



## JRC TECHNICAL REPORT

# Eutrophication in marine waters: harmonization of MSFD methodological standards at EU level

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## **Abstract**

The Marine Strategy Framework Directive (MSFD) establishes the legal framework for the protection, conservation and sustainable use of the marine environment at the Union level. Because of its negative effects on the marine water quality, eutrophication is one of the impacts assessed under MSFD. This report presents the results of the joint work between JRC and a network of Member State (MS) eutrophication designated experts to assess the level of harmonization in Eutrophication methodological standards and threshold definition at regional and EU level. The information compiled at regional and national level showed that methodologies are defined already for all the criteria specified for the assessment of eutrophication in Decision (EU) 2017/848. However, the degree of harmonization of methodological approaches across MS and MSFD marine regions varies. Harmonization is higher in the Baltic Sea, intermediate in the North-East Atlantic and rather low in the Mediterranean and Black Sea. In addition further developments are needed for some regions to agree on common indicators and threshold values. The degree of harmonization in coastal water was similar to the open sea. Based on these results the report highlights existing gaps and proposes recommendations to improve the eutrophication assessment framework at EU level.

# 1 Introduction

Eutrophication is defined as the adverse effects of an increase in nutrient inputs into a water body, resulting in excessive growth of primary producers and depletion of oxygen concentrations (Larsson et al 1985). Nutrient enrichment (mainly nitrogen and phosphorus) resulting from anthropogenic activities is the main cause of eutrophication in coastal areas (Cloern 2001); input of organic matter is also of importance in some areas. The main anthropogenic sources of nutrient input to marine waters are agriculture, industrial activities, municipal sewage water, traffic (including shipping) and atmospheric deposition (Elmgren and Larsson 2001, Wassmann and Olli 2006). Increase in nutrient concentration affects several biological components (e.g. changes in the structure of benthic communities and proliferation of opportunistic organisms) and environmental parameters (e.g. increased chlorophyll a concentration, water transparency reduction, oxygen concentration depletion), with potential associated ecological and socio-economic impacts.

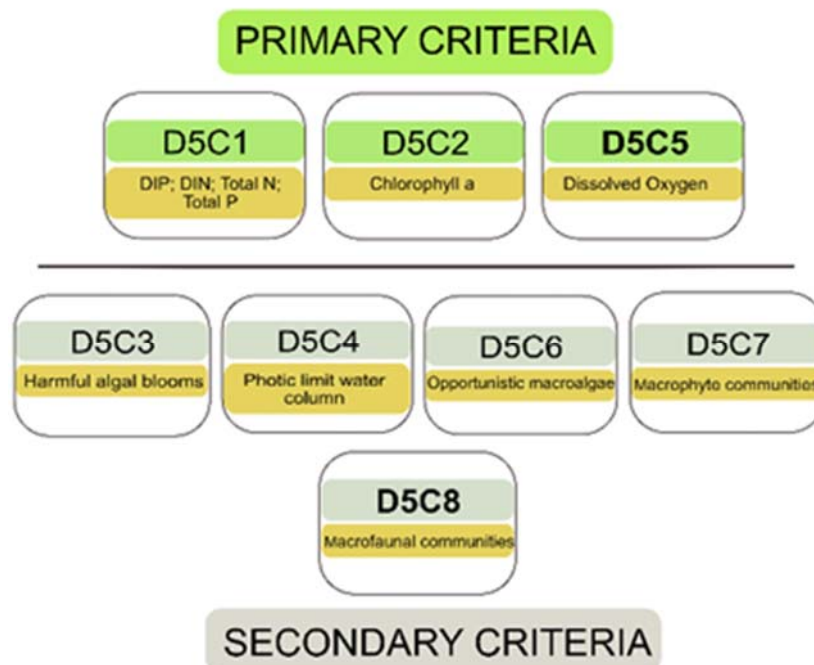
Due to its adverse effects and sometimes widespread nature, eutrophication is of concern in European marine waters and legal instruments have been developed at the EU level to ensure the protection of marine water quality. This was firstly through the introduction of the Water Framework Directive (WFD) (2000/60/EC), which addresses transitional, coastal, groundwater and inland surface waters. This was followed by the Marine Strategy Framework Directive (MSFD) (2008/56/EC) which establishes a framework for the protection, conservation and sustainable use of the marine environment and ecosystems at the Union level. Under this latter framework, the aim is to achieve and maintain Good Environmental Status (GES) in EU marine waters by 2020. GES is defined through a set of 11 qualitative descriptors (set out in Annex I of the MSFD), encompassing different aspects of the marine environment. Descriptor 5 (D5) refers to eutrophication and sets as objective that “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”. The qualitative descriptors for determining GES are detailed in the 2008/56/EC Directive. Commission Decisions (EU) 2017/848<sup>1</sup> establishes criteria and methodological standards for the determination of GES for the different descriptors. These criteria and standards are to be used by MS to ensure consistency and to allow for comparison between marine regions and subregions of the extent to which GES is being achieved. The Decision sets out a number of requirements for determining and assessing GES which must be established either at EU or regional level.

The assessment of eutrophication status under MSFD implies a need for monitoring of individual criteria, including nutrient levels and their adverse effects on the marine environment. These criteria are then integrated to describe the overall eutrophication status of an area. Some of these criteria are considered “primary” and their use is mandatory (except under justified circumstances) whilst others are “secondary”, meaning they can be used, according to individual MS judgement, to complement the eutrophication assessment based on primary criteria or when the marine environment is at risk of not achieving or not maintaining GES for that particular criterion.

<sup>1</sup> Replaces Decision 2010/477/EU.

MSFD eutrophication criteria are listed below (Figure 1):

- 1) Nutrients: D5C1 (**PRIMARY**): Nutrient concentrations in the water column: C1.1 (Dissolved Inorganic Nitrogen (DIN), C1.2 Total Nitrogen (TN), C1.3 Dissolved Inorganic Phosphorus (DIP) and C1.4 Total Phosphorus (TP)) are not at levels that indicate adverse eutrophication effects;
- 2) D5C2 (**PRIMARY**): Chlorophyll a concentrations are not at levels that indicate adverse effects of nutrient enrichment;
- 3) D5C3 (SECONDARY): The number, spatial extent and duration of harmful algal bloom events are not at levels that indicate adverse effects of nutrient enrichment;
- 4) D5C4 (SECONDARY): The photic limit (transparency) of the water column is not reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment;
- 5) D5C5 (**PRIMARY**): The concentration of dissolved oxygen is not reduced, due to nutrient enrichment, to levels that indicate adverse effects on benthic habitats (including on associated biota and mobile species) or other eutrophication effects (might be replaced by D5C8);
- 6) D5C6 (SECONDARY): The abundance of opportunistic macroalgae is not at levels that indicate adverse effects of nutrient enrichment;
- 7) D5C7 (SECONDARY): The species composition and relative abundance or depth distribution of macrophyte communities achieve values that indicate there is no adverse effect due to nutrient enrichment including via a decrease in water transparency;
- 8) D5C8 (SECONDARY (except when replacing D5C5)): The species composition and relative abundance of macrofaunal communities, achieve values that indicate that there is no adverse effect due to nutrient and organic enrichment.



**Figure 1.** Primary and secondary criteria for the MSFD eutrophication (D5) descriptor.

The MSFD states that MS should develop a marine strategy to achieve or maintain GES by 2020 at the latest, through cooperation, coherence and coordination at the regional and sub-regional level. The Commission Decision (EU) 2017/848 specifies that, where it does not establish criteria, methodological standards and threshold values for monitoring and assessment, MS should, where appropriate, build on the ones developed at regional level. Consistency of methodological approaches applied to coastal and open sea waters is also recommended.

The Decision sets out that the extent to which GES has been achieved in coastal waters is expressed according to the approaches defined under the WFD. Beyond coastal waters, an estimate of the extent of each area that is not subject to eutrophication is required, as indicated by the results of all criteria used, integrated in a manner agreed where possible at Union level, but at least at regional or subregional level. The use of the secondary criteria, beyond coastal waters, shall be agreed at regional or subregional level.

This report describes the work coordinated by JRC in collaboration with MS-nominated D5 experts to assess the harmonization in methodological standards and threshold setting at regional and EU level and between coastal and open sea waters, based upon the mandate set out in the Decision for EU or regional/subregional consistency in use of the criteria.



## 2 Methodology and Results

The data and analysis presented in this report are based on the combined information collected from Regional Sea Conventions (RSC) and MS-nominated eutrophication experts in relation to the methodologies used to assess eutrophication.

### 2.1 Regional Sea Conventions

At regional level, the information related to the methodological standards and threshold setting was extracted from the Regional Sea Conventions' (RSC) progress reports. The following reports were consulted:

- **OSPAR**: third integrated report on the eutrophication status of the OSPAR maritime area (2017);
- **HELCOM**: State of the Baltic Sea report: the integrated assessment of eutrophication (2018);
- **UNEP-MAP**: United Nations Environmental Programme Mediterranean Action Plan (2018);
- **Black Sea Commission**: Black Sea integrated monitoring and assessment programme (2017-2022).

A table was prepared with the compiled information from RSC reports and sent to the RSC secretariat or nominated eutrophication representatives for validation. Table 1 reports the compiled information.

**Table 1.** Methodological standards used for the assessment of Eutrophication criteria and criteria elements at regional level

Criteria	Element	OSPAR	HELCOM	UNEP MAP	Black Sea
Nutrients in the water column (D5C1)	Dissolved inorganic nitrogen (DIN)	<b>Coastal waters and Open sea:</b> Winter nutrient concentrations. Some contracting parties (CPs) use salinity-normalized assessment levels to ensure a coherent approach	<b>Coastal waters:</b> according to national WFD implementation  <b>Open sea:</b> Average DIN concentration in the surface (0–10m) during winter	<b>Coastal waters and Open sea:</b> No general assessment criteria agreed. Some countries presented geographical variability of some key nutrients (DIN and TP). For the data presentation Box and Whiskerplots are used	<b>Coastal waters and Open sea:</b> assessment criteria partly agreed at regional level. NO <sub>3</sub> , NO <sub>2</sub> , NH <sub>4</sub> monitoring mandatory. Maximum concentrations in surface layer during end of winter-spring
	Dissolved inorganic phosphorus (DIP)	<b>Coastal waters and Open sea:</b> Winter nutrient concentrations. Some CPs use salinity-normalized assessment levels to ensure a coherent approach	<b>Coastal waters:</b> according to national WFD implementation  <b>Open sea:</b> Average DIP concentration in the surface (0–10m) during winter	<b>Coastal waters and Open sea:</b> No general assessment criteria agreed. Some countries presented geographical variability of some key nutrients (DIN and TP). For the data presentation Box and Whiskerplots are used	<b>Coastal waters and Open sea:</b> assessment criteria partly agreed at regional level. PO <sub>4</sub> monitoring mandatory. Maximum concentrations in surface layer during end of winter-spring
	Total nitrogen (TN)	<b>Coastal waters and Open sea:</b> only some CPs consider useful, but not included as obligatory parameters in the Eutrophication Monitoring Programme.	<b>Coastal waters:</b> annual averages or seasonal averages (mean summer concentration or mean winter concentrations) depending on CPs (according to national WFD implementation)  <b>Open sea:</b> average (2011-2016) of total nitrogen concentration in the upper (0-10m) water layers throughout the year	<b>Coastal waters and Open sea:</b> No general assessment criteria agreed. Some countries presented geographical variability of some key nutrients (DIN and TP). For the data presentation Box and Whiskerplots are used	<b>Coastal waters and Open sea:</b> assessment criteria partly agreed at regional level. TN monitoring mandatory. Maximum concentrations in surface layer during end of winter-spring
	Total phosphorus (TP)	<b>Coastal waters and Open sea:</b> only some CPs considered useful, but not included as obligatory parameters in the Eutrophication Monitoring Programme.	<b>Coastal waters:</b> annual averages or seasonal averages (mean summer concentration or mean winter concentrations) depending on CPs (according to national WFD implementation)  <b>Open sea:</b> average (2011-2016) of total phosphorus concentration in the upper (0-10m) water layers throughout the year	<b>Coastal waters and Open sea:</b> No general assessment criteria agreed. Some countries presented geographical variability of some key nutrients (DIN and TP). For the data presentation Box and Whiskerplots are used	<b>Coastal waters and Open sea:</b> assessment criteria partly agreed at regional level. TP monitoring mandatory. Maximum concentrations in surface layer during end of winter-spring

Criteria	Element	OSPAR	HELCOM	UNEP MAP	Black Sea
Chlorophyll a in the water column (D5C2)	Chlorophyll-a concentration	<p><b>Coastal waters and Open sea:</b> Assessment during growing season using a mix of maximum, mean and 90<sup>th</sup> percentile values as considered appropriate by each CP. Observations from satellite data or Smart Buoy data in addition to <i>in situ</i> measurements depending on CPs</p>	<p><b>Coastal waters:</b> WFD indicator results on phytoplankton (mostly chlorophyll-a and biovolume)</p> <p><b>Open sea:</b> Chlorophyll-a: Average chlorophyll-a concentration in the surface (0 – 10 m) during summer</p>	<p><b>Coastal waters and Open sea:</b> Monitoring data collected by MEDPOL monitoring program with data from Mediterranean countries. Coastal Water types reference conditions and boundaries for chlorophyll-a in the Mediterranean were agreed and adopted. For the data presentation Box and Whiskerplots are used</p>	<p><b>Coastal waters and Open sea:</b> Monitoring mandatory 4 times a year. No assessment method defined</p>
Harmful algal blooms (e.g. cyanobacteria) in the water column (D5C3)	Indicator species	<p><b>Coastal waters and Open sea:</b> assessment levels for area-specific phytoplankton indicators (nuisance to toxic species), percentage of samples with at least one bloom defined by category and taxon size depending on CPs</p>	<p><b>Open sea:</b> Cyanobacterial Bloom Index based on 2 parameters: cyanobacteria surface accumulations and cyanobacteria biomass. Measured between 20Jun and 31Aug.</p> <p>Units of measurement : bloom events as number of events, duration in days and spatial extent in km<sup>2</sup> per year, cyanobacteria biomass in water samples</p>		<p><b>Coastal waters and Open sea:</b> assessment criteria partly agreed at regional level. <i>Noctiluca scintillans</i> and unspecified phytoplankton measured 4 times a year. Phytoplankton biomass and abundance, maximum concentration of blooming species, diatoms/dinoflagellates biomass ratio (only for spring), gelatinous macrozooplankton biomass and abundance</p>

