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Agenda ítem 3: Implementation of the Integrated Monitoring and Assessment Programme

Draft Indicator Guidance Factsheets for Contaminants (EO9) and Eutrophication (EO5)

For environmental and economy reasons, this document is printed in a limited number and will not be distributed at the meeting. Delegates are kindly requested to bring their copies to meetings and not to request additional copies.

UNEP/MAP
Athens, 2016

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1. Introduction

1. The 19th Meeting of Contracting Parties (COP 19), held in February 2016,adopted the Integrated Monitoring and Assessment Programme (IMAP)of the Meditrerranean Sea and Coast and Related Assessment Criteria. In its Decision IG. 22/7, a specific list of good environmental status common indicators and targets and principles of an integrated Mediterranean Monitoring and Assessment Programme, next to a clear timeline for the implementation of this Programmewere detailed. IMAP, through Decision IG.22/7 lays down the principles for an integrated monitoring, which will, for the first time, monitor biodiversity and non-indigenous species, pollution and marine litter, coast and hydrography in an integrated manner. The IMAP aims to facilitate the implementation of article 12 of the Barcelona Convention and several monitoring related provisions under different protocols with the main objective to assess GES. Its backbone are the 11 Ecological Objectives and their 27 common indicators as presented in the decision.

2. The UNEP/MAP Programme of Work (PoW) adopted at COP 19, includes the Output 1.4.3 for *the Implementation of IMAP (the EcAp-based integrated monitoring and assessment programme) coordinated, including GES common indicators fact sheets, and supported by a data information centre to be integrated into Info/MAP platform.*

3. Therefore, the draft guidance factsheets within each Common Indicator needs to be developed for coherent monitoring, as well as their targets defined and agreed in order to deliver the achievement of Good Environmental Status (GES), In this context, this document outlines the seven IndicatorGuidance Factsheets for the Ecological Objectives 9 (Contaminants) and 5 (Euthrophication)as follows:

- Common Indicator 13. Concentration of key nutrients in water column (EO5);
- Common Indicator 14. Chlorophyll-a concentration in water column (EO5);
- Common Indicator 17. Concentration of key harmful contaminants measured in the relevant matrix (EO9);
- Common Indicator 18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9);
- Common Indicator 19. Occurrence, origin (where possible), and extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances) and their impact on biota affected by this pollution (EO9);
- Common Indicator 20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (EO9);
- Common Indicator 21. Percentage of intestinal enterococci concentration measurements within established standards (EO9);

4. This document is based on 40 yearsof unique work and experience, within the MED POL Programme, as well as a number of initiative and research projects, such as the Horizon 2020 initiative for the depollution of the Mediterranean. Earlier work on indicators includes 36 Indicator Factsheets developed in 2005 by MEDPOL and the development of six indicators for Horizon 2020 in 2014[1].

5. The mainpurpose of this revised Indicator Guidance Factsheets is to provide concrete guidance and references to Contracting Parties to support implementation of their revised national monitoring programme towards the overall goal of implementing the Ecosystem Approach (EcAp) in the Mediterranean Sea and achieveing GES.

6. The structure of a Common Indicator Factsheets can be summarized looking at the different organization levels of the developed factsheet templates. A common set of relevant policy

[1] UNEP(DEPI)/MED WG. 399/4. 16 May 2014

and science-based information is required on each (ie. Indicator Title, Rational, Policy Context and Targets, Indicator analysis methods and Methodolgy for monitoring (temporal and spatial scope), Contacts and Document Registration). In each, detailed definitions, methodologies, references, gaps, uncertainties, data analysis approaches, basis for aggregation (if applies) and outputs complete the guidance factsheets (see scheme below).

7. This document, which present a first draft on seven Factsheets for the Ecological Objectives 9 (Contaminants) and 5 (Euthrophication) has been prepared by the Secretariat and will require further development and inputs from the CORMON and other experts.

Scheme of IMAP Factsheet Template:

Indicator Title			**IMAP Reference No and definition**
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**	
Rationale			**Scientific rationale and marine policy context (including relevant references)**
Justification for indicator selection			
Scientific References			
Policy Context and targets			
Policy context description			
Targets			
Policy documents			
Indicator analysis methods			**Agreed scientific methodologies in use, including detailed monitoring requirements**
Indicator Definition			
Methodology for indicator calculation			
Indicator units			
List of Guidance documents and protocols available			
Data Confidence and uncertainties			
Methodology for monitoring, temporal and spatial scope			
Available Methodologies for Monitoring and Monitoring Protocols			
Available data sources			
Spatial scope guidance and selection of monitoring stations			
Temporal Scope guidance			
Data analysis and assessment outputs			**Data reporting, analysis and aggregation (outpout)**
Statistical analysis and basis for aggregation			
Expected assessments outputs			
Known gaps and uncertainties in the Mediterranean			
Contacts and version Date			**Document Registration**
Key contacts within UNEP for further information			
Version No	**Date**	**Author**	

2. Common indicators Factsheet

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

Note that this builds upon a previous indicator factsheet developed under Horizon 2020[2]

Indicator Title	13. Concentration of key nutrients in water column (EO5)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
The biological community remains well-balanced and retains all necessary functions in the absence of undesirable disturbance associated with eutrophication (e.g. excessive algal blooms, low dissolved oxygen, declines in sea-grasses, kills of benthic organisms and/or fish) and/or where there are no nutrient-related impacts on sustainable use of ecosystem goods and services.	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.	For each considered marine spatial area (region, sub-region, local water mass, etc.) the levels should be within the averaged reference levels on a trend monitoring basis.
Rational		
Justification for indicator selector 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. These changes may occur due to natural processes. Management concern begins when they are attributed to anthropogenic sources. Additionally, although these shifts may not be harmful in themselves, the main worry concerns 'undesirable disturbance': the potential effects of increased production, and changes of the balance of organisms on ecosystem structure and function and on ecosystem goods and services.		
Scientific References Redfield A.C., 1934. On the proportions of organic derivations in sea water and their relation to the composition of plankton. In James Johnstone Memorial Volume. (ed. R.J. Daniel). University Press of Liverpool, 177–192pp. Redfield A.C., Ketchum B.H., Richards E.A., 1963. The influence of organisms on the composition of seawater. In The Sea, (M. N. Hill, ed.), Vol. 2, pp. 26-77. John Wiley, New York. 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. 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.		
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 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. In spite of a series of assessments reviewing the concept and state of eutrophication, there are important gaps in the capacity		

[2] H2020 Indicators Fact Sheets. Regional meeting on PRTR and Pollution indicators, Ankara (Turkey), 16-17 June 2014. (UNEP(DEPI)/MED WG. 399/4)

