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Agenda Item 7: Updated IMAP Guidance Factsheets for Common Indicators 13, 14, 15,16, 17, 18, 20 and 21; New proposal for Candidate Indicators 25, 26 and 27

Updated Thematic Assessments of the Eutrophication and Contaminants Status in the Mediterranean Marine Environment, as a Contribution to the 2019 State of Environment and Development Report (SoED)

UNEP/MAP
Athens, 2019

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22 March 2019
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Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring

Podgorica, Montenegro, 2-3 April 2019

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

Updated Thematic Assessments of the Eutrophication and Contaminants Status in the Mediterranean Marine Environment, as a Contribution to the 2019 State of Environment and Development Report (SoED)

UNEP/MAP
Athens, 2019

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Note by the Secretariat

The 2017 Mediterranean Quality Status Report (2017 MED QSR) was adopted by Decision 23/6 at the 20th Meeting of the Contracting Parties to the Barcelona Convention (Tirana, Albania, December 2017), as the first holistic assessment of the marine environment based on IMAP Common Indicators. It was prepared following the mandate given to the Secretariat by the Decision Decision IG.21/3 of the 18th Meeting of the Contracting Parties (Istanbul, Turkey, December 2013) on the Ecosystems Approach, including definitions of Good Environmental Status (GES) and targets and Decision IG.22/7of the 19th Meeting of the Contracting Parties (Athens, Greece, February, 2016) on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria.

During the period 2016-2018, MEDPOL data base has been updated with new datasets submitted by several Contracting Parties that are related to Common Indicators 13 and 14 (Egypt (2012, 2015), France (2013-2016), Israel (2013, 2015), Montenegro (2016-2017), Morocco (2013-2015), Tunisia (2015), Turkey (2014-2015)) and Common Indicator 17 (France (2015- 2016), Israel (2015), Montenegro (2016-2017), Slovenia (2016), Turkey (2014, 2015)).

Consequently, this document presents an update of the previous spatial regional assessments performed during the elaboration of the Med QSR 2017 for EO5 and EO9 aimed at updating the findings on the status of marine environment in the Mediterranean Sea, as well as contributing to the preparation of the State of Environment and Development Report 2019 (SoED) in line with the UNEP/MAP Programme of Work 2018-2019 and further guiding the needs to balance the environment and development in the Mediterranean region.

In line with Decision IG.23/6 related to 2017MED QSR adopted at COP 20 COP20 (Tirana, Albania, December 2017), the Contracting Parties and the Secretariat are encouraged to test updated assessment criteria for indicative purposes in the different contexts that exist in the Mediterranean. Therefore, the assessments provided in this document use the updated IMAP assessment criteria for contaminants recommended by Decision IG.23/6 and previously considered at the Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring (Marseille, France, 19-21 October 2016), Meeting of the MED POL Focal Point (Rome, May 2107) and 6th Meeting of the Ecosystem Approach Coordination Group (Athens, Greece, 11 September 2017). Furthermore, the assessment findings provided in this document are based on further estimated sub-regional Mediterranean background assessment concentrations (Med BACs) calculated from the background concentrations (BCs) recommended at sub-regional scale for heavy metals in biota, whilst the sediment sub-regional Med BACs have been considered but not applied.

Although more elaborated assessment criteria were applied, new updated assessment findings confirm GES achievement as provided in 2017 MED QSR is maintained..

List of Abbreviations / Acronyms

ADR	Adriatic Sea sub-region
AEL	Aegean and Levantine Seas
Cd	Total cadmium
CEN	Central Mediterranean Sea
CI	Common Indicator
CORMON	Correspondence Group on Monitoring
COP	Conference of the Parties
BC	Background Concentration
BAC	Background Assessment Criteria
EAC	Environmental Assessment Criteria
EcAp	Ecosystem Approach
EEA	European Environmental Agency
EO	Ecological Objective
EU	European Union
GES	Good Environmental Status
HELCOM	Baltic Marine Environment Protection Commission - Helsinki Commission
Hg/HgT	Total mercury
IMAP	Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria
MAP	Mediterranean Action Plan
Med BAC	Mediterranean BAC (MEDPOL datasets)
Med BC	Mediterranean BC (MEDPOL data sets)
MED POL	Programme for the Assessment and Control of Marine Pollution in the Mediterranean Sea
MED QSR	Mediterranean Quality Status Report
MRU	Marine Reporting Unit
MSFD	Marine Strategy Framework Directive
PAHs	Polycyclic Aromatic Hydrocarbons (group of petroleum hydrocarbons compounds)
Pb	Total lead
OCs	Organochlorinated compounds (group of compounds including PCBs and Pesticides)
OSPAR	Convention for the Protection of the Marine Environment for the North-East Atlantic
PoW	Programme of Work
WMS	Western Mediterranean Sea region

1. Eutrophication Status in the Mediterranean Marine Environment (Ecological Objective 5)

1.1 Background

Eutrophication is a process driven by enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of nutrients causing changes to the balance of organisms; and water quality degradation (IMAP, 2017). Seawaters depending on nutrient loading and phytoplankton growth are classified according to their level of eutrophication. Low nutrient/ phytoplankton levels characterize oligotrophic areas, water enriched in nutrients is characterized as mesotrophic, whereas water rich in nutrients and algal biomass is characterized as eutrophic. The Mediterranean is one of the most oligotrophic seas in the world and most of its biological productivity takes place in the euphotic zone (UNEP, 1989, UNEP/MAP, 2012). The development of nutrient/phytoplankton concentration scales has been a difficult task for marine scientists because of the seasonal fluctuations of nutrient and phytoplankton concentrations, phytoplankton patchiness and small-scale eutrophication phenomena. Although long-term scientific research (UNEP/FAO/WHO1996; Krom*et al.*, 2010) has shown that the main body of the Mediterranean Sea is in good condition, there are coastal areas, especially in enclosed gulfs near big cities in estuarine areas and near ports, where marine eutrophication is a serious threat.

1.2. Methodology

The updated assessments of the eutrophication status of the Mediterranean Sea follows the same methodology used in MED QSR 2017.Coastal water types (reference conditions) and boundaries were only agreed and adopted in the IMAP decision of 2016 (UNEP/MAP, 2016), for chlorophyll *a* in the Mediterranean Sea (i.e. CI14), however, due to the lack of new data and not defined reference conditions and boundaries for key nutrient concentrations in water column the assessment could not be performed (i.e. CI13) yet, only general comments will be applied. The main statistical analysis is based on the typology criteria and settings derived from the analysis of influence of freshwater inputs as the main nutrient drivers as shown below (more information is presented in document UNEP(DEPI)/MED WG 417/Inf.15):

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

As it can be seen, the Coastal water type III was split in two different sub basins, the western and the Eastern Mediterranean, according to the different trophic conditions and is well documented in literature. Thus, it is recommended to define the major coastal water types in the Mediterranean Sea to assess eutrophication (applicable for phytoplankton only; Table 1).

Table 1. Major coastal water types in the Mediterranean

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

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

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

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

* applicable to Gulf of Lion
** applicable to Adriatic

For the presentation of the data, in this document, the Box and Whisker plots are used. The statistical information contained in the plot are: Hspreads (interquartile range - the absolute value of the difference between the values of the two hinges) and fences that define outside and far outside values. Therefore:

Lower inner fence = lower hinge - (1.5 • (Hspread))
Upper inner fence = upper hinge + (1.5 • (Hspread))
Lower outer fence = lower hinge - (3 • (Hspread))
Upper outer fence = upper hinge + (3 • (Hspread))

The whiskers show the range of observed values that fall within the inner fences.

1.3. Data compilation for IMAP EO5 (CI13 and CI14)

The new datasets for the period 2014-2016 in the MED POL Database for each country are shown in Table 3. These datasets were received by the Secretariat in 2017 and 2018 and are used to replace or to add updated information on the regional assessments. In this assessment, whilst aware that for most of the northern Mediterranean countries data are available also in other databases (i.e. EEA, EIONET, EMODnet), only datasets obtained from the MED POL Database for chlorophyll *a* were used.

Table 3. Datasets from the MED POL Database in the updated eutrophication assessment for the Mediterranean Sea in this document.