Criteria	Element	OSPAR	HELCOM	UNEP MAP	Black Sea
Photic limit (transparency) of the water column (D5C4)	Transparency of the water column	<b>Coastal waters and Open sea:</b> used by 3 CPs. Can be included in COMP as part of the holistic assessment as light availability	<b>Coastal waters:</b> WFD indicators on water clarity or turbidity <b>Open sea:</b> Water clarity: average Secchi depth during summer measured as the depth in meters	<b>Coastal waters and Open sea:</b> recommended for a complete assessment of eutrophication and GES achievement. GES thresholds and reference conditions need to be established as minimum requirements on a regional/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	<b>Coastal waters and Open sea:</b> Secchi depth measured 4 times a year
Dissolved oxygen in the bottom of the water column (D5C5)	Oxygen concentration	<b>Coastal waters and Open sea:</b> used by 10 CPs according to COMP agreement, though only 7 of 9 did this in practice. The metric varies: generally based on 5 <sup>th</sup> or 10 <sup>th</sup> percentiles. 1 CP uses mean of lowest 25% of data. 1 CP uses minimum concentration and saturation. Also an OSPAR Common Indicator available	<b>Coastal waters:</b> WFD indicators on oxygen concentration or hypoxia <b>Open sea:</b> average oxygen debt below the halocline; Threshold values defined from the 95 <sup>th</sup> percentiles during the pre-eutrophied period, detected through change-point analysis for all assessment units. Under development shallow-water oxygen concentration	<b>Coastal waters and Open sea:</b> Recommended for a complete assessment of eutrophication and GES achievement. GES thresholds and reference conditions (background concentrations) are needed to be set for nutrients, transparency and oxygen as minimum requirements on a regional/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	<b>Coastal waters</b> (up to 50m depth): Oxygen saturation and dissolved on bottom layer during late summer <b>Open sea:</b> sigma-T equals to 15.4-15.5 during late summer

Criteria	Element	OSPAR	HELCOM	UNEP MAP	Black Sea
Opportunistic macroalgae of benthic habitats (D5C6)	Opportunistic macroalgae	<b>Coastal waters:</b> most CPs have relied on the assessment of the biological quality element macrophytes as used for the second WFD cycle	<b>Coastal waters:</b> WFD indicators on macrophytes.		<b>Coastal waters:</b> Macrophytobenthos monitored once per year Monitoring method: EEIc
Macrophyte communities of benthic habitats (D5C7)	Macrophyte communities	<b>Coastal waters:</b> most CPs have relied on the assessment of the biological quality element macrophytes as used for the second WFD cycle. Some limited use further offshore	<b>Coastal waters:</b> WFD indicators on macrophytes		
Macrofaunal communities of benthic habitats (D5C8)	Macrofaunal communities	<b>Coastal waters:</b> Changes in zoobenthos communities assessed by applying different indices developed in relation to WFD in inshore and coastal waters (though applied beyond coastal waters). 1 CP assessed biomass of benthic organisms in water > 1 nautical mile	<b>Coastal waters:</b> WFD indicators on macrozoobenthos  <b>Open sea:</b> State of the soft-bottom macrofauna community. Measured between May and June. Relative proportion of sensitive and tolerant species, as well as species richness and abundance		<b>Coastal waters:</b> Assessment criteria not agreed at regional level.  Assessment criteria agreed only between Romania and Bulgaria for sand bottom communities according to WFD.  Macrozoobenthos monitored once a year. Monitoring method: M-AMBI

## 2.2 National methods

To survey national methods, a request was sent to the WG GES for nomination of experts to support the work on Eutrophication by JRC. 31 experts were nominated from 20 MS and 2 RSC. Initially, a list of methodologies followed by MS in relation to D5C3 - Harmful algal blooms (e.g. cyanobacteria) in the water column, was compiled based on the contribution of 17 MS. The list was transmitted to EEA for incorporation in the web-forms for the 2018 MSFD reporting.

Following this work, a short survey was prepared (Annex I) and distributed to the MS D5 designated experts, aiming to collect structured and comparable information in relation to D5 criteria methodological standards and thresholds setting in coastal and open sea areas. 15 MS answered this survey. The information was extracted from the survey and, where necessary, experts were contacted for clarifications.

The information collected was compiled in tables summarizing the methods used per MS (or region within MS in case different methodologies were used for different coastal areas) and sent to the MS D5 nominated experts for final validation. Countries that did not contribute to the survey were still invited to participate at a later stage and the information received was integrated for 3 additional MS.

All the information compiled for coastal and open sea waters is synthesized in the following tables. Countries (or regions within a country) were grouped by RSC to better visualize the degree of harmonization within RSCs.

**Tables 2 to 12:** methodological standards (monitoring method, assessment period, assessment season and assessment depth) and threshold values assessment (existence of assessment methods and method followed) for the 8 MSFD Eutrophication criteria in open sea<sup>1</sup>.

General remarks:

Malta: most of the monitoring programmes target inshore and nearshore waters thus no open sea assessments are conducted.

**Tables 13 to 23:** Methodological standards (monitoring method, assessment period, assessment season and assessment depth) and threshold values assessment (existence of assessment methods and method followed) for the 8 MSFD Eutrophication criteria in coastal waters.

General remarks: For Sweden in Baltic coastal waters, the results of the latest WFD assessment (for each indicator) were used directly and aggregated according to HEAT.

**Table 2. Dissolved Inorganic Nitrogen (open sea)**

C1: Nutrients in the water column: <b>Dissolved Inorganic Nitrogen (DIN)</b>							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic Sea)	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Estonia	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Finland	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Germany (Baltic Sea)	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Latvia	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Poland	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Sweden (Baltic Sea)	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Belgium	Yes	B	2011-2016	Winter	surface	Yes	OSPAR
Denmark (North Sea, Skagerrak)	Yes	A	1990-2014	Winter	surface	No	OSPAR
France (Atlantic)	Yes	C	2012-2016	Winter	surface	Yes	National methods derived from WFD principle
Germany (North Sea)	Yes	A	2006-2014	Winter	surface	Yes	OSPAR
Ireland	Yes	A	2011-2016	Winter and Summer	Water column	Yes	OSPAR
Netherlands	Yes	A	2006-2014	Winter	surface	Yes	OSPAR
Spain (Atlantic)	Yes	A*	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	OSPAR, UNEP-MAP, WFD
Sweden (North Sea)	Yes	A	2006-2014	Winter	surface	Yes	National threshold values
Croatia	Yes	A	2011-2016	annual	surface	No	
France (Mediterranean)	Yes	C	2010-2014	annual	surface	Yes	National methods derived from WFD principle
Greece	Yes	D	2012-2018	annual	Water column	Yes	National
Italy	Yes	A	2015-2017	Winter, Spring, Summer, Autumn	surface	No	
Malta	No						
Spain (Mediterranean)	Yes	A*	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	OSPAR, UNEP-MAP, WFD
Bulgaria	Yes	D	2012-2017	Spring-Summer	Surface homogeneous layer or down the DCM	Yes	National
Romania	Yes	D**	2012-2017	annual	surface	Yes	OSPAR, HELCOM and expert judgement

**A:** Seasonal average DIN concentration in the surface; **B:** Average winter DIN concentration normalized to salinity 33.5 and modelled average winter concentration for spatial distribution; **C:** Median of seasonal nitrate concentration in the surface (with modeling data products); **D:** Annual average DIN concentration in the water column.

DCM: Deep Chlorophyll- a maximum.

\*90<sup>th</sup> does not exceed the threshold value

\*\*75<sup>th</sup> percentile does not exceed the threshold value

**Table 3. Dissolved Inorganic Phosphorus (open sea)**

C1: Nutrients in the water column: <b>Dissolved Inorganic Phosphorus (DIP)</b>							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Estonia	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Finland	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Germany (Baltic sea)	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Latvia	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Poland	Yes	A	2011-2016	Winter	surface	Yes	HELCOM
Sweden (Baltic sea)	Yes	A	2006-2014	Winter	surface	Yes	HELCOM
Belgium	Yes	B	2011-2016	Winter	surface	Yes	OSPAR
Denmark (North sea, Skagerrak)	Yes	A	1990-2014	Winter	surface	No	OSPAR
France (Atlantic)	Yes	C	2012-2016	Winter	surface	Yes	National methods based on modeling Pristine data
Germany (North sea)	Yes	A	2006-2014	Winter	surface	Yes	OSPAR
Ireland	Yes	A	2011-2016	Winter, Summer	Water column	Yes	OSPAR
Netherlands	Yes	A	2006-2014	Winter	surface	Yes	OSPAR
Spain (Atlantic)	Yes	A*	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	National thresholds
Sweden (North sea)	Yes	A	2011-2016	Winter	surface	Yes	National threshold values
Croatia	Yes	A	2011-2016	annual	surface	No	
France (Mediterranean)	Yes	C	2010-2014	annual	surface	Yes	National methods based on modeling Pristine data
Greece	Yes	D	2012-2018	annual	Water column	Yes	National
Italy	Yes	A	2015-2017	Winter, Spring, Summer, Autumn	surface	No	
Malta	No						
Spain (Mediterranean)	Yes	A*	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	National thresholds
Bulgaria	Yes	D	2012-2017	Spring-Summer	Surface homogeneous layer or down the DCM	Yes	National
Romania	Yes	D**	2012-2017	annual	surface	Yes	OSPAR, HELCOM and expert judgement

A: Seasonal average DIP concentration in the surface; B: Average winter DIP concentration normalized to salinity 33.5 and modelled average winter concentration for spatial distribution; C: Median of seasonal nitrate concentration in the surface (with modeling data products); D: Annual average DIP concentration in the water column (75<sup>th</sup> percentile does not exceed the threshold value).

DCM: Deep Chlorophyll-a maximum.

\*90th does not exceed the threshold value

\*\*75th percentile does not exceed the threshold value



**Table 4. Total Nitrogen (open sea)**

C1: Nutrients in the water column: <b>Total Nitrogen (TN)</b>							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)	Yes	A	2011-2016	annual	surface	Yes	HELCOM
Estonia	Yes	A	2011-2016	annual	surface	Yes	HELCOM
Finland	Yes	A	2011-2016	annual	surface	Yes	HELCOM
Germany (Baltic sea)	Yes	A	2011-2016	annual	surface	Yes	National methods
Latvia	Yes	A	2011-2016			Yes	HELCOM
Poland	Yes	A	2011-2016	annual	surface	Yes	HELCOM and National (for Bornholm basin)
Sweden (Baltic sea)	Yes	A	2011-2016	annual	surface	Yes	HELCOM
Belgium						No	
Denmark (North sea, Skagerrak)						No	
France (Atlantic)						No	
Germany (North sea)	Yes	A	2006-2014	annual	surface	Yes	National methods
Netherlands						No	
Spain (Atlantic)						No	
Sweden (North sea)						No	
Croatia						No	
France (Mediterranean)						No	
Greece	Yes	B	2012-2018	annual	Water column		No
Ireland						No	
Italy						No	
Malta						No	
Spain (Mediterranean)						Not	
Bulgaria	Yes	C	2012-2017	Spring-Summer	Surface homogeneous layer or down the DCM		No
Romania	Yes	D		annual			No

**A:** Annual average of total nitrogen concentration in the upper water layers; **B:** Annual average of total nitrogen concentration in the water column; **C:** Spring-summer average for the surface homogeneous layer; **D:** Seasonal average TN concentration in the water column. DCM: Deep Chlorophyll-a maximum.

**Table 5. Total Phosphorus (open sea)**

C1: Nutrients in the water column: <b>Total Phosphorus (TP)</b>							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)	Yes	A	2011-2016	annual	surface	Yes	HELCOM
Estonia	Yes	A	2011-2016	annual		Yes	HELCOM
Finland	Yes	A	2011-2016	annual		Yes	HELCOM
Germany (Baltic sea)	Yes	A	2011-2016	annual	surface	Yes	National threshold values
Latvia	Yes	A	2011-2016			Yes	HELCOM
Poland	Yes	A	2011-2016	annual		Yes	HELCOM and National (for Bornholm Basin and Eastern Gotland Basin)
Sweden (Baltic sea)	Yes	A	2011-2016	annual	surface	Yes	HELCOM
Belgium						No	
Denmark (North sea, Skagerrak)						No	
France (Atlantic)						No	
Germany (North sea)	Yes	A	2006-2014	annual	surface	Yes	National threshold values
Ireland						No	
Spain (Atlantic)						No	
Sweden (North sea)						No	
Croatia	Yes	A	2011-2016	annual	surface		No
France (Mediterranean)						No	
Netherlands						No	
Greece	Yes	B	2012-2018	annual	Water column		No
Italy	Yes	A	2015-2017	Winter, Spring, Summer, Autumn	surface		No
Malta						No	
Spain (Mediterranean)						No	
Bulgaria	Yes	C	2012-2017	Spring-Summer	Surface homogeneous layer or down the DCM		No
Romania	Yes	D		annual			No

**A:** Annual average of total phosphorus concentration in the upper water layers; **B:** Annual average of total phosphorus concentration in the water column; **C:** Spring-summer average for the surface homogeneous layer; **D:** Seasonal average TP concentration in the water column.

DCM: Deep Chlorophyll-a maximum.