Indicator Title	13. Concentration of key nutrients in water column (EO5)
to assess the intensity of this phenomenon, even more to compare or grade the various sites. 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.	
Targets For each considered marine spatial scale (region, sub-region, local water mass, etc.) the levels should be compared based on the averaged reference levels on a trend monitoring basis until commonly agreed thresholds have been determined, negotiated and agreed upon at a sub regional or regional levels for GES assessment	
Policy documents UNEP(DEPI)/MED IG.22/Inf.7. Draft Integrated Monitoring and Assessment Guidance. Athens, Greece, February 2016 UNEP/MAP/UNEP/MAP MED POL, 2003. Eutrophication Monitoring Strategy of UNEP/MAP MED POL. UNEP(DEPI)MED WG.231/14. UNEP, Athens. 32pp. UNEP/MAP/UNEP/MAP MED POL, 1990a. Activity IV: Research on the effects of pollutants on Marine Organisms and their Populations UNEP/MAP/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) 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 analysis methods	
Indicator Definition Concentration of key (inorganic) nutrients in the water column (Pressure Indicator): Total Nitrogen (TN) Nitrate (NO_3-N) Nitrite (NO_2-N) Ammonium (NH_4-N) Orthophosphate (P-PO_4) Total Phosphorus (TP) Silicate (Si) Sub-Indicators: Molar Ratios (Si:N, N:P, Si:P)	
Methodology for indicator calculation All: Spectrophotometry (manually or automated methods and instrumentation)	
Indicator units All: micromol per liter (μmol/L) Ratios: adimensional (simple mathematical derivation of ratios from nutrient concentrations)	
List of Guidance documents and protocols available UNEP/MAP/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, dissolved oxygen, inorganic nutrients, organic matter, suspended solids, light penetration, aquatic macro-phytes, zoo benthos, etc. They all may be determined either at the surface or at various depths. If only limited means are available, determination of those parameters that synthesize the most information should be retained. Chlorophyll determinations for example, although not very precise representations of the system, are data which provide a great deal of information. Reliable data on nutrients are extremely useful indicators of potential eutrophication. Turbidity and seawater colour (Forell scale, Wernard and van der Woerd, 2010) may also be a good measure of eutrophication, except near the mouths of rivers where inert suspended solids may be extremely abundant. Dissolved	

Indicator Title	13. Concentration of key nutrients in water column (EO5)
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 alternatives or 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. UNEP/MAP/UNEP/MAP MED POL, 2003. Eutrophication Monitoring Strategy of UNEP/MAP MED POL. UNEP(DEC)MED WG.231/14. UNEP, Athens. 32pp. UNEP/MAP/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	
Available data sources http://www.unepmap.org 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.	
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 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 heavy nutrient loads. However, some natural symptoms of eutrophication can also be found in upwelling areas. Additionally, the risk of eutrophication is linked to the capacity of the marine environment to confine growing algae in the well-lighted surface layer. The geographical extent of potentially eutrophic waters may vary widely, depending on: (i) the extent of shallow areas, i.e. with depth ≤ 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. 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	

Indicator Title	13. Concentration of key nutrients in water column (EO5)
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. Consequently, each Contracting Party would be required to determine the optimum frequency per year and optimum locations for their monitoring stations. Each Contracting Party is responsible for the choice of the most representative sampling stations in order to detect a change over a selected period.	
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. Furthermore in cooler regions winter is an optimal period for measuring nutrients since the data are not disturbed by (variable) uptake by algae/macrophytes. In those regions, spring/summer is an optimal period of the algal growing season and therefore for measuring effects of high nutrient availability. In warmer regions productivity continues during (a large part of) the winter period. In these regions, year round measurements of nutrients may be more appropriate. All: Each CP determine optimum frequency per year and optimum sampling locations (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; Further specify geographical scale of monitoring and assessment.	
Data analysis and assessment outputs	
Statistical analysis and basis for aggregation The TRIX index (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 index. 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: TRIX Index = $(\text{Log10}\ [\text{ChA}\cdot \text{aD\%O}\cdot \text{DIN}\cdot \text{TP}] + k)\cdot m$, where: ChA = Chlorophyll a concentration as μg/L; aD %O = Oxygen as absolute % deviation from saturation; DIN = Dissolved Inorganic Nitrogen, N-(NO_3+NO_2+NH_4) as μg/L; TP = Total Phosphorus as μg/L; k=1.5; m = 10/12 = 0.833	
Expected assessments outputs As sugested 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, negotiated and agreed upon at a sub regional or regional level, GES may be determined on a trend monitoring basis.	
Known gaps and uncertainties in the Mediterranean For a complete assessment of eutrophication and GES achievement, GES thresholds and reference conditions (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.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. 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, 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	

Indicator Title	13. Concentration of key nutrients in water column (EO5)	
through workshops, dialogue and comparative exercises at regional/subregional/subdivision levels in Mediterranean with a view to further develop common assessment methods.		
Contacts and version Date		
http://www.unepmap.org		
Version No	**Date**	**Author**
V.1	31/8/16	MEDPOL

2.2. Common Indicator 14 (EO5): Chlorophyll-a concentration in water column

Indicator Title	14. Chlorophyll-a concentration in water column (EO5)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
The biological community remains well-balanced and retains all necessary functions in the absence of undesirable disturbance associated with eutrophication (e.g. excessive algal blooms, low dissolved oxygen, declines in sea-grasses, kills of benthic organisms and/or fish) and/or where there are no nutrient-related impacts on sustainable use of ecosystem goods and services	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters	For each defined marine spatial area (region, sub-region, local water mass (typology), etc.) the levels should be within agreed threshold levels defining High/Good and Good/Medium environmental status
Rational		
Justification for indicator selector 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. These changes may occur due to natural processes. Management concern begins when they are attributed to anthropogenic sources. Additionally, although these shifts may not be harmful in themselves, the main worry concerns 'undesirable disturbance': the potential effects of increased production, and changes of the balance of organisms on ecosystem structure and function and on ecosystem goods and services		
Scientific References 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. 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. Vollenweider, R.A., Giovanardi F., Montanari, G., Rinaldi A., 1998. Characterization of the trophic conditions of marine coastal waters, with special reference to the NW Adriatic Sea: proposal for a trophic scale, turbidity and generalized water quality index. Environmetrics, 9, 329-357.		
Policy Context and targets		
Policy context description In the Mediterranean, the UNEP/MAP MED POL Monitoring programme included from its inception the study of eutrophication as part of its seven pilot projects approved by the Contracting Parties at the Barcelona meeting in 1975 (UNEP MAP, 1990a,b). The issue of a monitoring strategy and assessment of eutrophication was first raised at the UNEP/MAP MED POL National Coordinators		