Online Med QSR 2017 and (UNEP(DEPI)/MED WG.444/8 EcAp Coordination Meeting, September 2017, Athens)		Updated	Remarks
Country	Provided data		
Albania	2005-2006	*Idem*	
Algeria	-	2012	
Bosnia and Hercegovina	2006-2008	*Idem*	

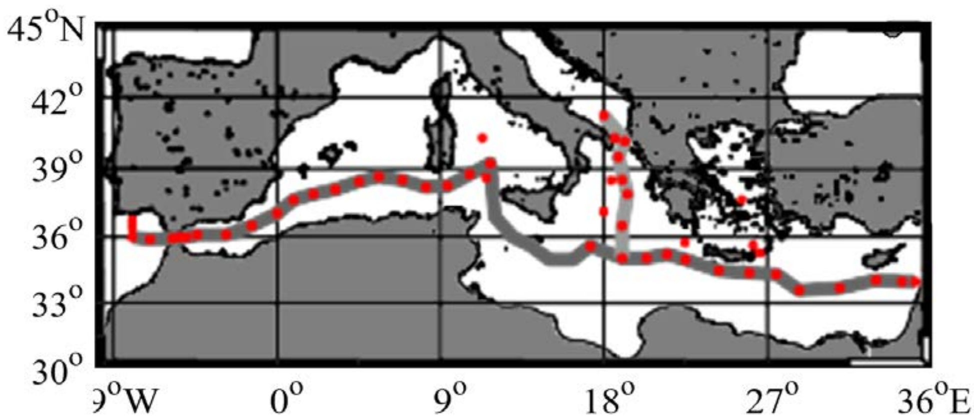
Croatia	2009, 2011-2014	*Idem*	
Cyprus	1999-2015	*Idem*	
Egypt	2009-2010	2012, 2015	
France	2009-2012	2013-2016	Provided only data for chlorophyll *a* concentration
Greece	1999-2000, 2004-2006	*Idem*	
Israel	2001-2012	2013, 2015	
Italy	-	*Idem*	
Libya	-	*Idem*	
Malta	-	*Idem*	
Monaco	-	*Idem*	
Montenegro	2008-2012, 2014-2015	2016-2017	
Morocco	2006-2008	2013-2015	
Syria	2007	*Idem*	
Slovenia	1999-2013, 2015-2016	*Idem*	
Spain	-	*Idem*	
Tunisia	2002-2013	2014	
Turkey	2005-2009, 2011, 2013	2014-2015	

1.4. Updated regional and sub-regional assessments

Common Indicator 13. Key nutrients concentration in water column – general comments on the status including trends in line with available literature data

Below general comments on the status and trends based on the findings of 2017 MED QSR are presented.

The highly populated coastal zone in the Mediterranean and the riverine input from a draining area of 1.5 10^6 km^2 (Ludwig *et al.*, 2009) induce eutrophic trends in coastal areas. The offshore waters of the Mediterranean have been characterized as extremely oligotrophic with a clear gradient toward east (Turley, 1999). The gradient is illustrated in Figure 1, from data collected during the Meteor M84/3 cruise (Tanhua*et al.* 2013).



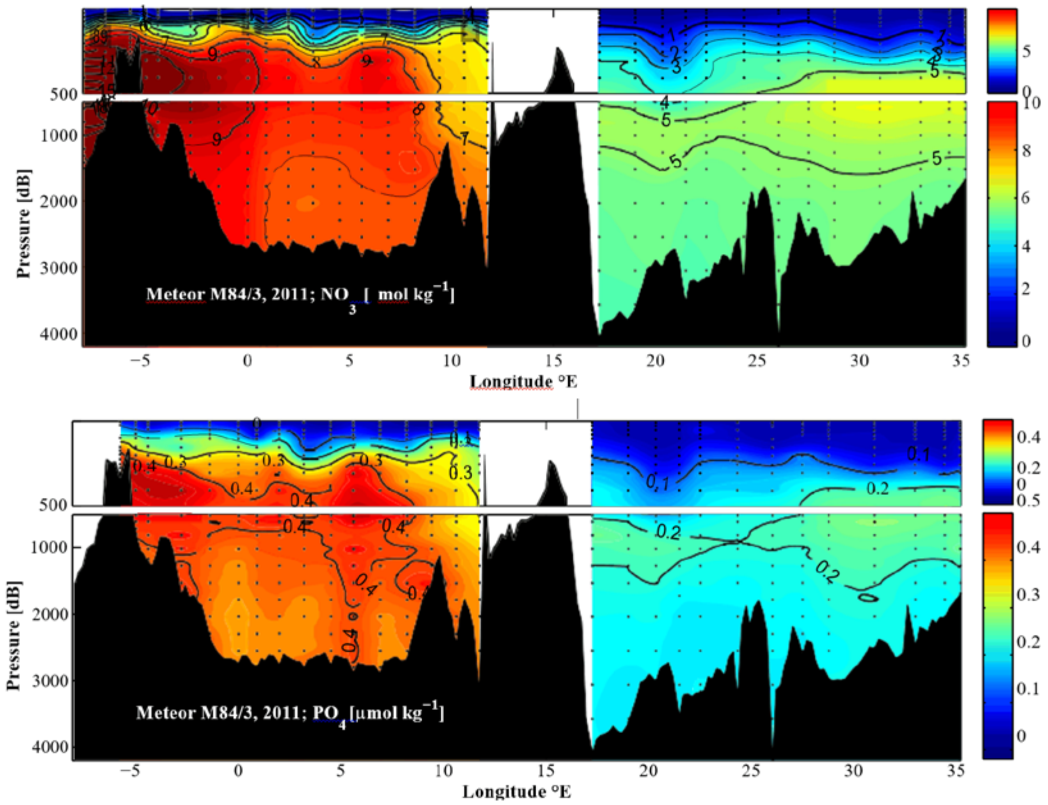


Figure 1. Distribution of nitrate (NO_3) and phosphate (PO_4) concentrations along a profile from off the coast of Lebanon to the Strait of Gibraltar during spring 2011. Data were collected during the Meteor 84/3 cruise. Reproduced from: Tanhua*et al.*, 2013.

It is observed that the Eastern Mediterranean Sea (EMS) is still the most oligotrophic area of the Mediterranean basin. This is due to the low nutrient content of EMS; the maximum concentrations recorded for nitrate were about 6 μmol L^{-1}, for phosphate 0.25 μmol L^{-1}, and for silicate 10–12 μmol L^{-1}, with the nitrate to phosphate ratio (N/P) >20 and in deep waters about 28:1, the EMS has been characterized as the largest phosphorus-limited body of water in the global ocean.

The coastal area of the south-eastern part of the Mediterranean shows clearly eutrophic trends. Although the River Nile is the major water resource in the area, its freshwater fluxes are becoming limited because of the Aswan Dam and increasing trends in anthropogenic water use in the lower Nile. Eutrophic conditions in the area are mainly induced by the sewage effluents of Cairo and Alexandria. The Northern Aegean shows mesotrophic to eutrophic trends. This can be explained by the river inputs from northern Greece and the water inflow from the nutrient rich Black Sea.

The nutrient regime and primary productivity in the Western Mediterranean Sea (WMS) are relatively higher compared to the EMS. There is limited nutrient supply through the Strait of Gibraltar due to different nutrient concentrations between the Atlantic and Mediterranean waters. The surface water entering from the Atlantic carries nutrients directly available for photosynthesis (EEA 1999) but at low concentrations. The phosphorus (phosphate) concentrations in the inflowing waters ranges from 0.05 to 0.20 μmol L^{-1}, the nitrogen (nitrate) concentrations being about 1–4 μmol L^{-1}, and the silicon (silicate) concentration is about 1.2 μmol L^{-1} (Coste*et al.* 1988). The nutrients of the surface layer are reduced as they propagate eastwards due to mixing with poor basin water and nutrient use by phytoplankton. However, the primary productivity of the main WMS, away from the coastal areas and influenced by rivers and urban agglomerations, is still higher than the primary productivity in the EMS.

The main coastal areas in the Mediterranean which are historically known to be influenced by natural and anthropogenic inputs of nutrients are the Gulf of Lions, the Gulf of Gabes, the Adriatic, Northern Aegean and the SE Mediterranean (Nile–Levantine). A recent work on nutrient and phytoplankton distribution along a large-scale longitudinal east–west transect (3 188 km) of the Mediterranean Sea extended over nine stations was published by Ignatiades*et al.* (2009). The results confirmed the oligotrophic character of the area and the nutrient and chlorophyll gradient characterized by decreasing concentrations from Gibraltar to the Levantine Sea. Phosphate maxima ranged from 0.05 to 0.26 μmol L^{-1}, nitrate from 4.04 to 1.87 μmol L^{-1}, chlorophyll *a* (chl*a*) from 0.96 to 0.39 μg L^{-1}.