**Table 6.** Chlorophyll a (open sea)

C2: Chlorophyll a							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)	Yes	A	2011-2016	Summer	surface	Yes	HELCOM
Estonia	Yes	A	2011-2016	Summer	1-10m	Yes	HELCOM
Finland	Yes	A	2011-2016	Summer	surface	Yes	HELCOM
Germany (Baltic sea)	Yes	A	2011-2016	Summer	surface	Yes	HELCOM
Latvia	Yes	A	2011-2016	Summer		Yes	HELCOM
Poland	Yes	B	2011-2016	Summer	surface	Yes	HELCOM
Sweden (Baltic sea)	Yes	A	2011-2016	Summer	0-10m	Yes	HELCOM
Belgium	Yes	C	2011-2016	Spring-Autumn		Yes	OSPAR
Denmark (North sea, Skagerrak)	Yes	B	1990-2014	Spring-Summer	Surface	No	
France (Atlantic)	Yes	D	2010-2016	Spring-Summer	Surface	Yes	National methods derived from WFD principle
Germany (North sea)	Yes	A	2006-2014	Summer	surface	Yes	OSPAR
Ireland	No						
Netherlands	Yes	E	2006-2014	Spring-Summer	surface	Yes	OSPAR
Spain (Atlantic)	Yes	F	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	WFD
Sweden (North sea)	Yes	A	2006-2014	Summer	0-10m	Yes	National threshold values
Croatia	Yes	G	2011-2016	annual		Yes	UNEP-MAP
France (Mediterranean Sea)	Yes	D	2010-2016	annual	surface	Yes	National methods derived from WFD principle
Greece	Yes	H	2012-2018	annual	euphotic zone	No	
Italy	Yes	G	2015-2017	annual	surface	No	
Malta	No						
Spain (Mediterranean)	Yes	F	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	WFD
Bulgaria	Yes	B	2012-2017	Spring-Summer	Surface homogeneous layer or down the DCM	Yes	Statistical methods
Romania	Yes	A*	2012-2017	Spring-Summer	0-10m	Yes	OSPAR, HELCOM and expert judgement

A: Chlorophyll a assessment during growing season: mean values and satellite data; B: Chlorophyll a assessment during growing season: 90<sup>th</sup> percentile, mean values and satellite data; C: 6 years average of 90<sup>th</sup> percentile of Chlorophyll a based on satellite data (validated by *in-situ* data); D: 90<sup>th</sup> percentile of 7 years of Chlorophyll a (seasonal) based on satellite data (validated by *in-situ* data); E: Chlorophyll a assessment during growing season: 90<sup>th</sup> percentile; F: Chlorophyll a assessment during whole year: 90<sup>th</sup> percentile; G: Average Chlorophyll a concentration in the surface; H: Mean integrated average on euphotic zone and 90<sup>th</sup> percentile.

DCM: Deep Chlorophyll-a maximum.

\*75<sup>th</sup> percentile does not exceed the threshold value

**Table 7. Harmful algal blooms (open sea)**

C3: Harmful algal blooms in the water column							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	Yes	A				Yes	HELCOM
Finland	Yes	A				Yes	HELCOM
Germany (Baltic sea)	Yes	A	2011-2016	Summer	Surface	Yes	HELCOM
Latvia	Yes	A				Yes	HELCOM
Poland	Yes	B				Yes	HELCOM
Sweden (Baltic sea)	Yes	A				Yes	HELCOM
Belgium	No						
Denmark (North sea, Skagerrak)	No						
France (Atlantic)	No						
Germany (North sea)	Yes	C	2006-2014	Annual		Yes	OSPAR
Ireland	No						
Netherlands	No						
Spain (Atlantic)	No						
Sweden (North sea)	Yes	D				Yes	OSPAR
Croatia	Yes	C				Yes	
France (Mediterranean)	No						
Greece	No						
Italy	No						
Malta	No						
Spain (Mediterranean)	No						
Bulgaria	Yes	E	2012-2017	Spring-Summer	Surface homogeneous layer or down the DCM	Yes	Not for all indicators
Romania	Yes	F	2012-2017	cold and warm season	0-10m	Yes	OSPAR, HELCOM and expert judgement

A: Cyanobacterial bloom index based on remote sensing and water sample cyanobacteria biomass measurements; B: Cyanobacteria surface accumulations combining information of volume, length of bloom period and severity of surface accumulations estimated from remote sensing observations and cyanobacterial bloom index; C: Area specific phytoplankton indicator species (cell counts); D: Phytoplankton indicator species; E: Area specific phytoplankton indicator species (cell counts), percentage of samples with at least one bloom defined by category and taxon size, phytoplankton tool combining indices for chlorophyll a (90<sup>th</sup> percentile), elevated counts and seasonal succession, phytoplankton biomass, phytoplankton abundance, maximum concentration of blooming species, diatoms/dinoflagellates biomass ratio, biovolume data measured by analyzing phytoplankton cells, molecular taxonomy of potentially toxic species and remote sensing (chlorophyll a); F: Phytoplankton indicator species biomass (median of biomass-*Noctiluca scintillans* (zooplankton)).  
DCM: Deep Chlorophyll-a maximum.

**Table 8. Photic limit (open sea)**

C4: Photic limit of the water column							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)	Yes	A	2011-2016	Summer		Yes	HELCOM
Estonia	Yes	A	2011-2016	Summer		Yes	HELCOM
Finland	Yes	A	2011-2016	Summer		Yes	HELCOM
Germany (Baltic sea)	Yes	A	2011-2016	Summer		Yes	HELCOM
Latvia	Yes	A	2011-2016	Summer		Yes	National
Poland	Yes	A	2011-2016	Summer		Yes	HELCOM and WFD for CW and TW
Sweden (Baltic sea)	Yes	A	2011-2016	Summer		Yes	HELCOM
Belgium	No*						
Denmark (North sea, Skagerrak)	No						
France (Atlantic)	Yes	B	2010-2016	Spring-Summer	surface	Yes	National methods
Germany (North sea)	Yes	A	2006-2014	Summer		Yes	National threshold values
Ireland	No						
Netherlands	No						
Spain (Atlantic)	Yes	A	2011-2016	Winter, Spring, Summer, Autumn		No	
Sweden (North sea)	Yes	A	2006-2014	Summer		Yes	National threshold values
Croatia	Yes	A	2011-2016	annual		Yes	UNEP-MAP
France (Mediterranean)	Yes	B	2010-2016	Spring-Summer	surface	Yes	National methods
Greece	Yes	C	2012-2018	annual	1% of light penetration	No	
Italy	No						
Malta	No						
Spain (Mediterranean)	Yes	A	2011-2016	Winter, Spring, Summer, Autumn		No	
Bulgaria	Yes	A	2012-2017	Spring-Summer	Surface	Yes	National method
Romania	Yes	A**	2012-2017	Summer	equal or more than 30m	Yes	HELCOM and expert judgement

A: Water clarity: average secchi depth; B: 90<sup>th</sup> percentile of turbidity measured as NTU during the growing season from satellite data (validated with *in situ* data); C: Water clarity: average secchi depth and transmissometer.

\*Criteria not relevant for the evaluation of eutrophication in Belgian waters due to high concentration of suspended matter.

\*\*Percentile 10 does not decrease below the threshold value or percentile 90 is higher than threshold value

**Table 9. Dissolved oxygen (open sea)**

C5: Dissolved oxygen in the bottom of the water column							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)	Yes	A	2011-2016	annual average	bottom layer	Yes	HELCOM
Estonia	Yes	A	2011-2016	annual average	bottom layer	Yes	HELCOM (only deep areas)
Finland	Yes	A	2011-2016	annual average	bottom layer	Yes	HELCOM
Germany (Baltic sea)	Yes	B	2011-2016	Summer-Autumn	bottom layer	Yes	HELCOM and national method
Latvia	Yes	A				Yes	HELCOM
Poland	Yes	A	2011-2016			Yes	HELCOM
Sweden (Baltic sea)	Yes	A	2011-2016	Annual average	bottom layer	Yes	HELCOM
Belgium	No*						
Denmark (North sea, Skagerrak)	Yes	C	1990-2014	stratified season (Autumn)	bottom layer	No	
France (Atlantic)	Yes	D	2012-2016	Summer	Within 0-10m from the bottom	Yes	WFD
Germany (North sea)	Yes	E	2006-2014	Summer-Autumn	bottom layer	Yes	OSPAR
Ireland	No						
Netherlands	Yes	F	2006-2014	whole year	bottom +3m; surface - 1m	Yes	OSPAR
Spain (Atlantic)	Yes	G	2011-2016	Winter, Spring, Summer, Autumn	bottom layer	Yes	OSPAR
Sweden (North sea)	Yes	H	2006-2014	Autumn	within 1m from the bottom	Yes	OSPAR
Croatia	Yes	I	2011-2016	annual	bottom layer	No	
France (Mediterranean)	Yes	J	2010-2014	Summer	surface	Yes	WFD
Greece	Yes	A	2012-2018	Spring, Autumn, and annual	water column	Yes	Hypoxia/anoxia levels defined by scientific literature
Italy	No						
Malta	No						
Spain (Mediterranean)	Yes	G	2011-2016	Winter, Spring, Summer, Autumn	bottom layer	Yes	OSPAR
Bulgaria	Yes	I	2012-2017	Spring-Summer	max 50m bottom/at the halocline	No	
Romania	Yes	C	2012-2017	Spring-Summer	30-50m	Yes	Literature and national legislation for WFD

**A:** Average oxygen debt below the halocline; **B:** Mean shallow water oxygen concentrations: median values of the annual station minima; **C:** Bottom oxygen percentile 10<sup>th</sup>; **D:** 10<sup>th</sup> percentile of spring bottom water oxygen concentration based on modeling data (validated with *in situ* data); **E:** Minimum oxygen concentration; **F:** Degree of oxygen deficiency; **G:** 10<sup>th</sup> percentile of bottom water oxygen concentration during whole year; **H:** Annual mean autumn bottom oxygen concentration from the lower quartile; **I:** Minimum level in the water bottom; **J:** 10<sup>th</sup> percentile of spring surface water oxygen concentration based on modeling data (validated with *in situ* data).

Malta: most of the monitoring programme targets inshore and nearshore waters thus no open sea assessments are conducted.

\*Criteria not relevant for the evaluation of eutrophication in Belgian waters due to strong currents.

**Table 10.** Opportunistic macroalgae (open sea)

C6: Opportunistic macroalgae of benthic habitats						
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic Sea)			No			
Estonia			No			
Finland			No			
Germany (Baltic sea)			No			
Latvia			No			
Poland			No			
Sweden (Baltic sea)			No			
Belgium			No			
Denmark (North sea, Skagerrak)			No			
France (Atlantic)			No			
Germany (North sea)			No			
Ireland			No			
Netherlands			No			
Spain (Atlantic)			No			
Sweden (North sea)			No			
Croatia			No			
France (Mediterranean)			No			
Greece			No			
Italy			No			
Malta			No			
Spain (Mediterranean)			No			
Bulgaria	Yes	A	2012-2017	Summer	<20m	Yes
Romania						No

A: WFD indicators on macrophytes.

**Table 11.** Macrophyte communities (open sea)

C7: Macrophyte communities of benthic habitats						
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)			No			
Estonia			No			
Finland			No			
Germany (Baltic sea)			No			
Latvia			No			
Poland			No			
Sweden (Baltic sea)			No			
Belgium			No			
Denmark (North sea, Skagerrak)			No			
France (Atlantic)			No			
Germany (North sea)			No			
Ireland			No			
Netherlands			No			
Sweden (North sea)			No			
Spain (Atlantic)			No			
Croatia			No			
France (Mediterranean)			No			
Greece			No			
Italy			No			
Malta			No			
Spain (Mediterranean)			No			
Bulgaria	Yes	A	2012-2017	Summer	<20m	Yes
Romania			No			

A: WFD indicators on macrophytes.



**Table 12.** Macrofaunal communities (open sea)

C8: Macrofaunal communities of benthic habitats							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	Yes	A	2011-2016	Summer	bottom	Yes	HELCOM
Finland	Yes	A	2011-2016	Summer	bottom	Yes	HELCOM
Germany (Baltic sea)	No*						
Latvia	Yes	A	2011-2016			Yes	HELCOM
Poland	Yes	B	2011-2016	annual	bottom	Yes	WFD and National
Sweden (Baltic sea)	No						
Belgium	No						
Denmark (North sea, Skagerrak)	No						
France (Atlantic)	No						
Germany (North sea)	Yes	C	2006-2014			Yes	OSPAR
Ireland	No						
Netherlands	No						
Spain (Atlantic)	No						
Sweden (North sea)	No						
Croatia	No						
France (Mediterranean)	No						
Greece	Yes	D	2012-2018	annual or bi-annual		Yes	MEDGIG for WFD
Italy	No						
Malta	No						
Spain (Mediterranean)	No						
Bulgaria	Yes	E	2012-2017	Summer		Yes	Statistical methods (for selected habitats only down to depth 90m-shelf)
Romania	Yes	F	2012-2017	annual		Yes	Literature

**A:** Relative proportion of sensitive and tolerant species; **B:** Relative proportion of sensitive and tolerant species and species richness and abundance; **C:** Changes in diversity and relation between sensitive and non sensitive species (multimetric index-M-AMBI); **D:** Biomass of benthic organisms; **E:** Relative proportion of sensitive and tolerant species and BENTIX index; **F:** Relative proportion of sensitive and tolerant species, species richness and abundance and biomass of benthic organisms.

\* Germany is assessing macrofaunal communities but is not using this parameter for assessment under MSFD

**Table 13.** Dissolved Inorganic Nitrogen (coastal waters)

C1: Nutrients in the water column: <b>Dissolved Inorganic Nitrogen (DIN)</b>							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	No						
Finland	No						
Germany (Baltic sea)	No*						
Latvia	Yes	A	2011-2016	Winter		Yes	HELCOM
Poland	Yes	B	2011-2016	Winter (lagoons annual)	Water column	Yes	National methods used under WFD
Sweden (Baltic sea)	Yes	A**	2011-2016	Winter	surface	Yes	HELCOM and OSPAR and coastal water thresholds harmonized with WFD values
Belgium	Yes	C	2011-2016	Winter		Yes	OSPAR***
Denmark (North sea)	No						
France (Atlantic)	Yes	D	2010-2015	Winter	Surface	Yes	National methods used under WFD and OSPAR
Germany (North sea)	Yes	A	2006-2014	Winter	surface	Yes	HELCOM
Ireland	Yes	A	2011-2016	Winter and Summer	Water column	Yes	OSPAR
Netherlands	Yes	A	2006-2014	Winter	surface	Yes	OSPAR
Spain (Atlantic)	Yes	A****	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	OSPAR, UNEP-MAP, WFD
Sweden (North sea)	Yes	A	2006-2014	Winter	surface	Yes	HELCOM and OSPAR and coastal water thresholds harmonized with WFD values
Croatia	Yes	A	2011-2016	annual	surface	No	
France (Mediterranean)	Yes	D	2010-2015	Winter	Surface	Yes	National methods used under WFD and OSPAR
Greece	Yes	E	2012-2018	annual	Water column	Yes	National
Italy	Yes	A	2012-2016	annual	surface	No	
Malta	Yes	A	2017-2019	Winter, Spring, Summer, Autumn	surface	No*****	
Spain (Mediterranean)	Yes	A****	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	OSPAR, UNEP-MAP, WFD
Bulgaria	Yes	B	2012-2017	Spring-Summer	Water column	Yes	Statistical methods on available historical and recent data
Romania	Yes	E	2012-2017	annual	surface	No*****	

A: Winter average DIN concentration in the surface; B: Spring-summer assessment; C: Average winter DIN concentration normalized to salinity 33.5 and modelled average winter concentration for spatial distribution; D: Winter DIN concentration normalized to salinity 33.5; E: Seasonal average DIN concentration in the water column.