Indicator Title	14. Chlorophyll-a concentration in water column (EO5)
Meeting in 2001 (Venice, Italy) which recommended to the Secretariat to elaborate a draft programme for monitoring of eutrophication in the Mediterranean coastal waters. 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, even more to compare or grade the various sites. 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.	
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 Chl-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 UNEP(DEPI)/MED IG.22/Inf.7. Draft Integrated Monitoring and Assessment Guidance. Athens, Greece, February 2016 UNEP/MAP/UNEP/MAP MED POL, 2003. Eutrophication Monitoring Strategy of UNEP/MAP MED POL. UNEP(OCA)MED WG.231/14. UNEP, Athens. 32pp. UNEP/FAO/WHO (1996). 'Assessment of the state of eutrophication in the Mediterranean Sea'. MAP Technical Reports Series No 106. UNEP, Athens, 211 pp. 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	
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: Spectrophotometry. 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 milligram per liter (mg/L) and % Saturation (if temperature and salinity is known) – Dissolved Oxygen	
List of Guidance documents and protocols available 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, 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 determinations for example, although not very precise representations of the system, are data which provide a great deal of information. Reliable data on nutrients are extremely useful indicators of potential eutrophication. Turbidity and seawater colour (Forell scale) 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 alternatives or 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. UNEP/MAP/UNEP/MAP MED POL, 2003. Eutrophication Monitoring Strategy of UNEP/MAP MED POL. UNEP(OCA)MED WG.231/14. UNEP, Athens. 32pp. UNEP/MAP/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	
Available data sources http://www.unepmap.org	
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 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 heavy nutrient loads. However, some natural symptoms of eutrophication can also be found in upwelling areas. Additionally, the risk of eutrophication is linked to the capacity of the marine environment to confine growing algae in the well-lighted surface layer. The geographical extent of potentially eutrophic waters may vary widely, depending on: (i) the extent of shallow areas, i.e. with depth ≤ 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.	

Indicator Title	14. Chlorophyll-a concentration in water column (EO5)
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. Consequently, each Contracting Party would be required to determine the optimum frequency per year and optimum locations for their monitoring stations. Each Contracting Party is responsible for the choice of the most representative sampling stations in order to detect a change over a selected period. All indicators: 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 complemented with the additional elements based on the above mentioned considerations and each country/sub region/area specificity. Further specify geographical scale of monitoring and assessment (coordinates/size of area concerned).	
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. Furthermore in cooler regions winter is an optimal period for measuring nutrients since the data are not disturbed by (variable) uptake by algae/macrophytes. In those regions, spring/summer is an optimal period of the algal growing season and therefore for measuring effects of high nutrient availability. In warmer regions productivity continues during (a large part of) the winter period. In these regions, year round measurements of nutrients may be more appropriate. Initial phase of IMAP: Chl-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: idem Chl-a Dissolved Oxygen: Each CP determine optimum frequency per year and optimum sampling locations; For open waters sampling frequency to be determined on a sub-regional level following a risk based approach	
Data analysis and assessment outputs	
Statistical analysis and basis for aggregation The TRIX index (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 index. 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: TRIX Index = $(\text{Log10}\,[\text{ChA}\cdot\text{aD\%O}\cdot\text{DIN}\cdot\text{TP}] + k)\cdot m$, where: ChA = Chlorophyll a concentration as μg/L; aD %O = Oxygen as absolute % deviation from saturation; DIN = Dissolved Inorganic Nitrogen, N-(NO_3+NO_2+NH_4) as μg/L; TP = Total Phosphorus as μg/L; k=1.5; m = 10/12 = 0.833 It is recommended also that the contracting parties rely on the classification scheme on chl-a concentration (μg/l) developed by MEDGIG as an assessment method easily applicable by all Mediterranean countries based on the indicative thresholds and reference values adopted.	
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 MED GIG intercalibration process of the EU Water Framework Directive (WFD).The Contracting Parties are recommended to rely on the classification scheme on chl-a concentration	

Indicator Title	14. Chlorophyll-a concentration in water column (EO5)	
(μg/l) in coastal waters as a parameter easily applicable by all Mediterranean countries based on the indicative thresholds and reference values of Chla in Mediterranean coastal water types (according to Commission Decision of 20 September 2013 (2013/480/EU) 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), 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. More information on typology criteria and setting is presented in document UNEP(DEPI)/MED WG 417/Inf.15.		
Known gaps and uncertainties in the Mediterranean For a complete assessment of eutrophication and GES achievement, GES thresholds and reference conditions (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. 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. 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, 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/subregional/subdivision levels in Mediterranean with a view to further develop common assessment methods.		
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2.3. Common Indicator 17 (EO9): Concentration of key harmful contaminants measured in the relevant matrix

Indicator Title	17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)	
Relevant GES definition	**Related Operational Objective**	**Proposed Target(s)**
Contaminants cause no significant impact on coastal and marine ecosystems and human health	Contaminants cause no significant impact on coastal and marine ecosystems and human health, therefore, observed concentrations are maintained at natural levels (or eliminated for synthetic compounds) in the marine environment.	Concentrations of substances identified comply with agreed Mediterranean assessment criteria (BAC/EAC). Alternatively, thresholds are set using reference levels and temporal trends.
Rational		
Justification for indicator selector Environmental chemical pollution, including the marine pollution, is directly linked with humankind activities and advancements. Marine environmental investigations have detected thousands of man-made chemicals (both inorganic and organic compounds, as well as radionuclides) all over the world oceans (including the Arctic and Antarctica), 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, marine and atmospheric) are the first steps to understand and 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 interacting with the different marine ecosystems (coastal, open ocean, deep-sea areas), increasing the complexity of the pollution threat for the marine environment and their future sustainability to deliver its benefits.		
Scientific References Clark, R.B., 1986. Marine Pollution, Oxford University Press. Goldberg, E. D., 1975. The Musssel Watch - a first step in global marine monitoring. *Mar.Poll.Bull.*, 6, 111. 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. Furdek, M., Vahcic, M., Šcancar, J., Milacic, R., Kniewald, G., Mikac, N., 2012. Organotin compounds in seawater and Mytilus galloprovincialis mussels along the Croatian Adriatic Coast. *Mar.Poll.Bull.*, 64, 189–199 Thébault et al., 2008. 137Cs baseline levels in the Mediterranean and Black Sea: A cross-basin survey of the CIESM Mediterranean Mussel Watch programme. *Mar.Poll.Bull.*, 57, 801-806. 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 Neff, J.M., 1979. Polycyclic aromatic hydrocarbons in the aquatic environment. Sources, fates and biological effects. Applied Science Publishers, Ltd., London. Barrie, L.A., Gregor, D., Hargrave, B., Lake, R., Muir, D. Shearer, R., Tracey, B., Bidleman, T., 1992. Arctic contaminants: sources, occurrence and pathways, Sci. Total Environ., 122, 1-74. Richardson, S., 2004. Environmental Mass Espectrometry: Emerging contaminants and current issues. Anal. Chem., 76, 3337-3364. 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		