The results of MED QSR 2017 assessment show that, in areas were assessmentis possible, the key nutrient concentrations in water column are in ranges characteristic for coastal areas and in line with the main processes undergoing in the interested area. The results also confirm the validity of this indicator as support in assessing eutrophication. Coastal Water type assessment criteria for reference condition and boundaries for key nutrients in the water column have to be built and harmonised through the Mediterranean region, which will greatly help the implementation of a clear sampling strategy with a simplified approach in monitoring design and data handling for the future implementation of IMAP.

Whilst data was available through the MEDPOL database, and substantial data is also available through EEA, EMODnet-Chemistry (http://www.emodnet-chemistry.eu/) and other sources, priority should be given to ensure Mediterranean countries regularly report quality assured data nutrient data to UNEP/MAP in line with IMAP, and ensure common reporting. Potential integration of datasets in the future could be considered with EMODnet-Chemistry.

Common Indicator 14. Chlorophyll a concentration in water column – assessment of present status, including trends

Below the status and trends based on updated findings of 2017 MED QSR are presented.

The blue offshore waters of the Mediterranean Sea have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards (Turley, 1999). Eutrophication and oligotrophy in the Mediterranean are illustrated as chlorophyll *a* distribution in remote sensing imagery (Figure2). This is due to the low nutrient content of EMS which has been characterized as the largest phosphorus-limited body of water in the global ocean.

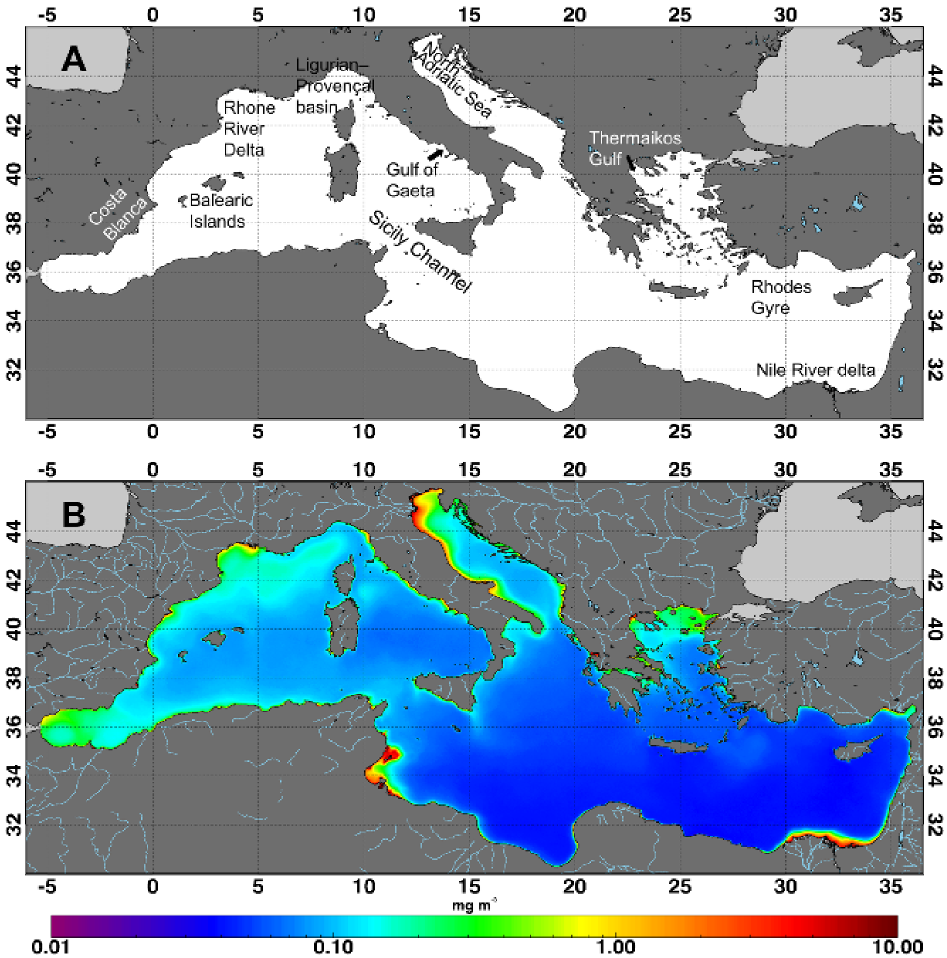


Figure 2. The Mediterranean basin and its chlorophyll *a* concentration pattern. (A) Geographic regions (B) chlorophyll a concentration (µg L^{-1}) climatology over the Mediterranean Sea relative to 1998–2009 time period. From: Colella *et al.*, 2016.

The coastal area of the south-eastern part of the Mediterranean shows clearly eutrophic trends. Although the River Nile is the major water resource in the area, its freshwater fluxes are becoming limited because of the Aswan Dam and increasing trends in anthropogenic water use in the lower Nile. Eutrophic conditions in the area are mainly induced by the sewage effluents of Cairo and Alexandria. The Northern Aegean shows mesotrophic to eutrophic trends. This can be explained by the river inputs from northern Greece and the water inflow from the nutrient rich Black Sea (Karydis and Kitsiou, 2012).

The main coastal areas in the Mediterranean which are historically known to be influenced by natural and anthropogenic inputs of nutrients are the Gulf of Lions, the Gulf of Gabes, the Adriatic, Northern Aegean and the SE Mediterranean (Nile–Levantine). A recent work on nutrient and phytoplankton distribution along a large-scale longitudinal east–west transect (3 188 km) of the Mediterranean Sea extended over nine stations was published by Ignatiades et al. (2009). The results confirmed the oligotrophic character of the area and the nutrient and chlorophyll gradient characterized by decreasing concentrations from Gibraltar to the Levantine Sea.

The results of assessment and status of chlorophyll *a* concentration in the water column based on the updated data available in the MEDPOL data base are presented in Figures 4-10. The Figure 3 represents the distribution of water types around the Mediterranean where the typology criteria were applicable.

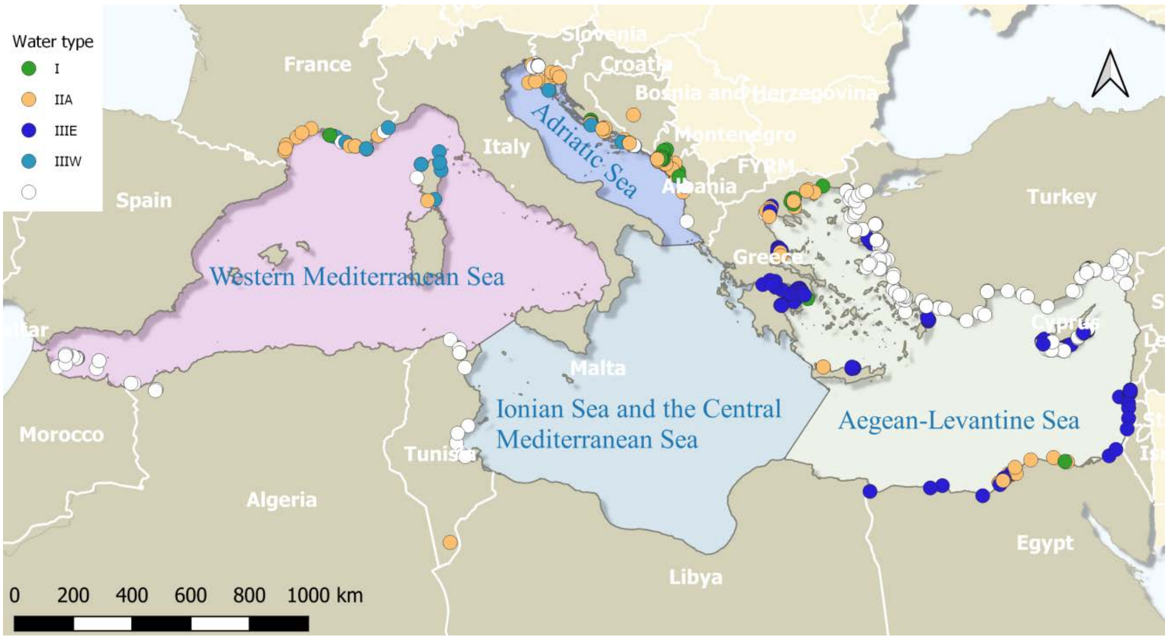


Figure 3. Stations in the Mediterranean region for which eutrophication parameter were sampled. Also shown the water types (applicable for phytoplankton; Decision IG.22/7) were applicable.

In Figures 4-13, the assessment data for all four sub-regions applying the Coastal Water types reference conditions and boundaries in the Mediterranean are presented. For the Western Mediterranean Sea sub-region (Figure4) only a set of data for France (from 2009 to 2016) were assessed indicating that none of the stations in the Golf of Lyon were in moderate state.