\* Germany is measuring DIN but is not using this parameter for assessment under WFD and MSFD; \*\*Sweden uses salinity correction in coastal waters, though IIRC up to salinity 27 in Skagerrak, 20 in Kattegat and not 33. Coastal levels harmonized with WFD.

\*\*\*Threshold value updated that will also be used in the framework of the next WFD evaluation; \*\*\*\*90<sup>th</sup> does not exceed the threshold value; \*\*\*\*\* Malta is set to establish thresholds following further data gathering; \*\*\*\*\* OSPAR, HELCOM and expert judgement threshold reference value were revised in 2017 but are not mandatory yet. Threshold available for NO<sub>2</sub>, NO<sub>3</sub>, NH<sub>4</sub> but not sum (DIN).

**Table 14.** Dissolved Inorganic Phosphorus (coastal waters)

C1: Nutrients in the water column: <b>Dissolved Inorganic Phosphorus (DIP)</b>							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	No						
Finland	No						
Germany (Baltic sea)	No*						
Latvia	Yes	A	2011-2016	Winter		Yes	HELCOM
Poland	Yes	B	2011-2016	Winter	Water column	Yes	National methods used under WFD
Sweden (Baltic sea)**	Yes	A	2011-2016	Winter	surface	Yes	HELCOM and OSPAR and coastal water thresholds harmonized with WFD values
Belgium	Yes	C	2011-2016	Winter		Yes	OSPAR, WFD
Denmark (North sea)	No						
France (Atlantic)	No						
Germany (North sea)	Yes	A	2006-2014	Winter	surface	Yes	OSPAR
Ireland	Yes	A	2011-2016	Winter, Summer	Water column	Yes	OSPAR
Netherlands	Yes	A	2006-2014	Winter	surface	No	
Spain (Atlantic)	Yes	A***	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	National thresholds
Sweden (North sea)	Yes	A	2006-2014	Winter	surface	Yes	HELCOM and OSPAR and coastal water thresholds harmonized with WFD values
Croatia	Yes	A	2011-2016	annual	surface	No	
France (Mediterranean)	No						
Greece	Yes	B	2012-2018	annual	Water column	Yes	National
Italy	Yes	A	2012-2016	annual	surface	No	
Malta	Yes	A	2017-2019	Winter, Spring, Summer, Autumn	surface	No****	
Spain (Mediterranean)	Yes	A***	2011-2016	Winter, Spring, Summer, Autumn	0-20m	Yes	National thresholds
Bulgaria	Yes	D	2012-2017	Spring-Summer	Water column	Yes	Statistical methods on available historical and recent data
Romania	Yes	B	2012-2017	annual	surface	No *****	

**A:** Winter average DIP concentration in the surface; **B:** Seasonal average DIP concentration in the water column; **C:** Average winter DIP concentration normalized to salinity 33.5 and modelled average winter concentration for spatial distribution; **D:** Spring-summer assessment.

\*Germany is measuring DIN but is not using this parameter for assessment for the WFD and MSFD; \*\*Sweden uses salinity correction in coastal waters, though IIRC up to salinity 27 in Skagerrak, 20 in Kattegat and not 33. Coastal levels harmonized with WFD; \*\*\*90<sup>th</sup> does not exceed the threshold value;

\*\*\*\* Malta is set to establish thresholds following further data gathering; \*\*\*\*\*Threshold values available for TP not DIP.

**Table 15. Total Nitrogen (coastal waters)**

C1: Nutrients in the water column: <b>Total Nitrogen (TN)</b>							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	Yes	A	2011-2016	Summer	surface	Yes	National
Finland	Yes	A	2011-2016	Summer	surface	Yes	national WFD values, also used in HELCOM
Germany (Baltic sea)	Yes	B	2007-2012	Winter	surface	Yes	National WFD values
Latvia	Yes	B	2011-2016			Yes	HELCOM
Poland	Yes	C	2011-2016	Summer (lagoons annual)	Water column	Yes	National methods used under WFD
Sweden (Baltic sea)	Yes	A	2011-2016	Winter, Summer	surface	Yes	WFD values
Belgium	No						
Denmark (North sea)	No						
Germany (North sea)	Yes	B	2006-2014	Annual	surface	Yes	WFD values
France (Atlantic)	No						
Ireland	No						
Netherlands	No						
Spain (Atlantic)	Yes	A	2011-2016		Water column		No
Sweden (North sea)	Yes	A	2006-2014	Winter, Summer	surface	Yes	National methods used under WFD**
Croatia	No						
France (Mediterranean)	No						
Greece	Yes	D	2012-2018	annual	Water column		No
Italy	No						
Malta	Yes	B	2017-2019	Winter, Spring, Summer, Autumn	surface		No
Spain (Mediterranean)	Yes	A	2011-2016		Water column		No
Bulgaria	Yes	A	2012-2017	Spring-Summer	Water column		No
Romania	Yes	D		annual	Water column		No*

A: Seasonal average of total nitrogen concentration in the upper water column; B: Annual average of total nitrogen concentration in the upper water layers; C: Seasonal average TN concentration in the water column; D: Annual average of total nitrogen concentration in the water column.

\*OSPAR, HELCOM and expert judgement threshold reference value were revised in 2017 but are not mandatory yet; \*\* Winter and summer assessment values, from WFD work, implemented and used in OSPAR Holistic Assessment for coastal waters (harmonized between OSPAR & WFD).

**Table 16.** Total Phosphorus (coastal waters)

C1: Nutrients in the water column: <b>Total Phosphorus (TP)</b>							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	Yes	A	2011-2016	Summer		Yes	National
Finland	Yes	A	2011-2016	Summer	surface	Yes	national WFD values, also used in HELCOM
Germany (Baltic sea)	Yes	B	2011-2016	Winter	surface	Yes	National WFD values acc. to surface water ordinance
Latvia	Yes	B	2011-2016			Yes	HELCOM
Poland	Yes	C	2011-2016	Summer (lagoons annual)	Water column	Yes	National methods used under WFD
Sweden (Baltic sea)	Yes	A	2011-2016	Winter and summer means	surface	Yes	HELCOM
Belgium	No						
Denmark (North sea)	No						
France (Atlantic)	No						
Germany (North sea)	Yes	B	2006-2014	Annual	surface	Yes	National WFD values acc. to surface water ordinance
Ireland	No						
Netherlands	No						
Spain (Atlantic)	Yes	A	2011-2016		Water column		No
Sweden (North sea)	Yes	A	2006-2014	Winter and summer means	surface	Yes	National methods used under WFD**
Croatia	Yes	B	2011-2016	annual			No
France (Mediterranean)	No						
Greece	Yes	D	2012-2014	annual	Water column		No
Italy	Yes	B	2012-2016	annual	surface		No
Malta	Yes	B	2017-2019	Winter, Spring, Summer, Autumn	surface		No
Spain (Mediterranean)	Yes	A	2011-2016		Water column		No
Bulgaria	Yes	A	2012-2017	Spring-Summer	Water column		No
Romania	Yes	C	2012-2017	annual	Water column	Yes	National methods used under WFD*

**A:** Seasonal average of total phosphorus concentration in the upper water column; **B:** Annual average of total phosphorus concentration in the upper water layers; **C:** Seasonal average TP concentration in the water column; **D:** Annual average of total phosphorus concentration in the water column.

\*OSPAR, HELCOM and expert judgement threshold reference value were revised in 2017 but are not mandatory yet; \*\* Winter and summer assessment values, from WFD work, implemented and used in OSPAR Holistic Assessment for coastal waters (harmonized between OSPAR & WFD).

**Table 17.** Chlorophyll a (coastal waters)

C2: Chlorophyll a							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)	Yes	A	1990-2014, 2007-2013 or 2011-2016	spring-summer		Yes	WFD
Estonia	Yes	B	2011-2016	summer	1-10 m	Yes	National
Finland	Yes	C	2007-2012	summer	2x secchi depth	Yes	national WFD values, also used in HELCOM
Germany (Baltic sea)	Yes	D	2007-2012	summer	surface	Yes	WFD
Latvia	Yes	B	2011-2016	summer	surface	Yes	HELCOM
Poland	Yes	B	2011-2016	Summer (lagoons annual)	Water column	Yes	National methods used under WFD
Sweden (Baltic Sea)	Yes	B	2006-2014	summer	0-10m	Yes	Harmonized values with WFD (reported to HELCOM and OSPAR)
Belgium	Yes	E	2011-2016	spring-autumn		Yes	WFD, OSPAR
Denmark (North sea)	Yes	A	1990-2014, 2007-2013 or 2011-2016	spring-summer		Yes	WFD
France (Atlantic)	Yes	F	2010-2015	Spring-summer	Surface	Yes	WFD (intercalibrated) used under OSPAR
Germany (North sea)	Yes	F	2006-2014	summer		Yes	WFD/OSPAR
Ireland	Yes	F		spring-summer	Surface and bed depth	Yes	WFD
Netherlands	Yes	F	2006-2014	spring-summer	surface	Yes	OSPAR
Spain (Atlantic)	Yes	G	2011-2016	Winter, spring, summer and autumn	0-20m	Yes	WFD
Sweden (North sea)	Yes	B	2006-2014	summer	0-10m	Yes	Harmonized values with WFD (reported to HELCOM and OSPAR)
Croatia	Yes	H	2011-2016	annual		Yes	UNEP-MAP
France (Mediterranean)	Yes	G	2010-2015	annual	Surface	Yes	WFD
Greece	Yes	I	2012-2018	annual	euphotic zone	Yes	MEDGIG
Italy	Yes	H	2012-2016	annual	surface	Yes	UNEP-MAP
Malta	Yes	H	2017-2019	monthly	surface and sub-surface	Yes	WFD
Spain (Mediterranean)	Yes	G	2011-2016	Winter, spring, summer and autumn	0-20m	Yes	WFD
Bulgaria	Yes	B	2012-2017	spring-summer	Water column	Yes	Statistical methods
Romania	Yes	B	2012-2017	spring-summer	0-10m	Yes	WFD

A: Chlorophyll a assessment during growing season: mean values and 90<sup>th</sup> percentile; B: Chlorophyll a assessment during growing season: mean values; C: Composite sample, 2x secchi-depth; D: Chlorophyll a assessment during growing season: mean values and WFD biological quality element phytoplankton; E: 6 years average of 90<sup>th</sup> percentile of Chlorophyll a based on satellite data (validated by *in-situ* data); F: Chlorophyll a assessment during growing season: 90<sup>th</sup> percentile; G: Chlorophyll a assessment during whole year : 90<sup>th</sup> percentile; H: Average Chlorophyll a concentration in the surface; I: Mean integrated average on euphotic zone and 90<sup>th</sup> percentile.

**Table 18.** Harmful algal blooms (coastal waters)

C3: Harmful algal blooms in the water column							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	No						
Finland	No						
Germany (Baltic sea)	Yes	A				Yes	WFD
Latvia	Yes	B				Yes	HELCOM
Poland	No						
Sweden (Baltic sea)	No						
Belgium	No						
Denmark (North sea)	No						
France (Atlantic)	No						
Germany (North sea)	Yes	A				Yes	WFD/OSPAR
Ireland	No						
Netherlands	No						
Spain (Atlantic)	No						
Sweden (North sea)	Yes	C				Yes	OSPAR
UK	Yes	D				Yes	
Croatia	Yes	E				Yes	
France (Mediterranean)	No						
Greece	No						
Italy	No						
Malta	No						
Spain (Mediterranean)	No						
Bulgaria	Yes	F	2012-2017	spring-summer	Water column (integrated sample)	Yes	Not for all indicators
Romania	Yes	G	2012-2017	cold and warm season	0-10m	Yes	OSPAR, HELCOM and expert judgement

**A:** Area specific phytoplankton indicator species (cell counts); **B:** Area specific phytoplankton indicator species (cell counts), percentage of samples with at least one bloom defined by category and taxon size, phytoplankton tool combining indices for chlorophyll a (90<sup>th</sup> percentile), elevated counts and seasonal succession, phytoplankton biomass, phytoplankton abundance, maximum concentration of blooming species, diatoms/dinoflagellates biomass ratio; **C:** Cyanobacteria surface accumulations combining information of volume, length of bloom period and severity of surface accumulations estimated from remote sensing observations and cyanobacterial bloom index; **D:** Phytoplankton indicator species; **E:** Area specific phytoplankton indicator species (cell counts), percentage of samples with at least one bloom defined by category and taxon size, phytoplankton biomass, phytoplankton abundance and maximum concentration of blooming species; **F:** Area specific phytoplankton indicator species (cell counts), percentage of samples with at least one bloom defined by category and taxon size, phytoplankton tool combining indices for chlorophyll a (90<sup>th</sup> percentile), elevated counts and seasonal succession, phytoplankton biomass, phytoplankton abundance, maximum concentration of blooming species, diatoms/dinoflagellates biomass ratio, biovolume data measured by analyzing phytoplankton cells, molecular taxonomy of potentially toxic species and remote sensing (chlorophyll a); **G:** Phytoplankton indicator species biomass (Noctiluca scintillans (zooplankton) biomass median).

Malta: phytoplankton composition is assessed in general up to species level.

**Table 19.** Photic limit (coastal waters)

C4: Photic limit of the water column							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	Yes	A	2011-2016	summer		Yes	National
Finland	Yes	A	2011-2016	summer		Yes	national WFD values, also used in HELCOM
Germany (Baltic sea)	Yes	A	2011-2016	summer		Yes	WFD
Latvia	Yes	A	2011-2016	summer		Yes	National
Poland	Yes	A	2011-2016	Summer (lagoons annual)		Yes	National methods used under WFD
Sweden (Baltic sea)	Yes	A	2011-2016	summer		Yes	Coastal thresholds from WFD
Belgium	No*						
Denmark (North sea)	No						
France (Atlantic)	Yes	B				Yes	
Germany (North sea)	No*						
Ireland	No						
Netherlands	No						
Spain (Atlantic)	Yes	A	2011-2016	Winter, spring, summer and autumn			No
Sweden (North sea)	Yes	A	2006-2014	summer		Yes	Coastal thresholds from WFD
Croatia	Yes	A	2011-2016	annual		Yes	UNEP-MAP
France (Mediterranean)	Yes	B				Yes	
Greece	Yes	C	2012-2018	annual	1% of light penetration		No
Italy	No						
Malta	Yes	A	2017-2019	monthly			No
Spain (Mediterranean)	Yes	A	2011-2016	Winter, spring, summer and autumn			No
Bulgaria	Yes	A	2012-2017	spring-summer	surface	Yes	Statistical method
Romania	Yes	A	2012-2017	warm season	5-30m	Yes	National legislation

A: Water clarity: average secchi depth; B: 90<sup>th</sup> percentile of turbidity measured as NTU during the growing season; C: Water clarity: average secchi depth and transmissometer.