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

Policy context description

In most Mediterranean countries, the monitoring of a range of chemicals (potential hazardous chemical substances) in different ecosystem compartments is undertaken in response to the UNEP/MAP Barcelona Convention (1975), its Land-Based Protocol, UNEP/MAP MED POL Monitoring Program, international (e.g. EU WFD or EU MSFD) or national drivers. A considerable amount of monitoring data from the past decades is available through the pollution monitoring and assessment component of UNEP/MAP MED POL Programme, including monitoring pilot programmes (ecotoxicological effects of contaminats). These data have been used e.g. for the identification of significant marine contaminants and the development of monitoring strategies and guidance. With respect to implementing the requirements of the Ecosystem Approach Process and IMAP, there are considerable benefits to be gained from taking advantage of monitoring data and information developed through the UNEP/MAP MED POL Monitoring programme.

Targets

Initial targets of GES under Common Indicator 17 will be based upon data of a relatively small number of chemicals, reflecting the scope of current programmes and the availability of suitable agreed assessment criteria (see document below, UNEP(DEPI)/MED IG.22/Inf.7).

Policy documents

UNEP(DEPI)/MED IG.22/Inf.7. Draft Integrated Monitoring and Assessment Guidance. Athens, Greece, February 2016

MTS 156. UNEP/MAP/MED POL: Inventories of PCBs and nine pesticides. UNEP/MAP: Athens, 2004. (English, French)

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.

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.

UNEP: 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.

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

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

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

ELOISE, 1996. European Land Ocean interactions Studies. European Commission Directorate General for Research http://www.nilu.no/projects/eloise

UNEP/GPA. United Nations Environment Programme. The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities http://www.unep.org/gpa

Indicator analysis methods

Indicator Definition

Concentrations of key contaminants in the following matrices:

Biota: In marine organisms matrices, primarily bivalves (Pressure indicator):
Trace/Heavy Metals (TM): Total mercury (HgT, Cadmium (Cd) and Lead (Pb) (Pressure indicator)
Organochlorinated compounds (Aldrin, Dieldrin, Hexachlorobencene, Lindane and ΣDDTs)
Polycyclic aromatic hydrocarbons (US EPA 16 Reference PAHs Compounds)

Sediments: In coastal, platform and offshore sediments (Pressure indicator):
Trace/Heavy Metals: Total mercury (HgT, Cadmium (Cd) and Lead (Pb) (Pressure indicator)

Indicator Title	17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)
Organochlorinated compounds (Aldrin, Dieldrin, Hexachlorobencene, Lindane and ΣDDTs) Polycyclic aromatic hydrocarbons (US EPA 16 Reference PAHs Compounds) Seawater: Monitoring of contaminants in seawater presents specific challenges and therefore recommended to be carried out on a country by country decision basis Aluminium (Al) and Total Organic Carbon (TOC) for normalization purposes for TM and OCs, respectively <u>Sub-indicators:</u> other relevant chemicals and emerging pollutants are recommended to be carried out on a country by country decision basis	
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 TOC: Elemental Analyser	
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 %)	
List of Guidance documents and protocols available Refer to UNEP Methods and Protocols for Marine Pollution, as well as from other regional conventions.	
Data Confidence and uncertainties Selected analytical methods are subject to Quality Assurance Protocols and interlaboratory exercises: QA/QC through UNEP/MAP MED POL/IAEA MESL, National QA/QC Procedures	
Methodology for monitoring, temporal and spatial scope	
Available Methodologies for Monitoring and Monitoring Protocols With regard the Ecosystem Approach Process and IMAP implementation, there are considerable benefits to be gained from taking advantage of monitoring data and information developed through the UNEP/MAP MED POL Monitoring programme. Such actions include (1) the use of existing experience in the design of monitoring programmes, (2) the use of existing guidance on analytical etc. methods to inform technical aspects of ecosystem approach monitoring, (3) the use of existing sampling station networks as a framework for ecosystem approach sampling networks, (4) the use of existing statistical assessment tools and work on assessment criteria as the basis for assessments of ecosystem approach data, (5) the use of existing data to describe the distributions of contaminants and effects in the sea, and (6) the use of existing time series as the basis of monitoring against a “no deterioration” objective. The availability of quality assured data with confirmed quality is of importance for the assessment of trends in pollutant concentrations. The precautionary principle requires that, in doubt, protective measures should be implemented. In particular the marine environment is vulnerable due to possible accumulation of contaminants in the specific food chains and the irreversibility of impact on its ecosystems.	
Available data sources	

Indicator Title	17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)
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. 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.	
Spatial scope guidance and selection of monitoring stations A strategy for monitoring should include master stations, distributed spatial spread and other approaches, such as transect sampling. The selection of sites for the monitoring of contaminants and biological effects in the marine environment is a direct function of the assessment of risks and the monitoring scope: • Areas of concern identified on the basis of the review of the existing information • Areas 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...). • Sites representative in monitoring of other sea-based (shipping) and atmospheric sources. • Reference sites: For reference values and background concentrations. • Representative sensitive pollution sites/areas at sub regional scale. • Deep-sea sites/areas of potential particular concern The selected sites should allow the collection of a realistic number of samples (e.g. be suitable for sediment sampling, 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. Coordination with monitoring for other Ecological Objectives is crucial for cost-effective approaches.	
Temporal Scope guidance Sampling frequencies will be determined by the purpose of the monitoring. They can range from shorter time scales (monthly) for seasonally variable parameters up to large time scales, e.g. sediment core monitoring (years to decades). For trend determination 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. As a guidance for coastal monitoring: annually, for biota (e.g. mussels) and lower frequencies (every 3-6 years) for sediments depending on the characteristics of sedimentation areas	
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 contaminants and biological effects, trends analysis and distribution levels could be carried out on sub-regional or even regional level, provided appropriate quality assured datasets available for levels and temporal trends. For the assessment of GES, it would be carried out using Mediterranean data from the MEDPOL database and applying a two level threshold classification (such as the OSPAR methodology). Therefore, the assessment of the background assessment concentrations (BACs) and environmental assessment criteria (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 could be performed.	
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	