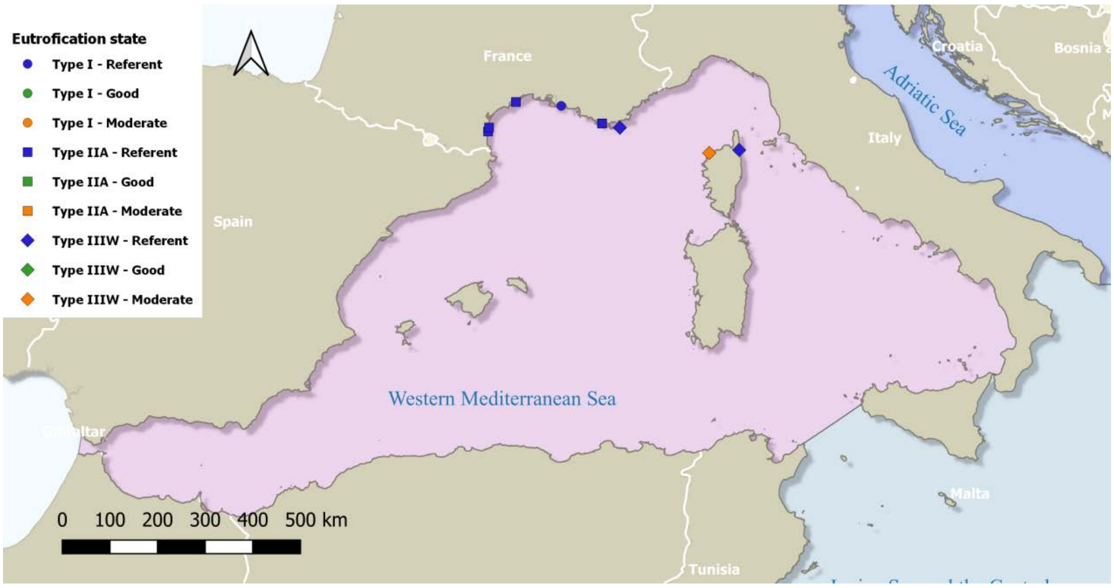
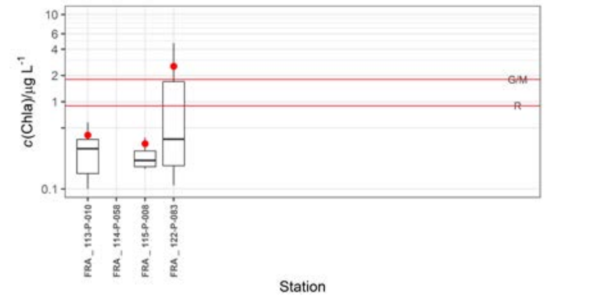


Figure 4. Stations in the Western Mediterranean Sea sub-region for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; Decision IG.22/7) for were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

Type I

Type II – FR-ES



Type IIIW – FR-ES

Figure 5. Box and whisker plot for chlorophyll *a* concentration in the Western Mediterranean sub-region by water type. For coastal Water types reference conditions and boundaries in the Mediterranean were applied for France (FRA) for the new 2016 datasets. The boundary values are related to the 90th percentile (red lines) and the data one with the red dot.

The evaluation for the last supplied year (2016) shows that all the stations are in the reference state with the exception of a station in the Corsica region (Fig. 5). When the data for all the available years are analysed (Fig. 6) it shows a pronounced interannual variability in the reference range for all stations.

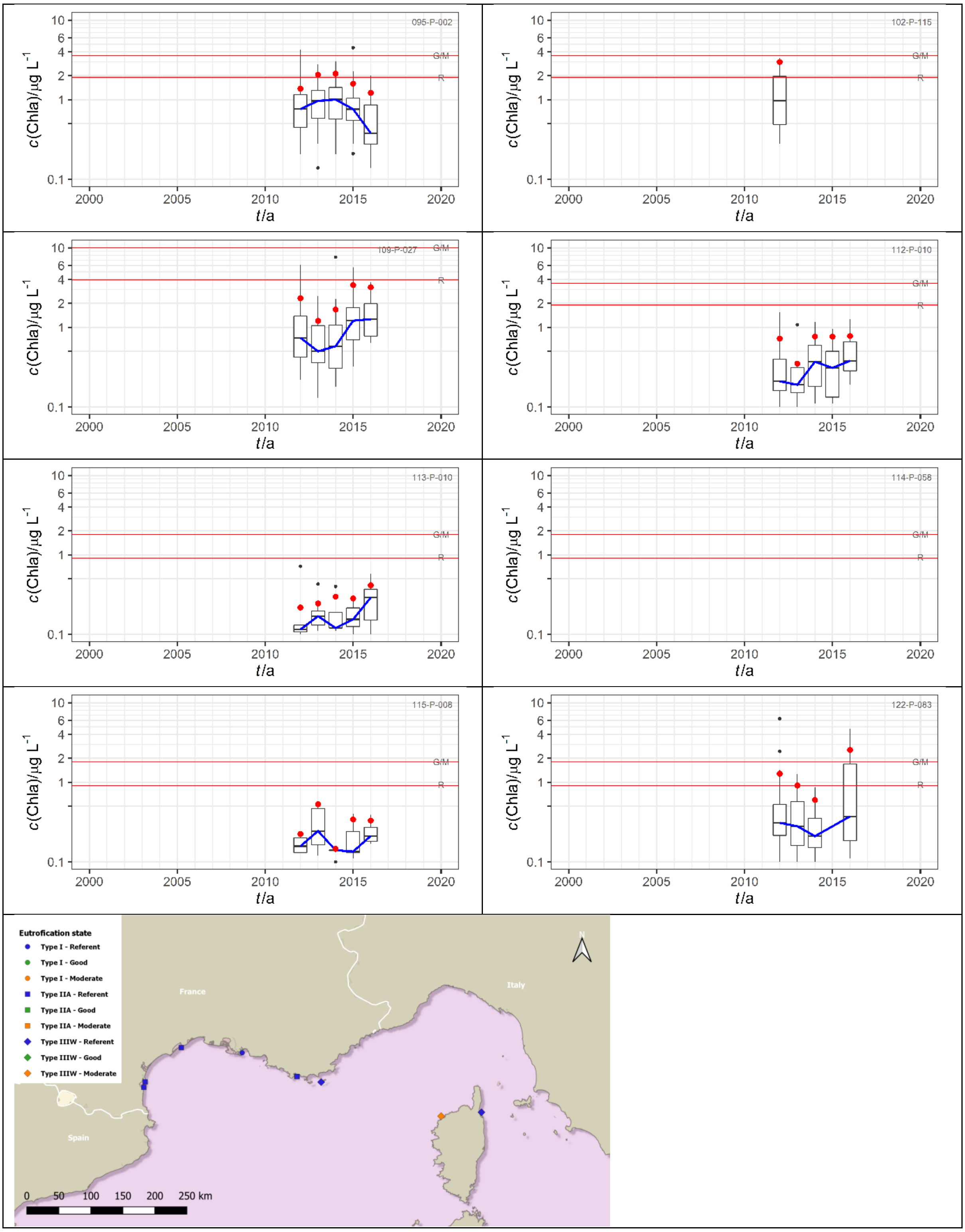


Figure 6. Boxplot representation of concentration of chlorophyll *a*(c) by year (a) at six stations along the French coast. The two red lines represent the boundaries between referent and good as well as good and moderate state. The blue line represents the mean of the annual values, as the ordinate is logarithmic, it is in fact the geometric mean. The red dots represent the 90th percentile.

In the Adriatic Sea sub-region (Figures7-11) only the eastern part was assessed (Slovenia, Croatia and Montenegro). The applied criteria show that all the stations in the assessed area at list in good status in relation to the criteria. The Box and Whisker plot (Figure7-11) shows even more details. Such a graphical representation is very useful for a geographical assessment and represent a good potential for the time series analysis as shown on Figures 9-11.