\*Criteria not relevant for the evaluation of eutrophication in German and Belgian waters due to high concentration of suspended matter.



**Table 20.** Dissolved oxygen (coastal waters)

C5: Dissolved oxygen in the bottom of the water column							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	No						
Finland	No						
Germany (Baltic sea)	Yes	A	2011-2016	autumn	bottom layer	Yes	national method
Latvia	Yes	B	2011-2016	summer	within 1m from the bottom	Yes	WFD
Poland	Yes	B	2011-2016	summer	within 1m from the bottom	Yes	WFD
Sweden (Baltic sea)	Yes	C	2011-2016	autumn	within 1m from the bottom	Yes	WFD target based on literature studies indicating "no adverse effects"
Belgium	No*						
Denmark (North sea)	No						
France (Atlantic)	Yes	D	2010-2015	spring	within 1m from the bottom	Yes	WFD, OSPAR
Germany (North sea)	Yes	E	2006-2014	summer-autumn	bottom layer	Yes	OSPAR
Ireland	Yes	F	2010-2015	summer	bottom layer	Yes	WFD
Netherlands	Yes	G	2006-2014	whole year	bottom +3m; surface - 1m	Yes	OSPAR
Spain (Atlantic)	Yes	C	2011-2016	winter, spring, summer a 3 <sup>rd</sup> autumn	bottom layer	Yes	OSPAR
Sweden (North sea)	Yes	C	2006-2014	autumn	within 1m from the bottom	Yes	WFD target based on literature studies indicating "no adverse effects"
Croatia	Yes	H	2011-2016	annual	bottom layer	No	
France (Mediterranean)	Yes	D	2010-2015	spring	within 1m from the bottom	Yes	WFD
Greece	Yes	I	2012-2018	annual	water column	Yes	Hypoxia/anoxia levels defined by scientific literature
Italy	Yes	A	2012-2015	summer	bottom layer	Yes	Hypoxia/anoxia levels defined by scientific literature
Malta	Yes	J	2017-2019	monthly		No	
Spain (Mediterranean)	Yes	C	2011-2016	winter, spring, summer and autumn	bottom layer	Yes	OSPAR
Bulgaria	Yes	J	2012-2017	spring-summer	water column	No	
Romania	Yes	K	2012-2017	warm season	surface	Yes	Literature and national legislation for WFD

A: Oxygen concentration in mg/l; B: Minimum oxygen concentrations in summer; C: 10<sup>th</sup> percentile of bottom water oxygen concentration during whole year; D: 10<sup>th</sup> percentile of spring bottom water oxygen concentration; E: Minimum oxygen concentration; F: 5<sup>th</sup> percentile and 95<sup>th</sup> percentile of oxygen saturation; G: Degree of oxygen deficiency; H: Minimum level in the water bottom; I: Average oxygen debt below the halocline; J: Bottom oxygen concentration and surface oxygen saturation; K: Bottom oxygen concentration and saturation at the bottom percentile 10<sup>th</sup>.

\*Criteria not relevant for the evaluation of eutrophication in Belgian waters due to strong currents.

**Table 21.** Opportunistic macroalgae (coastal waters)

C6: Opportunistic macroalgae of benthic habitats							
Member State	Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values		
Denmark (Baltic sea)	No						
Estonia	Yes	A	2011-2016	summer	Photic zone	Yes	National
Finland	No						
Germany (Baltic sea)	Yes	A	2007-2012			Yes	WFD
Latvia	No						
Poland	Yes	A	2011-2016	summer		Yes	WFD and national
Sweden (Baltic sea)	No						
Belgium	No						
Denmark (North sea)	No						
France (Atlantic)	Yes	A	2010-2015	Spring-summer		Yes	WFD EQR (CW-OGA)
Germany (North sea)	Yes	A	2007-2012			Yes	WFD
Ireland	Yes	A	2007-2011			Yes	WFD
Netherlands	No						
Spain (Atlantic)	Yes	A	2011-2016	winter, spring, summer and autumn		No	
Sweden (North sea)	No						
Croatia	Yes	A	2011-2016	summer	max 5m	No	
France (Mediterranean)	No						
Greece	Yes	A	2012-2018	Spring and autumn	1% of light penetration	No	
Italy	No						
Malta	Yes	A	2017-2019	summer		Yes	Intercalibrated
Spain (Mediterranean)	Yes	A	2011-2016	winter, spring, summer and autumn		No	
Bulgaria	Yes	A	2012-2017	summer	max 3m	Yes	
Romania	Yes	A	2012-2017	Warm season	0-5m	Yes	WFD

A: WFD indicators on macrophytes.

**Table 22.** Macrophyte communities (coastal waters)

C7: Macrophyte communities of benthic habitats							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)	Yes	A	2011-2013	summer		Yes	EU intercalibrated values
Estonia	Yes	A	2011-2016	summer	photic zone	Yes	National
Finland	Yes	A	2011-2016	summer		Yes	National coastal WFD
Germany (Baltic sea)	Yes	A	2007-2012			Yes	WFD values
Latvia	No						
Poland	Yes	A	2011-2016	summer		Yes	WFD and national
Sweden (Baltic sea)	Yes	A	2009-2015	summer	0-20m	Yes	WFD (approved though not intercalibrated) threshold values
Belgium	No						
Denmark (North sea)	Yes	A	2011-2013	summer		Yes	EU intercalibrated values
France (Atlantic)	Yes	A	2010-2015	Spring-summer		Yes	WFD EQR (QiSubMac + CCO + SBQ)
Germany (North sea)	Yes	A	2007-2012			Yes	WFD values
Ireland	Yes	A	2007-2012	annual	surface	Yes	WFD
Netherlands	Yes	A	2009-2015	growth period		Yes	intercalibrated
Spain (Atlantic)	No						
Sweden (North sea)	Yes	A	2009-2015	summer	0-20m	Yes	WFD (approved though not intercalibrated) threshold values
Croatia	Yes	A				No	
France (Mediterranean)	Yes	A	2010-2015	Spring		Yes	WFD EQR (CARLIT + PREI)
Greece	Yes	A	2012-2017	annual	Euphotic zone	Yes	MEDGIG results
Italy	No						
Malta	Yes	A	2017-2019	summer		Yes	Intercalibrated
Spain (Mediterranean)	No						
Bulgaria	Yes	A	2012-2017	summer	max 3m	Yes	
Romania	No						

A: WFD indicators on macrophytes.

**Table 23. Macrofaunal communities (coastal waters)**

C8: Macrofaunal communities of coastal habitats							
Member State		Monitoring method	Assessment period	Assessment season	Assessment depth	Threshold values	
Denmark (Baltic sea)		A	2008-2013	spring		Yes	EU intercalibrated values
Estonia	Yes	B	2011-2016	early summer	bottom	Yes	National
Finland	Yes	C	2011-2016	summer	bottom	Yes	national WFD values
Germany (Baltic sea)	Yes	A	2007-2012			Yes	WFD
Latvia	No						
Poland	Yes	C	2011-2016	annual	bottom	Yes	national WFD values
Sweden (Baltic sea)	Yes	D	2011-2016	annual		Yes	National (intercalibrated WFD values)
Belgium	No						
Denmark (North sea)	Yes	A	2008-2013	spring		Yes	EU intercalibrated values
France (Atlantic)	No						
Germany (North sea)	Yes	A	2007-2012			Yes	WFD
Ireland	Yes	E	2007-2012	annual		Yes	WFD
Netherlands	Yes	F	2009-2015	spring	bottom intercalibrated	Yes	WFD
Spain (Atlantic)	No						
Sweden (North sea)	Yes	D	2006-2014	annual		Yes	National (intercalibrated WFD values)
Croatia	Yes	G				No	
France (Mediterranean)	No						
Greece	Yes	H	2012-2018	annual or bi-annual		Yes	BENTIX
Italy	No						
Malta	Yes	H	2017-2019	summer		No*	
Spain	No						
Bulgaria	Yes	B	2012-2017	summer	15m	Yes	Statistical methods
Romania	Yes	D	2012-2017	annual	0-30m	Yes	Literature derived

**A:** Relative proportion of sensitive and tolerant species and species richness and abundance; **B:** Relative proportion of sensitive and tolerant species, species richness and abundance and biomass of benthic organisms; **C:** Relative proportion of sensitive and tolerant species; **D:** Benthic quality index (M-AMBI); **E:** Infaunal Quality Index; **F:** Species richness and abundance; **G:** Changes in diversity and relation between sensitive and non-sensitive species (multimetric index-M-AMBI); **H:** Relative proportion of sensitive and tolerant species and BENTIX index.

\*Intercalibration in process.

### 3 Analysis of results

The data synthesized in the tables above were analysed to answer the following questions:

- 1) To which extent the MSFD eutrophication criteria are being applied at the EU level (across MS and RSC in open sea and coastal areas);
- 2) What is the degree of harmonization of the eutrophication methodological standards in open sea and coastal waters at the EU level (across MS) and RSC level;
- 3) What are the developments on setting threshold values at the EU level (across MS).

#### 3.1 Extent of application of MSFD eutrophication criteria across RSC and MS

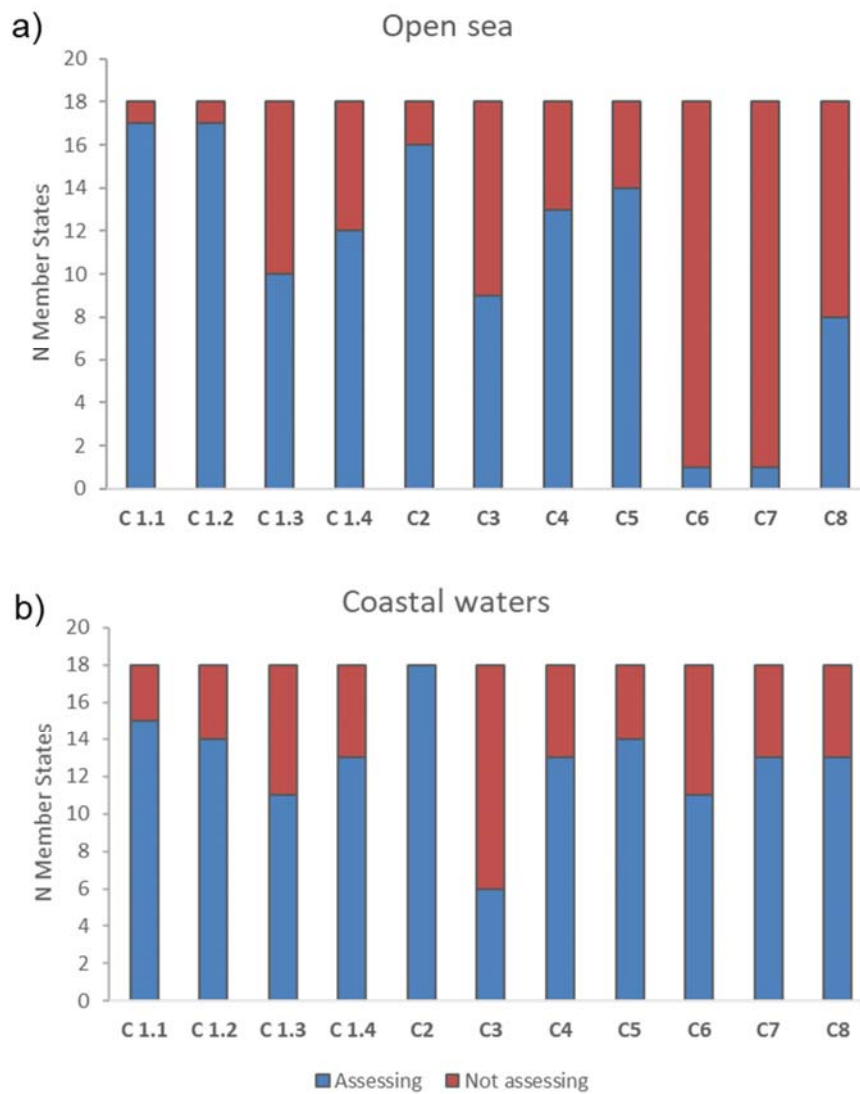
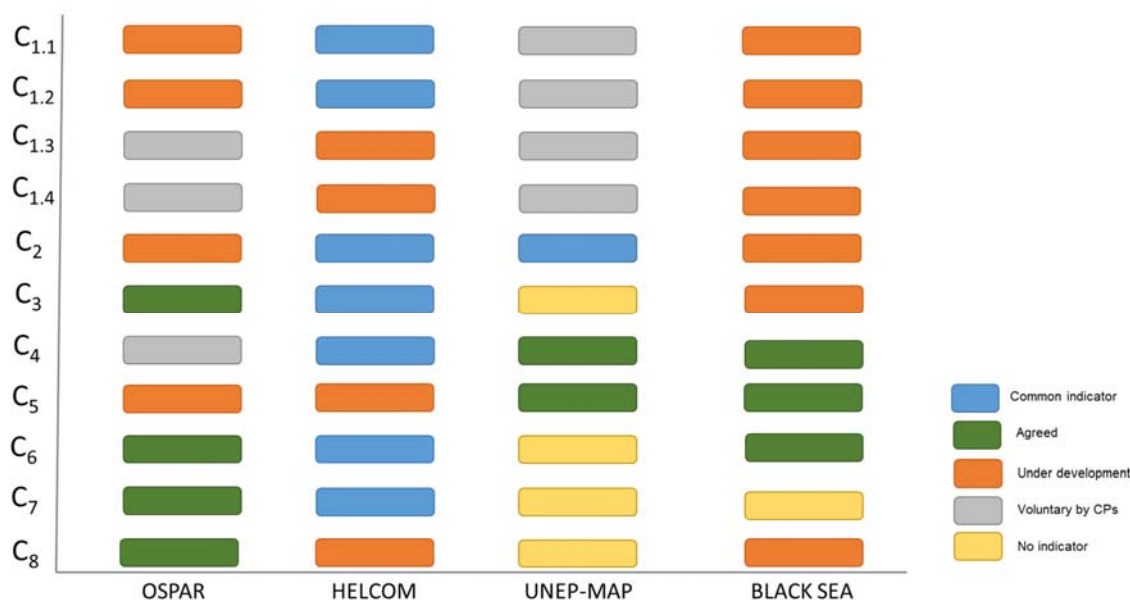


Figure 2. Criteria used at open sea (a) and coastal waters (b) by number of MS

The results of this analysis show that most of the eutrophication criteria are assessed by the majority of MS both for coastal waters and open sea. The exception is C3 (Harmful algal blooms in the water column) that was assessed only by 50% of the MS for open sea and less than 50% for coastal waters and C6 and C7 (macroalgae from benthic habitats) that were mainly assessed in coastal waters because benthic macroalgae are not commonly found in open sea areas (Figure 2).