Indicator Title	17. Concentration of key harmful contaminants measured in the relevant matrix (EO9)	
considered to be important within each assessment area are included in monitoring programmes. Through these, and other, actions, it will be possible to develop targeted and effective monitoring programmes tailored to meet the needs and conditions within each GES assessment sub-region. It has been recognized that the open and deep sea is much less covered by monitoring efforts than coastal areas. There is a need to include within monitoring programmes also areas beyond the coastal areas in a representative and efficient way, where risks warrant coverage.		
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2.4. Common Indicator 18 (EO9): Level of pollution effects of key contaminants where a cause and effect relationship has been established

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)**
Contaminants cause no significant impact on coastal and marine ecosystems and human health	Contaminants cause no significant impact on coastal and marine ecosystems and human health (therefore, biological effects linked to chemical contamination are not observed)	Levels of biomarkers identified comply with agreed Mediterranean assessment criteria (BAC/EAC). Alternatively, thresholds are set using reference levels and temporal trends
Rational		
Justification for indicator selector Upon exposure to 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 subcellular level. These *'sublethal'* effects, when integrated, often converge to visible harm for the organisms and to the whole population at a later stage, when it is too late to limit the extent of biological damage resulting from environmental deterioration. Most of these symptoms have been reproducibly obtained in the laboratory and the various biological mechanisms of response to major xenobiotics are now sufficiently well understood. Therefore, the use of biomarkers (provided there is a cause and effect relationship), has came into common practice as pollution monitoring tools to signal the onset of harmful effects at the cellular and sub-cellular levels.		
Scientific References Moore, M.N. (1985), Cellular responses to pollutants. *Mar.Pollut.Bull.*, 16:134-139 Moore, M.N. (1990), Lysosomal cytochemistry in marine environmental monitoring. *Histochem.J.*, 22:187-191 Scarpato, R., L. Migliore, G. Alfinito-Cognetti and R. Barale (1990), Induction of micronuclei in gill tissue of *Mytilus galloprovincialis* exposed to polluted marine waters *Mar.Pollut.Bull.*, 21:74-80 Lowe, D., M.N. Moore and B.M. Evans (1992), Contaminant impact on interactions of molecular probes with lysosomes in living hepatocytes from dab *Limanda limanda. Mar.Ecol.Progr.Ser.*, 91:135-140 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 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 chemicals (potential hazardous chemical substances) in different ecosystem compartments is undertaken in response to the UNEP/MAP Barcelona Convention, its Land-Based Protocol, UNEP/MAP MED POL Monitoring Program, international (e.g. EU WFD or EU MSFD) or national drivers. A considerable amount of monitoring data from the past decades is available through the pollution monitoring and assessment component of UNEP/MAP MED POL Programme, including monitoring pilot programmes (ecotoxicological effects of contaminats). These data have been used e.g. for the identification of significant marine contaminants and the development of monitoring strategies and guidance. With respect to implementing the requirements of the Ecosystem Approach Process and IMAP, there are considerable benefits to be gained from taking advantage of monitoring data and information developed through the UNEP/MAP MED POL Monitoring programme.		
Targets		

Indicator Title	18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)
Initial targets of GES under Common Indicator 18 will be based upon data of a relatively small number of contaminants and biological effects parameters, reflecting the scope of current programmes and the availability of suitable agreed assessment criteria (see document below, UNEP(DEPI)/MED WG.421/Inf.9).	
Policy documents UNEP(DEPI)/MED IG.22/Inf.7. Draft Integrated Monitoring and Assessment Guidance. Athens, Greece, February 2016 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. UNEP (1997), Report of the Meeting of Experts to Review the MED POL Biomonitoring Programme. UNEP(OCA)/MED WG.132/7, Athens, 19 p. 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 *Mytilus galloprovincialis*) Lysosomal Membrane Stability (LMS) as a method for general status screening. Reduction of survival in air or Stress on Stress (SoS). 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-indicator: biomarkers in other marine species are recommended to be carried out on a country by country decision basis	
Methodology for indicator calculation Lysosomal Membrane Stability (LMS) : Biological techniques (neutral red retention), including microscopy Reduction of survival in air or Stress on Stress (SoS): Mortality protocol Acetylcholinesterase (AChE) assay: Biological techniques, including spectrophotometry Micronucleus assay: Biological techniques, including microscopy	
Indicator units (retention) minutes - Lysosomal Membrane Stability (LMS) Number of survived days - Reduction of survival in air or Stress on Stress (SoS) nmol/min mg protein in gills (bivalves) - Acetylcholinesterase (AChE) assay Number of cases, ‰ in haemocytes - Micronucleus assay	
List of Guidance documents and protocols available	

Indicator Title	18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)
UNEP/RAMOGE: Manual on the Biomarkers Recommended for the UNEP/MAP MED POL Biomonitoring Programme. UNEP, Athens, 1999. 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. ICES Cooperative Research Report. No.315. Integrated marine environmental monitoring of chemicals and their effects. I.M. Davies and D. Vethaak Eds., November, 2012.	
Data Confidence and uncertainties Selected analytical methods are subject to Quality Assurance Protocols and interlaboratory exercises: QA/QC through UNEP/MAP MED POL Inter-calibration exercises in agreement with University of Piemonte Orientale Italy (DiSAV)	
Methodology for monitoring, temporal and spatial scope	
Available Methodologies for Monitoring and Monitoring Protocols With regard the Ecosystem Approach Process and IMAP implementation, there are considerable benefits to be gained from taking advantage of monitoring data and information developed through the UNEP/MAP MED POL Monitoring programme. Such actions include (1) the use of existing experience in the design of monitoring programmes, (2) the use of existing guidance on analytical etc. methods to inform technical aspects of ecosystem approach monitoring, (3) the use of existing sampling station networks as a framework for ecosystem approach sampling networks, (4) the use of existing statistical assessment tools and work on assessment criteria as the basis for assessments of ecosystem approach data, (5) the use of existing data to describe the distributions of contaminants and effects in the sea, and (6) the use of existing time series as the basis of monitoring against a "no deterioration" objective. The availability of quality assured data with confirmed quality is of importance for the assessment of trends. 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 biomonitoring activities, in line with the new monitoring requirements Molluscs have been taken as the bioindicators of choice on the basis of their wide geographic distribution, their straightforward availability in the field and through aquaculture, and their suitability for caging experiments along coastlines.	
Available data sources *MEDPOL Database*	
Spatial scope guidance and selection of monitoring stations A strategy for monitoring should include master stations, distributed spatial spread and other approaches, such as transect sampling. The selection of sites for the monitoring of contaminants and biological effects in the marine environment is a direct function of the assessment of risks and the monitoring scope: • Areas of concern identified on the basis of the review of the existing information • Areas 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...). • Sites representative in monitoring of other sea-based (shipping) and atmospheric sources. • Reference sites: For reference values and background concentrations. • Representative sensitive pollution sites/areas at sub regional scale. • Deep-sea sites/areas of potential particular concern The selected sites should allow the collection of a realistic number of samples (e.g. be suitable for sediment sampling, 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. Coordination with monitoring for other Ecological Objectives is crucial for cost-effective approaches.	
Temporal Scope guidance	