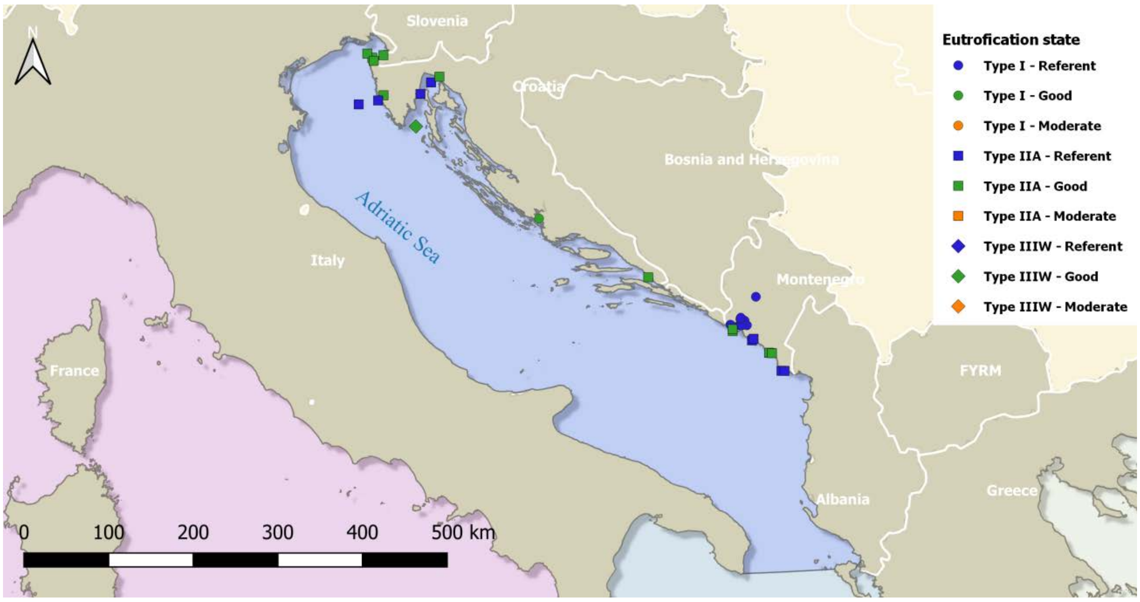
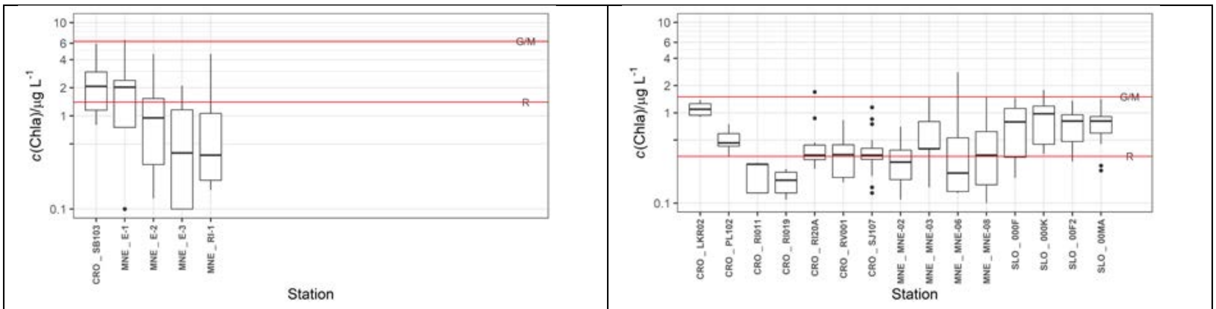
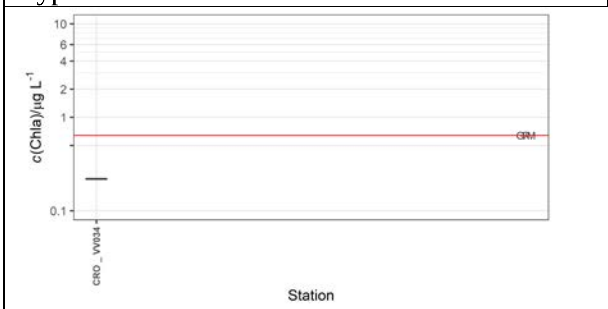


Figure 7. Stations in the Adriatic Sea sub-region for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; Decision IG.22/7) for were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)



Type I	Type IIA - Adriatic



Type IIIW

Figure 8. Box and whisker plot for chlorophyll *a* concentration in the Adriatic Sea sub-region by water type. For coastal Water types reference conditions and boundaries in the Mediterranean were applied for Croatia (CRO), Montenegro (MNE) and Slovenia (SLO).

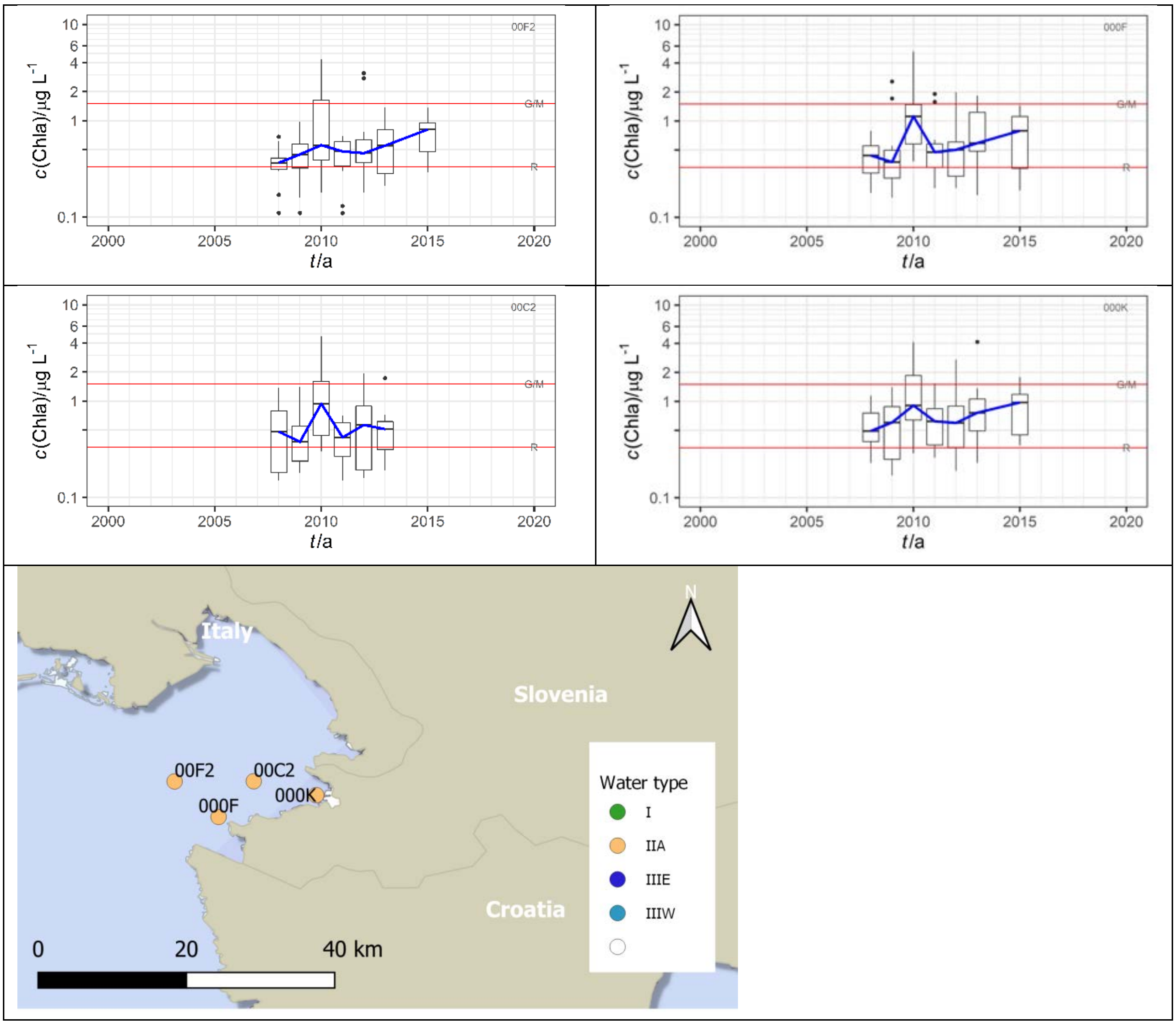


Figure 9. Boxplot representation of concentration of chlorophyll *a*(c) by year (a)at two stations along the Slovenian coast. The stations are of type IIA. The two red lines represent the boundaries between referent and good as well as good and moderate state. The blue line represents the mean of the annual values, as the ordinate is logarithmic, it is in fact the geometric mean.