Primary criteria (C1 (nutrients in the water column), C2 (Chlorophyll-a) and C5 (Dissolved oxygen)) are assessed by most of the MS, both for open sea and coastal waters (Figure 2).

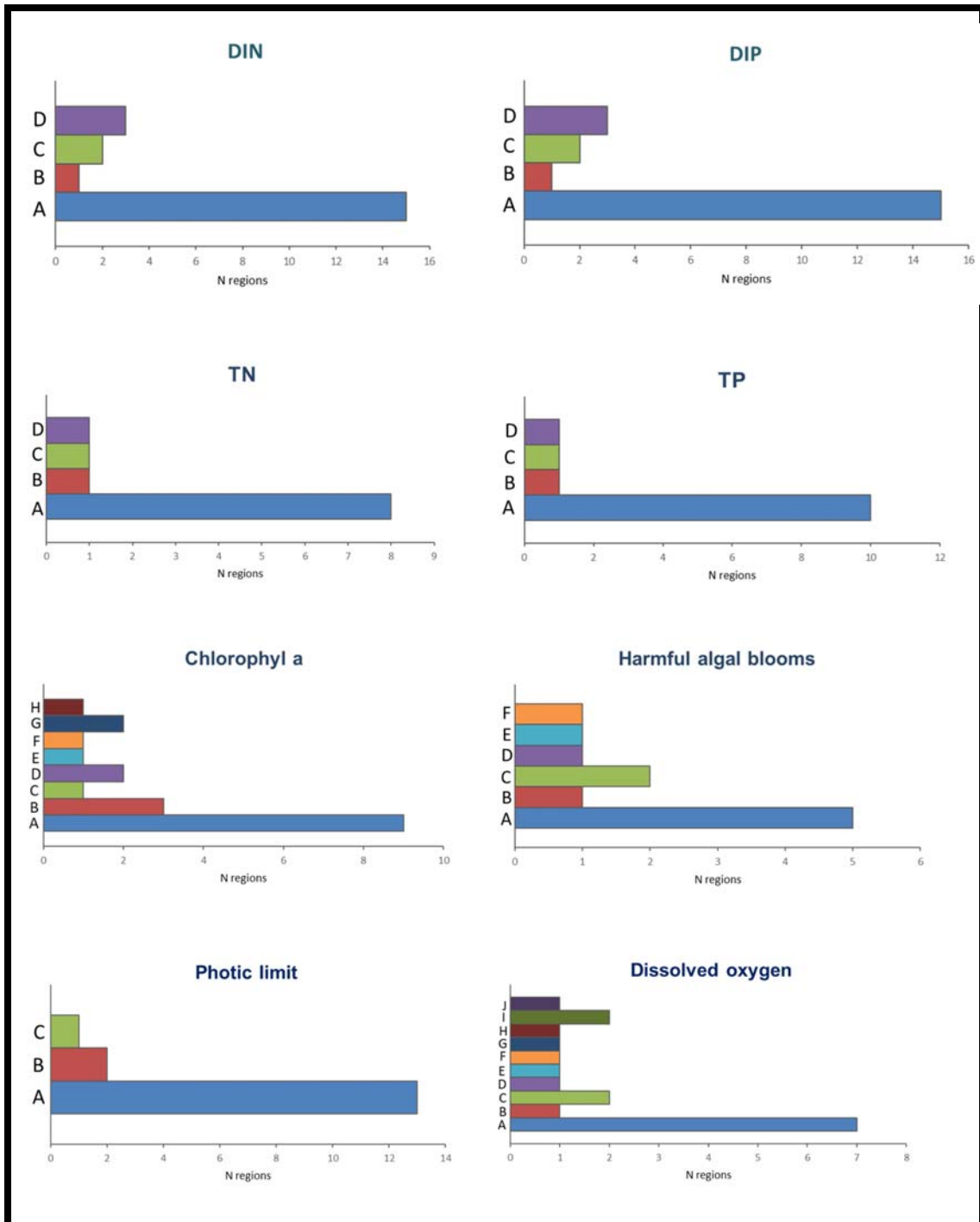


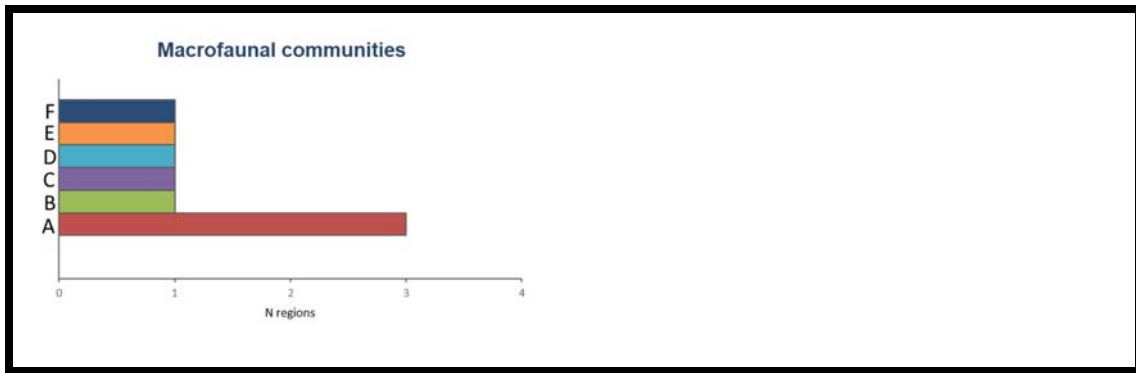
**Figure 3.** Status of development of the different eutrophication criteria across RSC. Common indicator: indicator fully operational and with agreed common thresholds; Agreed: indicator agreed but not assessed against regional thresholds (might be assessed against national thresholds); Under development: indicator not yet fully operational or no common threshold values yet; Voluntary by CPs: monitoring voluntary and methods not agreed at regional level; No indicator: no indicator available.

The status of development, agreement and integration of indicators in a common eutrophication assessment framework varies across RSCs. HELCOM has developed and agreed on a number of common indicators, most of them already evaluated against thresholds. In OSPAR, there are currently no common indicators but there are four common indicators under development that are all MSFD primary criteria. The rest of the indicators are used nationally and evaluated against national thresholds. Some criteria are not included as obligatory in the Eutrophication Monitoring Programme and thus reporting by MS is voluntary. For UNEP-MAP there is one common indicator and two indicators under development. Some other indicators are used nationally and some criteria are not assessed. Most of the Black Sea Commission indicators are under development or agreed. The development of common indicators at the regional level is an important step further that should be pursued by all RSCs and that will be key to achieve higher harmonization between MS.

### 3.2 Degree of harmonization of methodological standards at the EU level

OPEN SEA



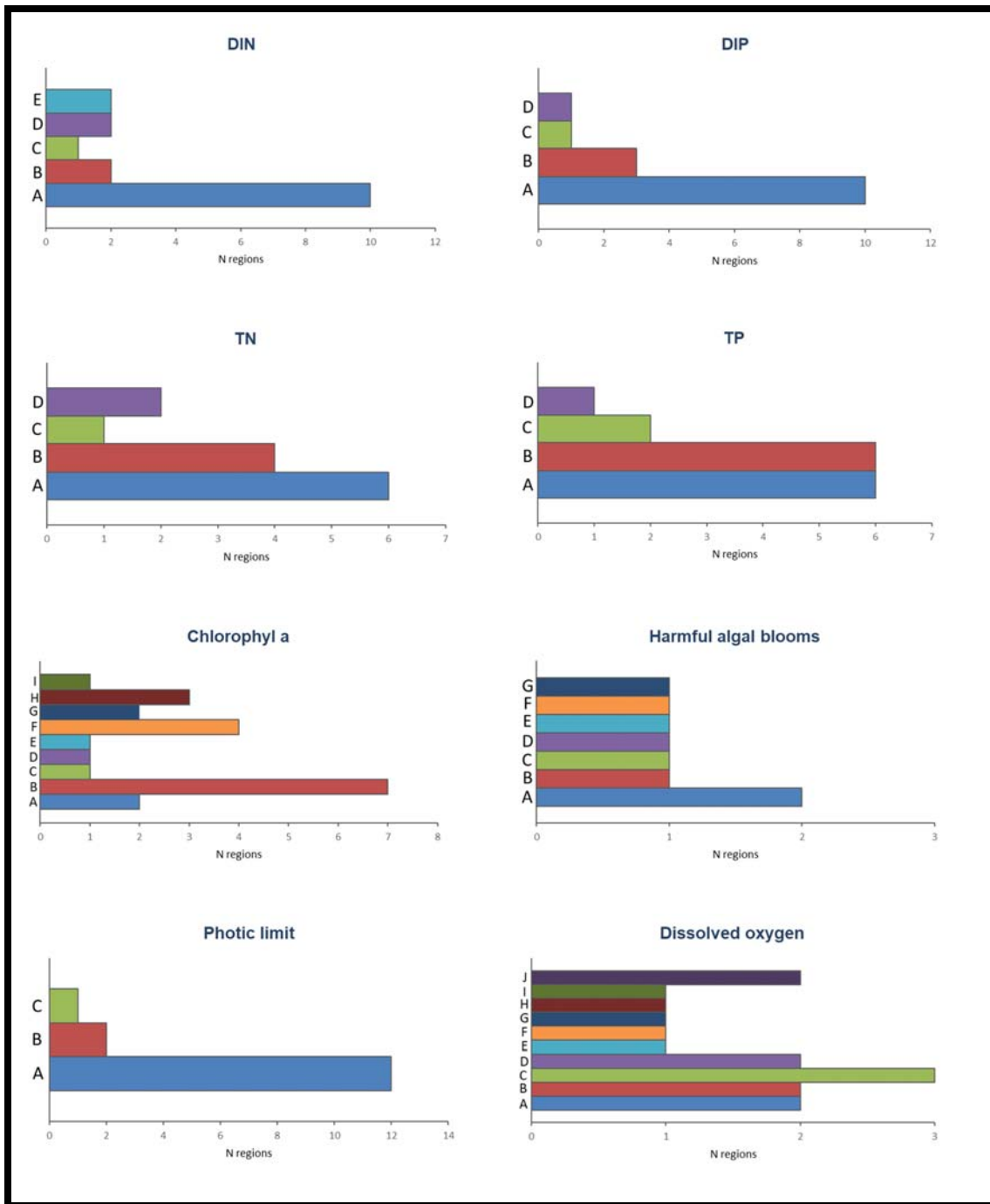


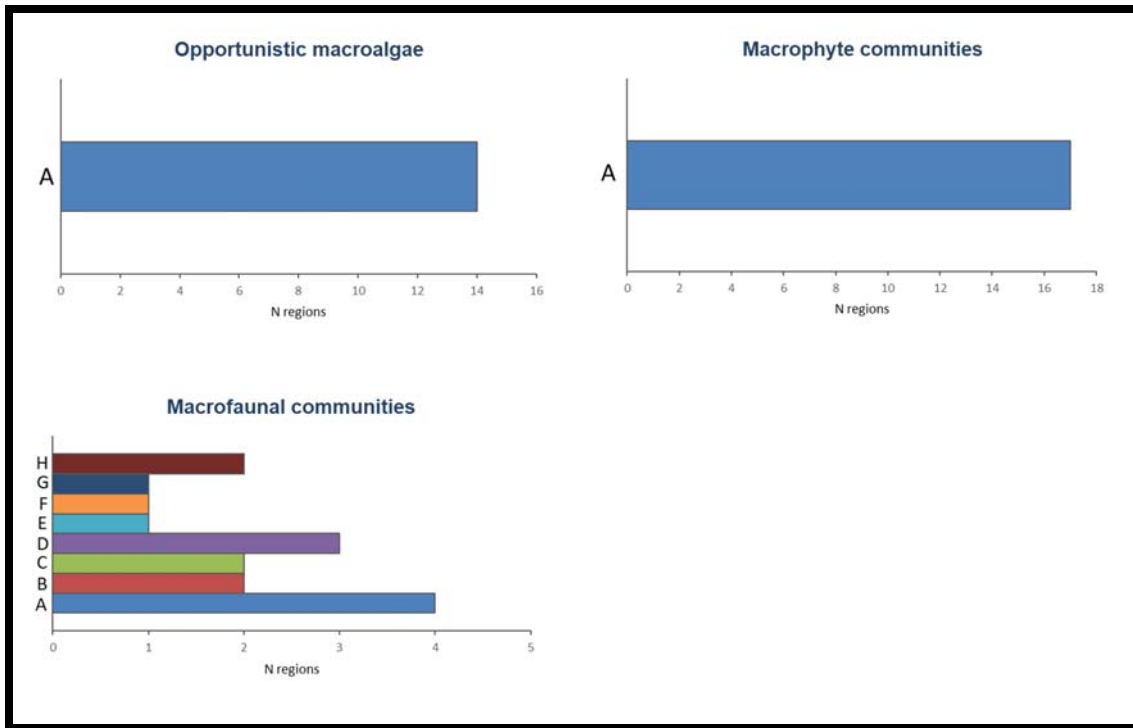
**Figure 4.** Frequency of the methods used for the assessment of each of the eutrophication criteria (C6 and C7 not included because not applicable for open sea) by MS for open sea areas. The different letters and colours in each graph correspond to the different methods detailed in tables 2-12.