Indicator Title	18. Level of pollution effects of key contaminants where a cause and effect relationship has been established (EO9)	
Sampling frequencies will be determined by the purpose of the monitoring. They can range from shorter time scales (monthly) for seasonally variable parameters up to large time scales, e.g. sediment core monitoring (years to decades). For trend determination 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. As a guidance for coastal monitoring: annually, for biota (e.g. mussels)		
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 contaminants and biological effects, trends analysis and distribution levels could be carried out on sub-regional or even regional level, provided appropriate quality assured datasets available for levels and temporal trends. For the assessment of GES, it would be carried out using Mediterranean data from the MEDPOL database and applying a two level threshold classification (such as the OSPAR methodology). In a similar manner to contaminant concentrations, ICES/OSPAR has proposed two/three categories to assess the biological effects observed, by using two assessment criteria: BAC and EAC. Assessing biomarker responses against BAC and EAC 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. However, unlike contaminant concentrations in environmental matrices, biological responses cannot be assessed against guideline values without consideration of factors such as species, gender, maturation status, season and temperature.		
Known gaps and uncertainties in the Mediterranean Important development areas in the Mediterranean Sea over the next few years will include harmonisation of monitoring targets (determinants and matrices) within assessment sub-regions, development of suites of assessment criteria integrated chemical and biological assessment methods,, and review of the scope of the monitoring programmes to ensure that those contaminants which are considered to be important within each assessment area are included in monitoring programmes. Through these, and other, actions, it will be possible to develop targeted and effective monitoring programmes tailored to meet the needs and conditions within each GES assessment sub-region. It has been recognized that the open and deep sea is much less covered by monitoring efforts than coastal areas. There is a need to include within monitoring programmes also areas beyond the coastal areas in a representative and efficient way, where risks warrant coverage.		
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2.5. Common Indicator 19 (EO9): Occurrence, origin (where possible), and extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances) and their impact on biota affected by this pollution

<table>
<tr><td>Indicator Title</td><td colspan="2">19. Occurrence, origin (where possible), and extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances) and their impact on biota affected by this pollution (EO9)</td></tr>
<tr><td>Relevant GES definition</td><td>Related Operational Objective</td><td>Proposed Target(s)</td></tr>
<tr><td>Contaminants cause no significant impact on coastal and marine ecosystems and human health</td><td>Accute and chronic pollution events cause no significant impacton coastal and marine ecosystems</td><td>Minimum tolerance (near to 0 events) is considered under MARPOL Annex I for the Mediterranean Sea (special area)</td></tr>
<tr><td colspan="3">Rational</td></tr>
<tr><td colspan="3">Justification for indicator selector
Oil spills and acute/chromic events of oil introduction in the marine environment cause proven imparinrment of the health of ecosystems at all levels (coastal habitats, seabirds, marine mammal populations, offshore, etc.), as well as socio-economical impacts (mainly on tourism, fisheries and aquaculture).</td></tr>
<tr><td colspan="3">Scientific References
http://www.rempec.org
http://www.imo.org
http://www.itopf.com</td></tr>
<tr><td colspan="3">Policy Context and targets</td></tr>
<tr><td colspan="3">Policy context description
The UNEP/MAP-Barcelona Convention and its Prevention and Emergency Protocol aim at the protection of the environment against oil and chemical spills with a coherent coverage and equal level of protection for the entire Mediterranean Sea.. The Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) is responsible for the prevention of, preparedness for and response to marine pollution. In this regard, the Centre’s database on alerts and accidents in the Mediterranean Sea contains data on accidents causing or likely to cause pollution of the sea by oil (since 1977) and by other harmful substances (since 1989).

Further, in view of the adoption in COP 19 of the UNEP/MAP Barcelona Convention Offshore Protocol Action Plan (The Protocol for the Protection of the Mediterranean Sea against Pollution from the Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil (Offshore Protocol). The Protocol entered into force on 24 March, 2011 and according to the Offshore Action Plan Contracting Parties that have not already done so should endeavor to ratify the Protocol, the development and adoption of Mediterranean monitoring procedures and programmes for offshore activities, is envisaged to take place building on the IMAP of the EcAp.</td></tr>
<tr><td colspan="3">Targets
Reduction of oil spills and acute/chronic events (minimum tolerance, near to 0 events) considered under MARPOL Annex I for the Mediterranean Sea (special area)</td></tr>
<tr><td colspan="3">Policy documents
UNEP(DEPI)/MED IG.22/Inf.7. Draft Integrated Monitoring and Assessment Guidance. Athens, Greece, February 2016
Protocol concerning cooperation in preventing pollution from ships and, in case of emergency, combating pollution of the Mediterranean Sea (2002), Prevention and Emergency Protocolo f the Barcelona Convention), and its original 1976 Emergency Protocol.
MARPOL (International Convention for the Prevention of Pollution from ships) Annex I. Regulating oil discharges.
MARPOL (International Convention for the Prevention of Pollution from ships) Annex II. Noxious liquid substances in bulk.
MARPOL (International Convention for the Prevention of Pollution from ships) Annex III. Hamfrul substances carried by sea in package form.</td></tr>
</table>