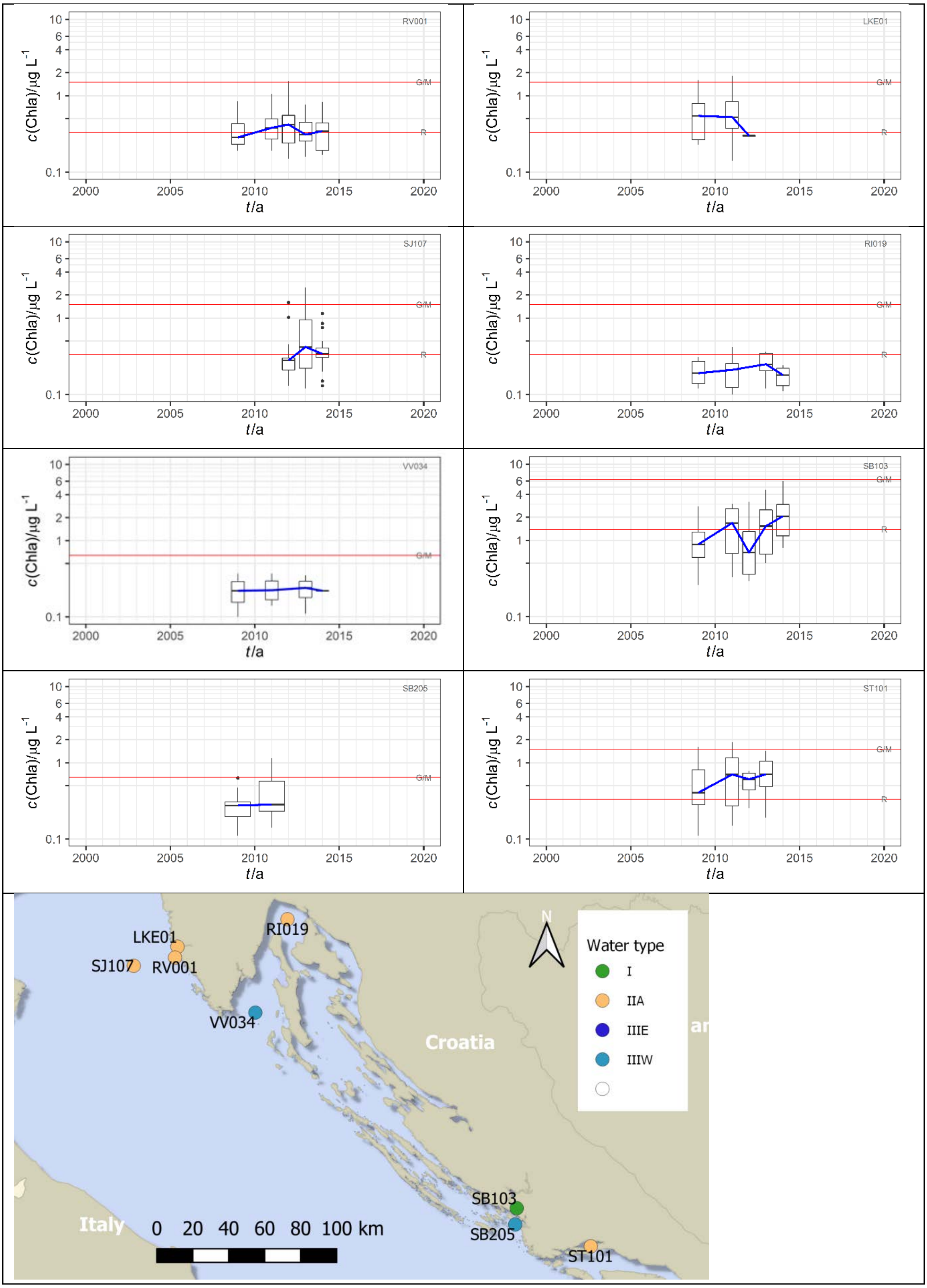


Figure 10. Boxplot representation of concentration of chlorophyll *a*(c) by year (a)at eight stations along the Croatian coast. The stations are of type IIA. The two red lines represent the boundaries between referent and good as well as good and moderate state. The blue line represents the mean of the annual values, as the ordinate is logarithmic, it is in fact the geometric mean.

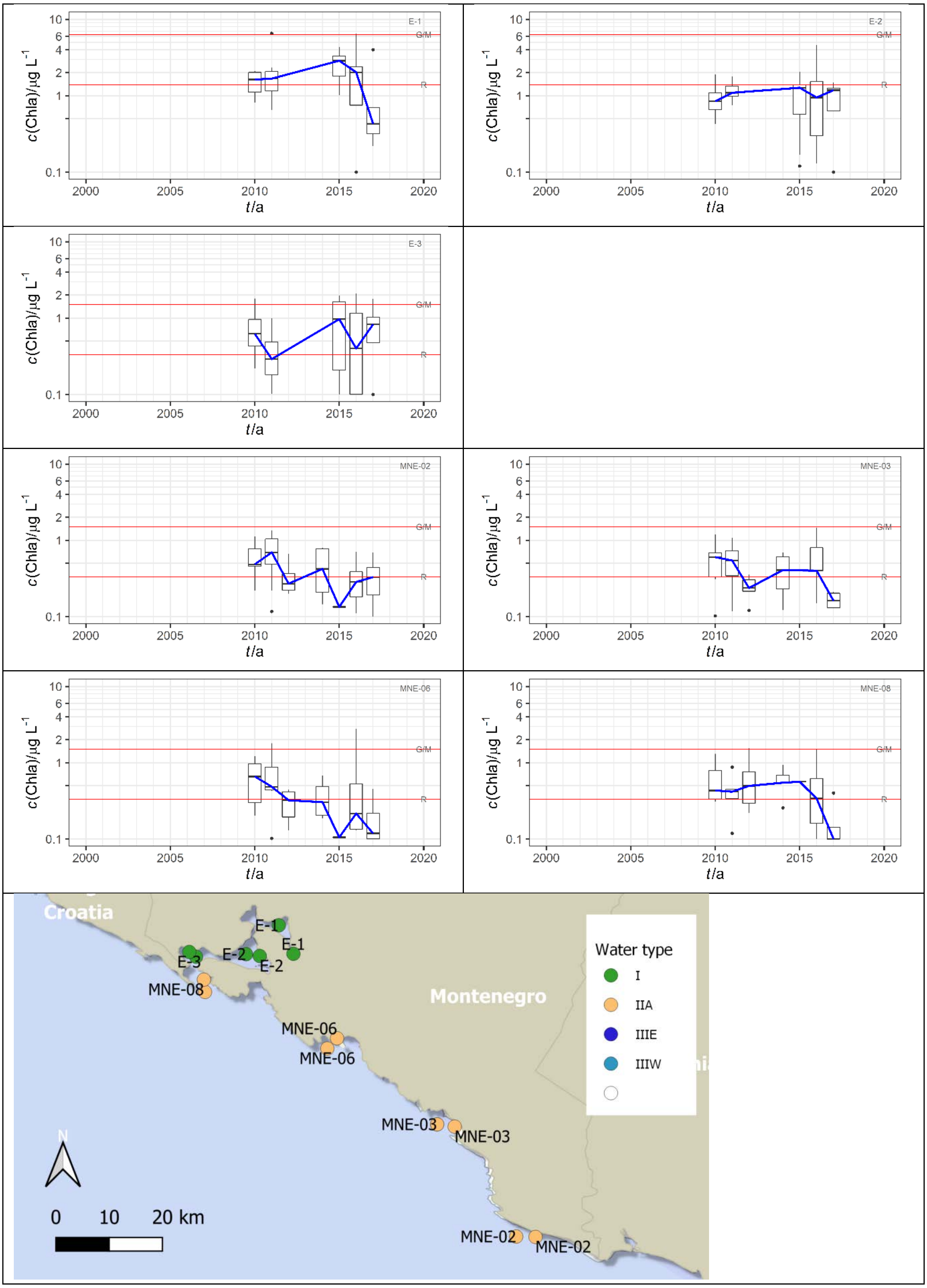


Figure 11. Boxplot representation of concentration of chlorophyll *a*(c) by year (a)at seven stations along the Montenegro coast. The stations are of type IIA. The two red lines represent the boundaries between referent and good as well as good and moderate state. The blue line represents the mean of the annual values, as the ordinate is logarithmic it is the geometric mean.

For the Ionian Sea and the Central Mediterranean Sea sub-region, as already stated in 2017 MED QSR, the assessment was not performed as insufficient data were available.