For the open sea, several of the criteria (e.g. the different parameters considered under C1 and C4) are assessed dominantly by one method although 3 or 4 different methods are applied by different MS (Figure 4). For other criteria (e.g. C2, C3, C5), more than 5 different assessment methods are used and only for some of the criteria is there a dominant method followed by MS (in any case always corresponding to less than 50% of the total MS using it) (Figure 4). It is important to evaluate the impact for GES assessment of the use of different methodological approaches for monitoring eutrophication parameters. For example for Chlorophyll a the use of *in situ* measurements or remote sensing methods might result in different assessment outcomes, in particular for open sea areas (Novoa et al 2012). The reasons behind a given choice of methods might be related with environmental specific issues of the assessment unit, technical limitations or lack of resources to implement a specific method. An additional limitation identified during the preparation of this report is the variation in the terminologies used to designate the same method. Guidelines should be defined to harmonize the terminologies used. This will facilitate an objective analysis of the next MSFD reporting cycle.



COASTAL WATERS





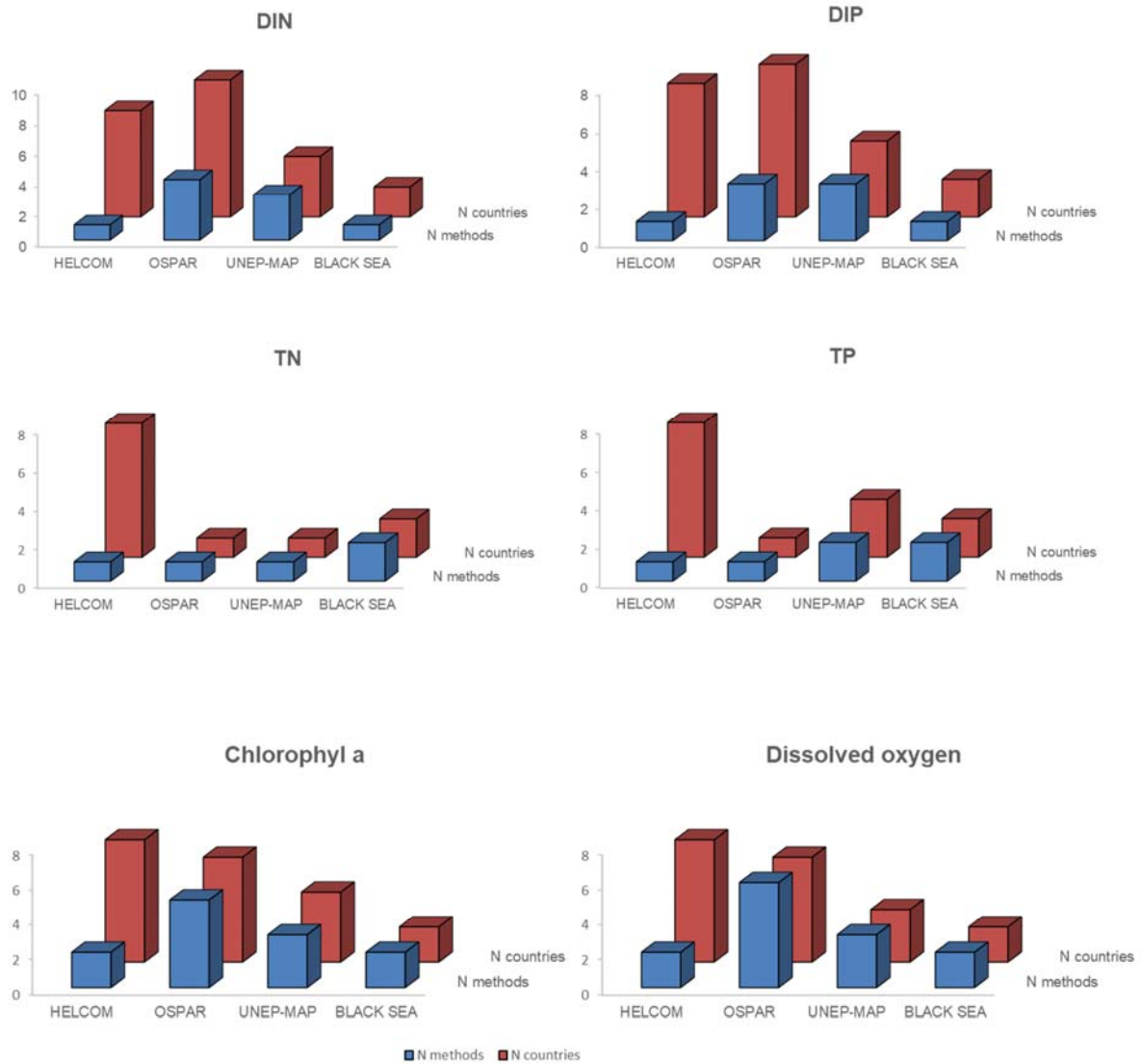
**Figure 5.** Frequency of the methods used for the assessment of each of the eutrophication criteria by MS for coastal waters. The different letters and colours in each graph correspond to the different methods detailed in tables 13-23.

For coastal waters, similarly to open sea areas, several of the criteria (e.g. some of the parameters considered under C1 and C4) are assessed dominantly by one method although 3 or 4 different methods are applied by different MS. For other criteria (e.g. C2, C3, C5, C8) different assessment methods are used and there is no dominance of a specific method among the different MS (Figure 5). For example C5 (oxygen) is assessed by using 10 different assessment methods with variations reported also in the assessment season or assessment depth. On the contrary, for C6 and C7 there is a full harmonization of methodological approaches between MS with a common method followed for all the assessment areas (Figure 5). The limitations discussed before for open sea apply also for coastal areas. Also for coastal areas it is important to understand the implications of the use of the different monitoring methods for the assessment of GES.

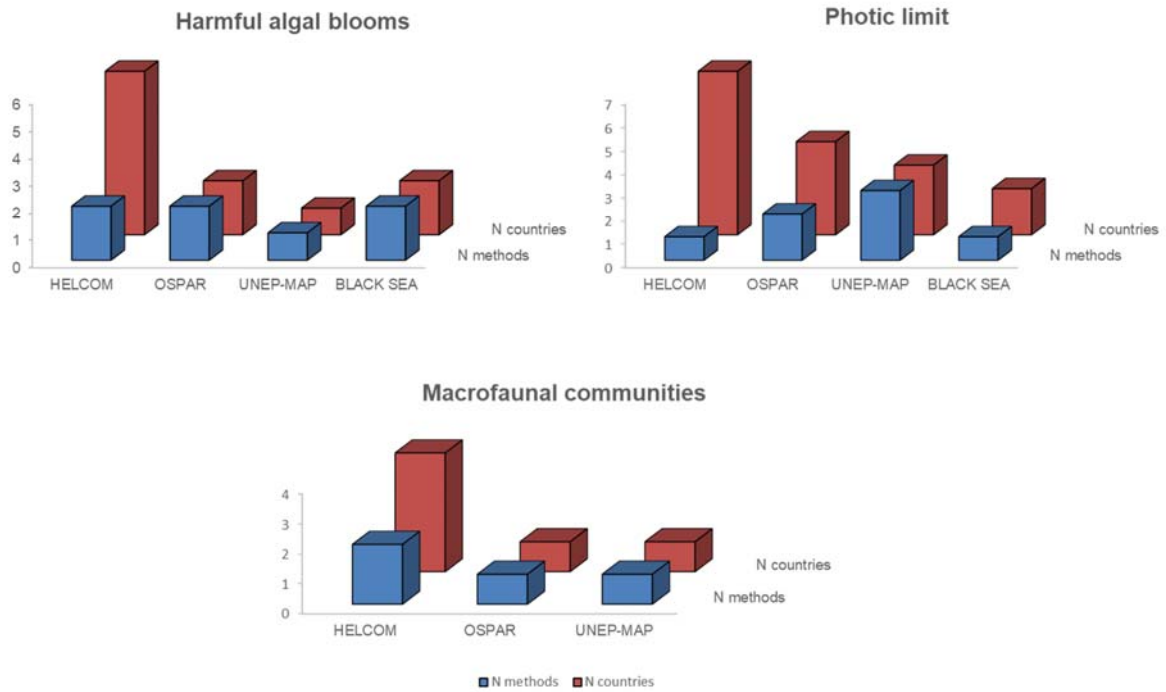
### 3.3 Degree of harmonization of methodological standards across RSC

The degree of harmonization of the primary and secondary criteria for open sea areas was also assessed. According to the Commission Decision (EU) 2017/848 the use of secondary criteria shall be agreed at regional or subregional level beyond coastal waters. The primary criteria C1 (nutrients: DIN, DIP, TN, TP), C2 (chlorophyll a) and C5 (dissolved oxygen) and the secondary criteria C3 (harmful algal blooms), C4 (photic limit) and C8 (macrofaunal communities) were considered. C6 and C7 were not included since these criteria are mostly assessed in coastal areas. The results show that the degree of

harmonization in the assessment varies with criteria identity and RSC. A higher harmonization is consistently found in RSC like HELCOM than in others such for example UNEP-MAP (Figure 6, Figure 7). Additionally, the number of countries monitoring the secondary criteria in open sea is higher in HELCOM than in the other RSC for all the criteria. A high degree of harmonization is found for some criteria like the nutrients or the photic limit, while for others (e.g. harmful algal blooms) it is low.



**Figure 6.** Harmonization at regional level for the primary criteria in open sea. Higher degree of harmonization corresponds to a higher mismatch between the number of different methods (in blue) and the number of countries (in red).

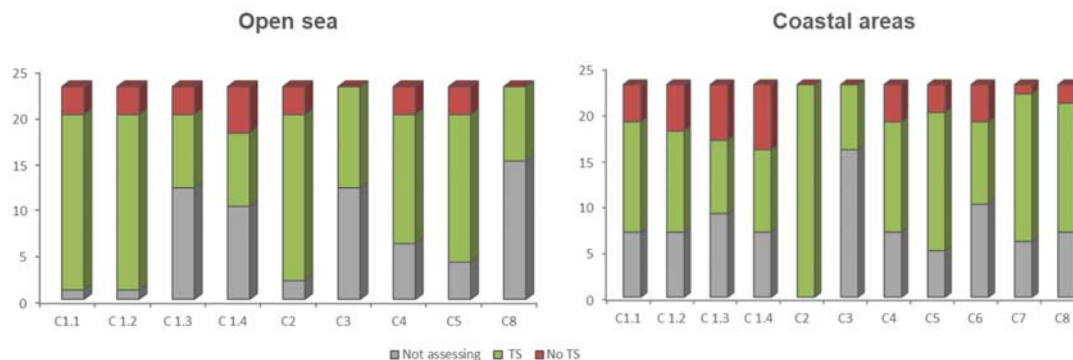


**Figure 7.** Harmonization at regional level for the secondary criteria in open sea (C6 and C7 are mostly assessed in coastal areas). Higher degree of harmonization corresponds to a higher mismatch between the number of different methods (in blue) and the number of countries (in red).

The degree of harmonization for some primary criteria like nutrients is high in particular for RSC like HELCOM and OSPAR.

The identified regional variability in the harmonization of methodological approaches might be related with the regional ecological context given that the eutrophication of coastal and open sea waters has different status in different regions. For example in the Baltic Sea it is a priority issue given the extension of the marine area affected by this phenomenon (HELCOM, 2018) while in the Mediterranean region it is not such an important pressure (it might be at a local scale such as in some areas of the Adriatic Sea) (UNEP-MAP 2018). This might justify why for some regions the development of common secondary eutrophication criteria is not a priority. However, for the primary eutrophication criteria this effort should be done regardless of the region specific context. For most of the MS this assessment is performed at the national level (tables 2-23).

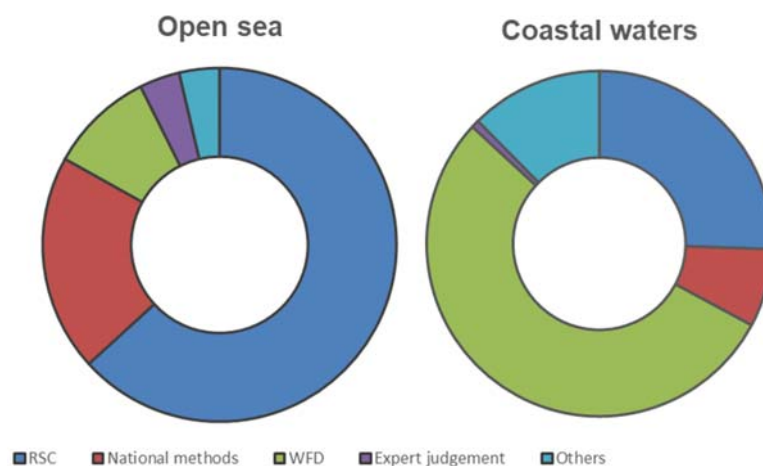
### 3.4 Development of methods for threshold setting at the EU level (across MS)



**Figure 8.** Number of MS regions (if MS assess D5 criteria for different regions each region was counted as one entry) with established methods (TS) for setting thresholds in open sea and coastal waters. MS regions where each method is not assessed (not assessing) or without established threshold values (no TS) are also represented.

For most of the criteria, methods for threshold setting are developed for the majority of the regions assessing a given criteria. For coastal waters threshold values are available for all the regions for Chlorophyll-a. The status is similar for the MS assessing harmful algal blooms, both for coastal waters and open sea. For some of the criteria, like for example the assessment of nutrients level, a higher number of MS regions did not agree yet on threshold values (Figure 8).

In relation to the method used to establish threshold values discrepancies were registered for open sea and coastal areas. In open sea most of the MS followed the RSC established methods or national methods while for coastal waters most of the MS followed the WFD methods but also the RSCs. HELCOM was the RSC most referred by MS since it is also the most developed in defining threshold values for the different eutrophication criteria (Figure 9).



**Figure 9.** Methods followed by the different MS to establish thresholds values for open sea and coastal water.

## 4 Conclusions

For all the MSFD Eutrophication criteria there are assessment methods available and in place for implementation in coastal and open sea areas across EU waters.

However, for some of the criteria there is still a low degree of harmonization in the methodological approaches used as is the case, among others, for Chlorophyll-a and Oxygen. In these cases, an evaluation of the reasons for the reported heterogeneity (e.g. specific local conditions, unavailability of resources for implementation of specific methodological approaches or different terminologies used to designate similar methods) and the implications of the use of different methodologies to the adequate assessment of eutrophication across MS water bodies should be undertaken.