Indicator Title	19. Occurrence, origin (where possible), and extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances) and their impact on biota affected by this pollution (EO9)
OPRC. International Convention on Oil Pollution Preparadness, Repsonse and Cooperation (OPRC, 1990). Protocolo on Preparadness, Response and Cooperation for pollution incidents by hazardous and noxious substances (OPRC-HNS Protocol).	
Indicator analysis methods	
Indicator Definition Location, origin, type and extent (Pressure, Impact indicator).	
Methodology for indicator calculation Direct observations: sampling, quantification of oil and other chemical spills and their size by observation and reporting (direct marine survellinace by air/sea, satellite radar images (SAR) and imaging approaches).. Indirect observations: backtracking of oil spills to their source by hind cast modelling together with authomatic information system data.	
Indicator units Location (standard coordinates, country, cause, date, time) Origin (ship name, category – IMO number, offshore installations ID number, port facility name) Pollutant type (classification by chemical properties, such as volatility, animal/vegetal oil, HNS, etc.) Extent: volume (metric tons, cubic meters); Surface area (square meters/kilometres) and thickness (Bonn Agreement Color Code)	
List of Guidance documents and protocols available Reference methods are available through International Maritime Organization (IMO) http://www.imo.org UNEP MAP Emergency Protocol Reporting Guidelines (available through REMPEC) http://www.rempec.org Other especializad organizations (CEDRE, IPIECA, ITOPF)	
Data Confidence and uncertainties Currently, there is a high degree of confidence in the oil transported by ships as a bunker or cargo. For chemicals there is also a high confidence on quantities and types transported by liquid bulk ships. However, confidence of data for chemicals transported in container ships is relatively low.	
Methodology for monitoring, temporal and spatial scope (Monitoring activities are developed for large scale incidents, although there is a provision under Article 5)	
Available Methodologies for Monitoring and Monitoring Protocols **Reporting Procedures for oil spills and HNS:** the organizational framework under which the monitoring of oil and other chemical spills is being dealt with under the UNEP/MAP Barcelona Convention is REMPEC. Mediterranean coastal States, contracting Parties to the 2002 Prevention and Emergency Protocol to the UNEP/MAP Barcelona Convention, committed themselves (Article 9 of the Prevention and Emergency Protocol) to inform each other, either directly or through the Regional Centre (i.e. REMPEC) on: • all accidents causing or likely to cause pollution of the sea by oil and other harmful substances • the presence, characteristics and extent of spillages of oil or other harmful substances observed at sea which are likely to present a serious and imminent threat to the marine environment or to the coast or related interests of one or more of the Parties; • their assessments and any pollution combating actions taken or envisaged to be taken the evolution of the situation. In relation to their obligations under the above mentioned Article 9 of the Prevention and Emergency Protocol, at their Fifth Ordinary Meeting, the Contracting Parties to the UNEP/MAP Barcelona Convention adopted the Guidelines For Co-operation In Combating Marine Oil Pollution In The Mediterranean (UNEP/IG.74/5, UNEP/MAP, 1987) which recommend Parties to report to REMPEC at least all spillages or discharges of oil in excess of 100 cubic metres. In 2015, the Joint Session of	

Indicator Title	19. Occurrence, origin (where possible), and extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances) and their impact on biota affected by this pollution (EO9)
the MEDPOL and REMPEC Focal Points Meeting agreed to report spillages over 50 cubic meters in accordance to MARPOL. Further, the Article 18 of the UNEP/MAP Barcelona Convention Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil (Offshore Protocol), states that in cases of emergency the Contracting Parties shall implement mutatis mutandis the provisions of the Emergency Protocol.	
Available data sources http://www.imo.org http://www.rempec.org	
Spatial scope guidance and selection of monitoring stations To be filled din later	
Temporal Scope guidance To be filled in later	
Data analysis and assessment outputs	
Statistical analysis and basis for aggregation Frequencies and quantitative statistical analysis. The basis for agreegation would be a "nested approach" over a geographical scale	
Expected assessments outputs Temporal trends analysis and distribution maps	
Known gaps and uncertainties in the Mediterranean While Contracting Parties are under the obligation for the above monitoring, data submitted to REMPEC is still scarce. Thus the main aim during the Initial Phase of the IMAP is to strengthen monitoring efforts towards this already existing obligation. Further, there is a lack of obligation for Reporting on Coastal and marine habitats and biota impacted or physically affected . It Could be used as a new pressure,/impact indicador to assess the overall impact in the marine ecosystems.	
Contacts and version Date	
http://www.rempec.org	

Version No	**Date**	**Author**
V.1	19/9/16	MEDPOL/REMPEC

2.6. 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

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)**
Contaminants cause no significant impact on coastal and marine ecosystems and human health	Contaminants cause no significant impact on coastal and marine ecosystems and human health; therefore, contaminants of human health concern do not pose a risk for seafood consumption.	Chemical contaminants of human health concern identified do not exceed regulatory levels set by national, and international bodies
Rational		
Justification for indicator selector One of the potential risks associated with the occurrence of harmful chemicals and other harmful substances (nanoparticles, microplastics, toxins) in the marine environment is the human exposure through target commercial fish and shellfish species (primarily, from fisheries and aquaculture). In a similar way, these organisms are also exposed to environmental contaminants which enter their		

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)

organism through different mechanisms and pathways according their thropic level, which include from filter feeding to predatory strategies (crustaceans, bivalves, fish, mamifers). Consequently, there are both bioaccumulation and biomagnification processes of the chemicals released in the marine environment. Common examples are the well-known bioaccumulation of metals and organic compounds in bivalve species (such as the *Mytillus galloprovincialis* in the Mediterranean Sea) or alkyl mercury compounds in tuna fish (methylmercury), which should be shadowed by new and emerging contaminants in the near future.

Scientific References

Vandermeersch, G. et al. 2015. Environmental contaminants of emerging concern in seafood – European database on contaminant levels. Environmental Research, 143B, 29-45.
Maulvault, A.M. et al. 2015. Toxic elements and speciation in seafood samples from different contaminated sites in Europe. Environmental Research, 143B, 72-81.
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.
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.
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.
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.
Cruz, R. Brominated flame retardants and seafood safety: A review. Environment International, 77, 116-131.
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.
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) and the food safety prevention, including emerging contaminants, through the consumption of potentially poisoned seafood is a challenge and a priority for governments, as well as a major societal concern. There are different initiatives and regulations at national and international levels, 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 and FAO are also national and international authorities with regard seafood safety.

Targets

Chemical contaminants of human health concern do not exceed regulatory levels in seafood set/recommended/agreed by national and/or international authorities.

Policy documents

UNEP(DEPI)/MED IG.22/Inf.7. Draft Integrated Monitoring and Assessment Guidance. Athens, Greece, February 2016
EU 1881/2006. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. European Commission.
US FDA http://www.fda.gov/Food/FoodborneIllnessContaminants/Metals/ucm115644.htm
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.