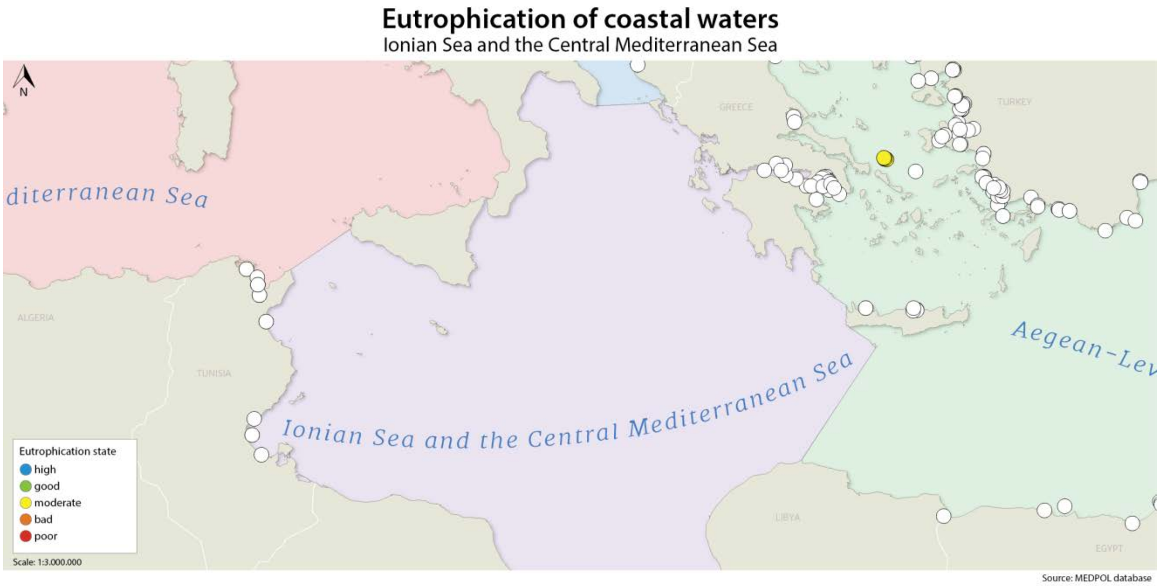


Figure 12. Stations in the Ionian Sea and the Central Mediterranean Sea subregion for which eutrophication were assessed (Med QSR 2017).

For the Aegean-Levantine Sea sub-region (Figure 13) in this iteration the status could not be assessed. The previous assessment (i.e. Med QSR2017) shown that applied criteria (Water type IIIE) indicated that practically all the stations in the Cyprus area are in good status. For Israel and Mersin area (Turkey) the assessment indicated that the areas presented a moderate state. Probably, the assessment criteria for Water type IIIE in this area are too rigorous because they are close to the coast and ports.

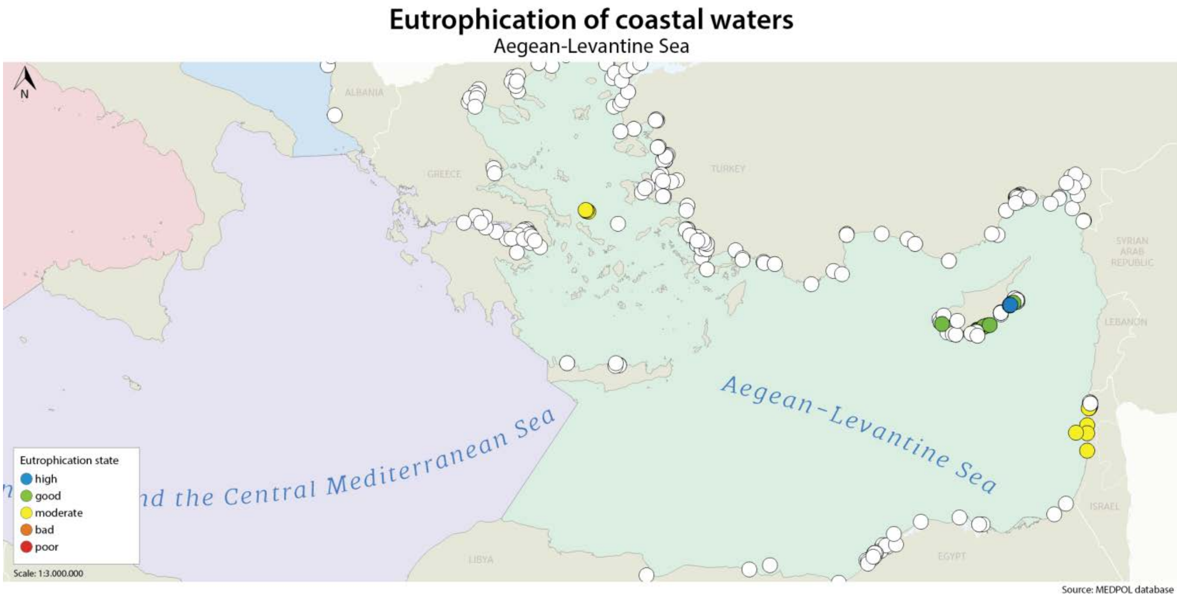


Figure 13. Stations in the Aegean-Levantine Sea sub-region for which eutrophication were assessed (Med QSR 2017).

As already stated in Med QSR2017 the new evaluation for France and the eastern Adriatic coast (Croatia, Montenegro and Slovenia) confirms that to detect a significant chlorophyll *a* trend, long time data series monitoring are necessary to be able to capture biomass changes in coastal waters. The analysis of short time series can lead to misinterpret some spatial patterns produced by random processes, as chlorophyll *a* concentration trend changes.

Alternatively, satellite synoptic measurements for the estimation of chlorophyll *a* concentration trends have the potential to detect anomalous, local biogeochemical processes and to assess the different requirements of environmental regulations. Recent use of this data (Colella *et al.*, 2016) allowed for a consistent monitoring of biogeochemical parameters in the Mediterranean basin. In this paper, at large scale, positive trends off the South-East Spanish coast, in the Ligurian–Provençal basin, and in the Rhodes Gyre region, while an intense negative trend in the North Adriatic Sea, off the Rhone River mouth, and in the Thermaikos Gulf (Aegean Sea) were detected.

This potential to assess eutrophication should be welcomed, however, the satellite framework might need of larger, multi-sensor datasets and it surely requires to be combined with the analysis of in situ supplementary biogeochemical data (e.g. field calibration).

1.5. Conclusion

Overall, the updated assessment reinforces the statement that the available data show that the IMAP assessment criteria for eutrophication based on CI14 (Chlorophyll a concentration in the water column) are applicable and confirm the main status of eutrophication in the coastal area. Compared to 2017 MED QSR findings on GES achievement, it confirms that near Cyprus the status is maintained also in France and Eastern Adriatic.

Coastal water type assessment criteria for reference condition and boundaries for CI13 (Key nutrients concentration in the water column), have to be built and harmonised through the Mediterranean region, which will greatly help the implementation of a clear sampling strategy with a simplified approach in monitoring design and data handling for the future implementation of IMAP. For CI14 (Chlorophyll a concentration in the water column) reference condition and boundaries have to be harmonised through the south Mediterranean region and assessment efforts further strengthen. The assessment can also help to identify areas were the criteria have to be improved.

There are no main gaps identified in the Mediterranean Sea concerning the assessment of the Common Indicator 14. However, at eutrophication hot spots in the Mediterranean Sea a comprehensive trend analysis of key nutrient concentrations in the water column would be beneficial. Moreover, significant chlorophyll a trend also needs to be assessed and for that purpose data availability have to be improved with a longer data series. For both, a possible approach is to additionally use data stored in other databases were some of the Mediterranean countries regularly contribute.

2. Contaminants Status in the Mediterranean Marine Environment (Ecological Objective 9)

2.1. Background

The impairment of marine ecosystem by chemical pollution is a consequence of the pressures (ca. activities) in the marine environment promoted by anthropogenic drivers. The sources of contaminants leading to pollution effects can be from natural origin (e.g. heavy and trace metals, polycyclic aromatic hydrocarbons) or synthetic man-made chemicals (e.g. pesticides); and however, for the former, if exceeds natural backgrounds could pose a threat to biodiversity and ecosystems. The chemical contaminants enter the marine ecosystem through three main routes: land-based sources, sea-based sources and atmospheric sources.

In the Mediterranean Sea, there are still both contamination and pollution threats, as well as new types of chemical contamination (e.g. pharmaceuticals, personal care products, flame retardants), although the trends and levels of the so called legacy pollutants (e.g. heavy metals and persistent organic pollutants), have decreased significantly in many areas of the Mediterranean Sea after the successful implementation of environmental measures (e.g. leaded-fuels ban, mercury regulations, anti-fouling paints ban), as observed in the Western Mediterranean Sea (UNEP/MAP/MEDPOL, 2011a; Med QSR 2017).

