br><br>Within the context of Ecosystem Approach and IMAP implementation its applicability beyond bathing waters (recreational waters) protection and management would need to be determined, although intuitively reflects the health status of the coastal environment in terms of their delivery of benefits (e.g. tourism). | | |
| **Contacts and version Date** | | |
| **http://www.unepmap.org** | | |
| **Version No** | **Date** | **Author** |
| V.2 | 31.05.17 | MEDPOL |
| V.3 | 12.12.18 | MEDPOL |