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)
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 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 Sub-indicators: other relevant chemicals and emerging pollutants are recommended to be carried out on a country by country decision basis	
Methodology for indicator calculation Number of detected contaminants: national regulatory and inspection bodies statistics and yearly databases Number of detected contaminants exceeding regulatory limits: national regulatory and inspection bodies statistics and yearly databases (Additional parameters required: sample identification, location, date and biometrics).	
Indicator units (frequencies, %) - Number of detected contaminants in individual commercial species (by year) (frequencies, %) - Number of detected contaminants exceeding regulatory limits in appropriate units (by year), for example, mg/kg fresh weight (parts per million, ppm, fresh weight) or µg/g fresh weight (part per billion, ppb, fresh weight).	
List of Guidance documents and protocols available Refer to UNEP Methods and Protocols for Marine Pollution, as well as from other regional conventions. (Pre-treatment of samples (marine organisms) might differ between analytical methods and care should be taken.	
Data Confidence and uncertainties Data confidence in directly related to the number of available tests performed to commercial species and their regularity	
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 within the new IMAP implementation. Risk-based public health methodologies to define monitoring are recommended.	
Available data sources Both national and environmental databases (*tentatively*)	
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	

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)
Risk-based methodologies to define monitoring are recommended.	
Data analysis and assessment outputs	
Statistical analysis and basis for aggregation Risk-based analysis is recommended. Geographic reporting scales (within IMAP implementation) should be considered by contracting Parties in terms of Common Indicator aggregation: (1) Whole region (i.e. Mediterranean Sea); (2) Mediterranean sub-regions, as presented in the Initial Assessment of the Mediterranean Sea, UNEP(DEPI)/MED IG.20/Inf.8; (3) Coastal waters and other marine waters; (4) Subdivisions of coastal waters provided by Contracting Parties	
Expected assessments outputs Assessment outputs would be based on trend analysis and annual statistics	
Known gaps and uncertainties in the Mediterranean As this is a new Common Indicator within the context of marine environmental protection policy (*ca*. Ecosystem Approach and IMAP implementation) its applicability beyond food consumer protection and public health would need to be determined, although intuitively reflects the health status of the marine environment in terms of their delivery of benefits (e.g. fisheries industry). Thus, monitoring protocols, risk-based approaches, analytical testing and assessment methodologies would need to be examined between Contracting Parties national food safety authorities and/or environmental agencies.	
Contacts and version Date	
http://www.unepmap.org	

Version No	**Date**	**Author**
V.1	31/8/16	MEDPOL

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

<table>
<tr><td>Indicator Title</td><td colspan="2">21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)</td></tr>
<tr><td>Relevant GES definition</td><td>Related Operational Objective</td><td>Proposed Target(s)</td></tr>
<tr><td>Marine bathing waters are of excellent or good quality with regard to potential faecal pollution allowing recreational purposes</td><td>Levels of enterococci are maintained at their natural levels in the different habitats in the marine environment, particularly, in areas related to recreational uses.</td><td>Levels of intestinal enterococci comply with established national or international standards, such as EU 2006/7 Directive (excellent or good quality levels)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">Rational</td></tr>
<tr><td colspan="3">Justification for indicator selector
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 has improved the potential for microbiological pollution. High levels of enterococci bacteria in recreational marine waters (coasts, beaches, tourism spots, etc) are known to be indicative of human pathogens due to non-treated discharges into the marine environment to some extent, although they might be widely distributed in different habitats, and to cause human infections. Therefore, enterococci concentrations are frequently used as a faecal indicator bacteria, or general indicators of faecal contamination. 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 humans contracting gastroenteritis during recreational water use. Further, it was suggested and latterly demonstrated that enterococci might be more appropriate than 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 (EPA) for brackish and marine waters, since they correlate better than faecal coliforms or E.coli. 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, in water quality assessments.</td></tr>
<tr><td colspan="3">Scientific References
Ostrolenk M, Kramer N, Cleverdon RC. 1947. Comparative studies of enterococci and Escherichia coli as indices of pollution. J. Bacteriol. 53: 197–203
Wolf HW. 1972. The coliform count as a measure of water quality, p 333–345.In Mitchell R (ed), Water pollution microbiology. Wiley Interscience, New York, NY.
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
Byappanahalli, MN. et al. 2012. Enterococci in the environment. Microbiol. Mol. Biol.Rev., 76, 685-706
Moellering RC Jr. 1992. Emergence of Enterococcus as a significant pathogen. Clin. Infect. Dis., 15, 58–62
Mote BL, Turner JW, Lipp EK. 2012. Persistence and growth of the fecal indicator bacteria enterococci in detritus and natural estuarine plankton communities. Appl. Environ. Microbiol.,78, 2569–2577
Sadowsky MJ, Whitman RL (ed). 2010. The fecal bacteria. ASM Press, Washington, DC.
Kay D, et al. 1994. Predicting likelihood of gastroenteritis from sea bathing: results from randomised exposure. Lancet, 344, 905–909
Prüss A. 1998. Review of epidemiological studies on health effects from exposure to recreational water. Int. J. Epidemiol., 27, 1–9</td></tr>
<tr><td colspan="3">Policy Context and targets</td></tr>
<tr><td colspan="3">Policy context description</td></tr>
</table>

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

The World Health Organisation 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 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). 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

Levels of intestinal enterococci comply with established national or international standards, particularly, the EU 2006/7 Directive, under excellent (95^{th} percentile<100 CFU/100 mL) or good (95^{th} percentile<200 CFU/100 mL) quality categories for the “last assessment”, last four years (see document below, Directive 2006/7/EC)

Policy documents

UNEP(DEPI)/MED IG.22/Inf.7. Draft Integrated Monitoring and Assessment Guidance. Athens, Greece, February 2016

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

WHO, 2003. Guidelines for safe recreational water environments. VOLUME 1: Coastal and fresh waters. WHO Library. ISBN 92 4 154580. World Health Organisation, 2003.

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

Concentration (CFU) of intestinal enterococci in the sample (normalised to 100 mL)

Methodology for indicator calculation

An 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 percentile value 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 + 1,65σ).

Indicator units

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

List of Guidance documents and protocols available

Indicator Title	21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)
ISO 7899-1[Water quality – Detection and enumeration of intestinal enterococci: Part 1: Miniaturized method (Most Probable Number) for surface and wastewater] or ISO 7899-2 [Water quality – Detection and enumeration of intestinal enterococci: Part 2: Membrane filtration method].	
Data Confidence and uncertainties ISO 7899-2 describes the isolation of intestinal enterococci (*Enterococcus faecalis, E. faecium, E. durans* and *E. hirae*). 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. For purposes of water examination, enterococci can be regarded as indicators of faecal pollution. However it should be noted 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). 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 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	
Spatial scope guidance and selection of monitoring stations Sampling should be performed in recreational waters of concern where microbiological pollution could threat the recreational uses	
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 setof 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 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, location 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: (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	

Indicator Title	21. Percentage of intestinal enterococci concentration measurements within established standards (EO9)	
Expected assessments outputs For pathogenic microorganisms in bathing water, monitoring for the assessment of GES could be carried out on a sub-regional or even local level due to the nature of microbiological contamination (the impact is restricted to a relatively short distance from the pollution source due to the short survival time of microorganisms in seawater and dilution effects). Distribution maps and temporal trend assessment (short periods) are also envisaged.		
Known gaps and uncertainties in the Mediterranean As this is a new Common Indicator within the context of marine environmental protection policy (*ca*. Ecosystem Approach and IMAP implementation) its applicability beyond 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.1	31/8/16	MEDPOL