Similarly, at the regional level a higher degree of harmonization, at least for primary eutrophication criteria, is also needed to support and guide the work to be done at national level in relation to the methods used for monitoring and definition of threshold values. The importance of this work is demonstrated by the higher harmonization for regions with common developed indicators and the high number of MS that follow the RSC methods on threshold setting even if most of the RSC have not yet agreed on threshold values for most of the MSFD criteria. For some regions a high level of agreement is already achieved in terms of methodological standards and even for threshold values setting (e.g. HELCOM) but in others this work is still to be done. The highest agreement in terms of criteria assessment and methodological standards is achieved in the Baltic Sea, while other regions lack clearly behind.

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## **Annexes**

**Annex 1.** Survey on the methodological standards and threshold setting methods sent to the MS and RSC nominated experts.

# D5-Eutrophication

## Member State identity

---

Member State identity

	MS
Bulgaria	<input type="radio"/>
Croatia	<input type="radio"/>
Denmark	<input type="radio"/>
Estonia	<input type="radio"/>
Finland	<input type="radio"/>
France	<input type="radio"/>
Germany	<input type="radio"/>
Greece	<input type="radio"/>
Ireland	<input type="radio"/>
Italy	<input type="radio"/>
Latvia	<input type="radio"/>
Malta	<input type="radio"/>
The Netherlands	<input type="radio"/>
Poland	<input type="radio"/>
Portugal	<input type="radio"/>
Romania	<input type="radio"/>
Slovenia	<input type="radio"/>
Spain	<input type="radio"/>
Sweden	<input type="radio"/>
UK	<input type="radio"/>
UNEP-MAP	<input type="radio"/>
OSPAR	<input type="radio"/>
HELCOM	<input type="radio"/>

Black-Sea Commission	<input type="radio"/>
Belgium	<input type="radio"/>

## Criteria

---

Question 1: For each criteria, please mark the options assessed for open sea waters

	Open Sea
C1: Nutrients in the water column (DIN)	<input type="radio"/>
C1: Nutrients in the water column (DIP)	<input type="radio"/>
C1: Nutrients in the water column (TN)	<input type="radio"/>
C1: Nutrients in the water column (TP)	<input type="radio"/>
C2: Chlorophyl a in the water column	<input type="radio"/>
C3: Harmful algal blooms in the water column	<input type="radio"/>
C4: Photic limit of the water column	<input type="radio"/>
C5: Dissolved oxygen in the bottom of the water column	<input type="radio"/>
C6: Opportunistic macroalgae of benthic habitats	<input type="radio"/>
C7: Macrophyte communities of benthic habitats	<input type="radio"/>
C8: Macrofaunal communities of benthic habitats	<input type="radio"/>

Question 2: For each criteria marked as being assessed for open sea, please signal if the assessment included also as part of the MSFD reporting

	MSFD reporting	Only national assessment
C1: Nutrients in the water column (DIN)	<input type="radio"/>	<input type="radio"/>
C1: Nutrients in the water column (DIP)	<input type="radio"/>	<input type="radio"/>
C1: Nutrients in the water column (TN)	<input type="radio"/>	<input type="radio"/>
C1: Nutrients in the water column (TP)	<input type="radio"/>	<input type="radio"/>
C2: Chlorophyl a in the water column	<input type="radio"/>	<input type="radio"/>
C3: Harmful algal blooms in the water column	<input type="radio"/>	<input type="radio"/>
C4: Photic limit of the water column	<input type="radio"/>	<input type="radio"/>

C5: Dissolved oxygen in the bottom of the water column	<input type="radio"/>	<input type="radio"/>
C6: Opportunistic macroalgae of benthic habitats	<input type="radio"/>	<input type="radio"/>
C7: Macrophyte communities of benthic habitats	<input type="radio"/>	<input type="radio"/>
C8: Macrofaunal communities of benthic habitats	<input type="radio"/>	<input type="radio"/>

Question 3: For each criteria, please mark the options assessed for coastal waters

	Coastal waters
C1: Nutrients in the water column (DIN)	<input type="radio"/>
C1: Nutrients in the water column (DIP)	<input type="radio"/>
C1: Nutrients in the water column (TN)	<input type="radio"/>
C1: Nutrients in the water column (TP)	<input type="radio"/>
C2: Chlorophyl a in the water column	<input type="radio"/>
C3: Harmful algal blooms in the water column	<input type="radio"/>
C4: Photic limit of the water column	<input type="radio"/>
C5: Dissolved oxygen in the bottom of the water column	<input type="radio"/>
C6: Opportunistic macroalgae of benthic habitats	<input type="radio"/>
C7: Macrophyte communities of benthic habitats	<input type="radio"/>
C8: Macrofaunal communities of benthic habitats	<input type="radio"/>

Question 4: For each criteria marked as being assessed for coastal waters, please signal if the assessment is included also as part of the MSFD reporting

	MSFD reporting	Only national assessment
C1: Nutrients in the water column (DIN)	<input type="radio"/>	<input type="radio"/>
C1: Nutrients in the water column (DIP)	<input type="radio"/>	<input type="radio"/>
C1: Nutrients in the water column (TN)	<input type="radio"/>	<input type="radio"/>
C1: Nutrients in the water column (TP)	<input type="radio"/>	<input type="radio"/>
C2: Chlorophyl a in the water column	<input type="radio"/>	<input type="radio"/>
C3: Harmful algal blooms in the water column	<input type="radio"/>	<input type="radio"/>
C4: Photic limit of the water column	<input type="radio"/>	<input type="radio"/>

C5: Dissolved oxygen in the bottom of the water column	<input type="radio"/>	<input type="radio"/>
C6: Opportunistic macroalgae of benthic habitats	<input type="radio"/>	<input type="radio"/>
C7: Macrophyte communities of benthic habitats	<input type="radio"/>	<input type="radio"/>
C8: Macrofaunal communities of benthic habitats	<input type="radio"/>	<input type="radio"/>

## Criteria 1: Nutrients in the water column: Dissolved Inorganic Nitrogen (DIN)

---

### Criteria 1 (DIN) Monitoring method

---

a.1) Method used

	Open sea	Coastal waters
Seasonal average DIN concentration in the surface	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer was "other" please specify

b) Assessment period (years)

c) Assessment season (if applicable)

d) Assessment depth (if applicable)

### Criteria 1 (DIN) Threshold value assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment
- Other

c) If your answer to question b was RSC please specify

- HELCOM
- OSPAR
- UNEP-MAP
- Black Sea Commission

d) If your answer to question b was "Other" please specify

## Criteria 1: Nutrients in the water column: Dissolved Inorganic Phosphorus (DIP)

---

### Criteria 1 (DIP) Monitoring method

---

a.1) Monitoring method used

	Open sea	Coastal waters
Seasonal average DIP concentration in the surface	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer was "other" please specify

b) Assessment period (years)

c) Assessment season (if applicable)

d) Assessment depth (if applicable)

## Criteria 1 (DIP) Threshold value assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment  
 Other

c) If your answer to question b was RSC please specify

- HELCOM  
 OSPAR  
 UNEP-MAP  
 Black Sea Commission

d) If your answer to question b was "Other", please specify

## Criteria 1: Nutrients in the water column: Total Nitrogen (TN)

---

### Criteria 1 (TN) Monitoring method

---

a.1) Monitoring method used

	Open sea	Coastal waters
Seasonal average of Total Nitrogen concentration in the upper water layers	<input type="checkbox"/>	<input type="checkbox"/>
Annual average of Total Nitrogen concentration in the upper water layers	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer to the previous question was "other" please specify

b) Assessment period (year)

c) Assessment season (if applicable)



d) Assessment depth (if applicable)

## Criteria 1 (TN) Threshold value assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment  
 Other

c) If your answer to question b was RSC please specify

- HELCOM  
 OSPAR  
 UNEP-MAP  
 Black Sea Commission

d) If your answer to question b was "Other" please specify

## Criteria 1: Nutrients in the water column: Total Phosphorus (TP)

---

### Criteria 1 (TP) Monitoring method

---

a.1) Monitoring method used

	Open sea	Coastal waters
Seasonal average of Total Phosphorus concentration in the upper water layers	<input type="checkbox"/>	<input type="checkbox"/>
Annual average of Total Phosphorus concentration in the upper water layers	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer to the previous question was "other" please specify

b) Assessment period (years)

c) Assessment season (if applicable)

d) Assessment depth (if applicable)

## Criteria 1 (TP) Threshold value assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment  
 Other

c) If your answer to question b was RSC please specify

- HELCOM  
 OSPAR  
 UNEP-MAP  
 Black Sea Commission

d) If your answer to question b was "Other" please specify

## Criteria 2: Chlorophyll a in the water column

---

### Criteria 2 (Chlorophyll a) Monitoring method

---

a.1) Monitoring method used

<input type="text"/>	Open sea	Coastal waters
----------------------	----------	----------------

Average chlorophyll a concentration in the surface	<input type="checkbox"/>	<input type="checkbox"/>
Chlorophyll a assessment during growing season. Maximum values	<input type="checkbox"/>	<input type="checkbox"/>
Chlorophyll a assessment during growing season. Mean values	<input type="checkbox"/>	<input type="checkbox"/>
Chlorophyll a assessment during growing season. 90 percentile	<input type="checkbox"/>	<input type="checkbox"/>
Chlorophyll a assessment during growing season. Satellite data	<input type="checkbox"/>	<input type="checkbox"/>
Chlorophyll a assessment during growing season. Smart Buoy data	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer to the previous question was "other" please specify

b) Assessment period (years)

c) Assessment season (if applicable)

d) Assessment depth (if applicable)

## Criteria 2 (Chlorophyll a) Threshold value assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment  
 Other

c) If you answer to question b was RSC please specify

- HELCOM  
 OSPAR  
 UNEP-MAP  
 Black Sea Commission

d) If your answer to question b was "Other" please specify

### Criteria 3: Harmful algal blooms

---

#### Criteria 3 (Harmful algal blooms) Monitoring method

---

This information was already collected to prepare the EEA lists. In case you didn't send details on methods used for D5C3 assessment before, please include this information in the space below

#### Criteria 3 (Harmful algal blooms) Threshold value assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment  
 Other

c) If your answer to question b was RSC please specify

- HELCOM  
 OSPAR  
 UNEP-MAP  
 Black Sea Commission

d) If your answer to question b was "Other" please specify

### Criteria 4: Photic limit of the water column

---

#### Criteria 4 (Photic limit of the water column) Monitoring method

---

a.1) Monitoring method used

	Open sea	Coastal waters
--	----------	----------------

Photic limit of the water column: Water clarity: Average Secchi depth	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer to the previous question was "other" please specify

b) Assessment period (years)

c) Assessment season (if applicable)

d) Assessment depth (if applicable)

## Criteria 4 (Photic limit of the water column) Threshold value assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment  
 Other

c) If your answer to question b was RSC please specify

- HELCOM  
 OSPAR  
 UNEP-MAP  
 Black Sea Commission

d) If your answer to question b was "Other" please specify

## Criteria 5: Dissolved oxygen in the bottom of the water column

---

## Criteria 5 (Dissolved oxygen in the bottom of the water column) Monitoring method

---

a.1) Monitoring method used

	Open sea	Coastal waters
Average oxygen debt below the halocline	<input type="checkbox"/>	<input type="checkbox"/>
Annual mean autumn bottom oxygen concentration from the lower quartile (mg/l)	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer to the previous question was "other" please specify

b) Assessment period (years)

c) Assessment season (if applicable)

d) Assessment depth (if applicable)

## Criteria 5 (Dissolved oxygen in the bottom of the water column) Threshold value assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment  
 Defined from the 95 percentiles during the pre-eutrophied period  
 Other

c) If your answer to question b was RSC please specify

- HELCOM

- OSPAR
- UNEP-MAP
- Black Sea Commission

d) If your answer to question b was "Other" please specify

## Criteria 6: Opportunistic macroalgae of benthic habitats

---

### Criteria 6 (Opportunistic macroalgae of benthic habitats) Monitoring methods

---

a.1) Monitoring method used

	Open sea	Coastal waters
WFD indicators on macrophytes	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer to the previous question was "other" please specify

b) Assessment period (years)

c) Assessment season (if applicable)

d) Assessment depth (if applicable)

### Criteria 6 (Opportunistic microalgae of benthic habitats) Threshold values assessment

---

a) Are threshold values defined for this criteria?

- Yes
- No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment
- Other

c) If your answer to question b was RSC please specify

- HELCOM
- OSPAR
- UNEP-MAP
- Black Sea Commission

d) If your answer to question was "Other" please specify

## Criteria 7: Macrophyte communities of benthic habitats

---

### Criteria 7 (Macrophyte communities of benthic habitats): Monitoring methods

---

a.1) Monitoring method used

	Open sea	Coastal waters
WFD indicators on macrophytes	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer to the previous question was "other" please specify

b) Assessment period (years)

c) Assessment season (if applicable)

d) Assessment depth (if applicable)



## Criteria 7 (Macrophyte communities of benthic habitats): Threshold values assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment  
 Other

c) If your answer to question b was RSC please specify

- HELCOM  
 OSPAR  
 UNEP-MAP  
 Black Sea Commission

d) If your answer to question b was "Other" please specify

## Criteria 8: Macrofaunal communities of benthic habitats

---

### Criteria 8 (Macrofaunal communities of benthic habitats): Monitoring methods

---

a.1) Monitoring method used

	Open sea	Coastal waters
Relative proportion of sensitive and tolerant species	<input type="checkbox"/>	<input type="checkbox"/>
Species richness and abundance	<input type="checkbox"/>	<input type="checkbox"/>
Biomass of benthic organisms	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>	<input type="checkbox"/>

a.2) If your answer to the previous question was "other" please specify

b) Assessment period (years)

c) Assessment season (if applicable)

d) Assessment depth (if applicable)

## Criteria 8 (Macrofaunal communities of benthic habitats): Threshold values assessment

---

a) Are threshold values defined for this criteria?

- Yes  
 No

b) If your answer to the previous question was "Yes", please specify the method used to establish the threshold values

- Regional Sea Convention (RSC) Assessment  
 Other

c) If your answer to question b was RSC please specify

- HELCOM  
 OSPAR  
 UNEP-MAP  
 Black Sea Commission

d) If your answer to question b was "Other" please specify

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