The land-based sources of contaminants enter the coastal and marine environment both via treated (or non-treated) wastewater discharges and represent a major input; whilst in terms of diffuse pollution sources, land-based run-off and atmospheric deposition (wet/dry deposition and diffusive exchange) are the two major contributors to the coastal ecosystems. The sea-based sources are generally point-source (e.g. oil extraction platforms) or diffuse (e.g. maritime traffic), which could be permanent chronic sources of pollution in the marine environment, including the potential for acute pollution events.

Within the Ecosystem Approach and the implementation of the Integrated Monitoring and Assessment Programme (IMAP), the main indicator to monitor progresses towards the GES achievement is the Common Indicator 17 (EO9 – Contaminants); and overall, the levels of chemicals should be maintained to avoid chronic effects and deterioration trends; as well as, accompanied by the reduction of contaminant emissions form land-based and sea-based sources (UNEP/MAP, 2013; UNEP/MAP, 2015).

2.2. Methodology

The updated assessments of the contaminant status of the Mediterranean Sea follows the same methodology undertaken for the elaboration of the Med QSR 2017for CI17, with the particularity of using the updated set of assessment criteria recommended to be tested as per Annex II in Decision 23/6 of the 20th Meeting of the Contracting Parties (COP 20). The earlier assessment datasets for the Med QSR 2107 and the new datasets available from MED POL were revised and used to elaborate the revision of the Contaminants status in the Mediterranean Sea. The new datasets were replaced for each of the matrices at a regional and sub-regional scale for the whole Mediterranean Sea.

A limited number of monitoring datasets have been submitted to the Secretariat since the online publication of the Med QSR 2017. The new updated datasets in the Mediterranean mainly correspond to a small amount of additional data from bivalves and sediment monitoring for the years between 2014 and 2017 for few countries (France, Israel, Slovenia, Turkey and Montenegro). Data on heavy metals, namely, cadmium, mercury and lead, and organic compounds such as petroleum hydrocarbons and persistent organic pollutants (POPs), in line with requirements for IMAP EO9 CI17 were reported. As for the Med QSR 2017, however, the update of spatial assessments and percentages accounting the classification between assessment categories are solely performed for heavy metals and using as a basis the previous datasets with the replacement of the new datasets for these countries (Table 5).

The datasets reported for petroleum hydrocarbons (e.g. PAHs) and organochlorinated compounds (e.g. pesticides and PCBs) by few Contracting Parties and updated in the latest submissions are not sufficient to regionally assess the state of the Mediterranean marine environment as required under MED POL and IMAP yet, but serves to a national scale. In any case, this fact aggravates the lack of regional coverage in addition to mostly non-detected concentrations in biota and sediments matrices in the recent years for organic contaminants in general.

For these reason, scientific literature has been also included in the final section to provide a regional assessment combining the information from the MED POL database and the scientific knowledge, including petroleum hydrocarbons and organochlorinated compounds latest research (with sufficient spatial coverage). To this end, a bibliographic survey was undertaken in major specialized databases (e.g. Web of Science) to search for national research publications related to marine pollution in the last 10 years, followed with a selection of those publications which assessed the pollution status using a wider national spatial coverage, from one-off monitoring activities and reviews of scientific scattered data. Particularly, the selection targeted countries without recent updates to the MED POL Database, such as Spain, Italy, Morocco, Algeria, Tunisia, Libya, Egypt and Greece.

The environmental assessment criteria (EACs; either ECs or ERLs for biota and sediment matrices, respectively), were adopted at the COP19 in February 2016 for the Mediterranean Sea along the Integrated Monitoring and Assessment Programme - IMAP (Annex to the UNEP(DEPI)/MED IG. 22/7 Decision). At the COP20 in December 2017 it has been recommended to test the use of the updated assessment criteria (e.g. Med BACs) at regional and sub-regional calculated entirely with Mediterranean datasets (Annex II to the UNEP(DEPI)/MED IG. 23/6 Decision).

Therefore, in the updated assessments in this document, those assessment criteria (i.e. Med BACs) have been considered for the three different matrices evaluated, bivalves, fish and sediments. On the other hand, with respect the current EACs defining the potential for the occurrence of toxicological effects, it should be mentioned that these have not been agreed yet for Cd, Hg and Pb and the current values are based on European policy (EC/EU 1881/2006 and 629/2008 Directives for maximum levels for certain contaminants in foodstuffs) and US ERL values (US Effects Range Low sediment toxicological criteria), for biota and sediment samples, respectively. Despite this practical limiting fact this approach is aligned with other Regional Sea Conventions (e.g. OSPAR).

The species of bivalves (*Mytilus galloprovincialis, MG;Mactracorralina, MC and Donaxtrunculus, DT)*) and fish (*Mullus barbatus MB)* have been evaluated, as well as the coastal and platform sediment samples for the additional datasets submitted to the Secretariat (2014-2017). The methodology is based on the calculation of the percentages of stations (i.e. units) with levels below or above the BACs and above environmental criteria (ca. ECs and ERLs) and mapped for additional interpretations. As mentioned, the new received datasets by the Secretariat have been added or replaced to the earlier datasets assessed for the Med QSR 2017 (Table 5). In a similar manner, the latest year of reported datasets (or more than one year if alternate yearly sampling stations were monitoring, that is, different coordinates), including the new data sets, were selected allowing the maximum spatial coverage by matrix to construct updated regional state assessments. The temporal integration of the datasets continues to be difficult issue to resolve but reflects the temporal submission frequencies and availability of MED POL Datasets.

The biota (ca. bivalves and fish) datasets were examined to evaluate their consistence (i.e. coordinates, values, methods, DLs) before the selection of the latest dataset for an updated and regionally integrated assessment, as well as the units converted to dry weight or fresh weight in the case of bivalves and fish, respectively, if necessary. The sediment datasets from CPs, as mentioned, were mixed to provide a greater spatial coverage when locations changed for submitted years, as well as averaged when reported yearly replicate samples for the same station. Therefore, the units employed for the assessment were µg/kg dry weight (ppb) for bivalve samples (whole soft tissue) and µg/kg fresh weight (ppb) for fish (fillet tissue), whilst for sediments µg/kg dry weight (ppb). The levels of contaminants in sediment samples includes different fractions as available in the MED POL Database submitted by CPs and these were combined spatially for the evaluation (ranging from >63µm up to the whole sediment sample analysis), despite clearly provides a source of uncertainty when the assessment is performed regionally and should be taken into account for interpretation.

The use of the revised criteria to provide regional and sub-regional assessments has been a recommendation through Decision IG.23/6(Point 9. *Take note* of the proposed update of the pollution assessment criteria and thresholds as presented in Annex II to the present Decision and encourage the Contracting Parties and the Secretariat to test them for indicative purposes in the different contexts that exist in the Mediterranean) at COP20 (Tirana, Albania, December 2017).

Therefore, in this document, these revised assessment criteria (Table 4) developed in the document UNEP(DEPI)/MED WG.427/Inf.3 (Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring Marseille, France, 19-21 October 2016) and recommended by Decision IG. 23/6 (COP 20th, Tirana, Albania, 2018) are used. Furthermore, the tables below (Table 4a and 4b) show the estimated sub-regional Med BACs calculated from the background concentrations (BCs) recommended at sub-regional scale for heavy metals, and therefore, provide an update at sub-regional level of the Med BACs presented in Table 4 (where the first’s columns are also shown for mussel and sediments). However, the sediment sub-regional Med BACs (Table 4b) have been considered but not applied, as the value for HgT in the Adriatic Sea present high uncertainty and is above the regional ERL value for mercury pointing to the need of more reference data in the area. In any case, the mussel assessment criteria at sub-regional scale (Table 4a) have been used in the present update.

Table 4. Regional Mediterranean Sea Background Concentrations (Med BCs), Med BACs and EACs; Calculation =>BC = 50th (median); BAC=1.5 x BC (mussel, sediment); BAC=2.0 x BC (fish). These values were recommended by COP20 in December 2018 (Annex II to the UNEP(DEPI)/MED IG. 23/6 Decision and UNEP(DEPI)/MED IG.23/Inf.19).

	Mussel (MG) µg/kg d.w.			Fish (MB) µg/kg f.w.			Sediment µg/kg d.w.		
Trace metal	BC	Med BAC	EC*	BC	Med BAC	EC*	BC	Med BAC	ERL**
Cd	730.0	1095.0	5000	(3.7)[a]	(16.0)[b]	50	85.0	127.5	1200
Hg	115.5	173.2	2500	50.6	101.2	1000	53.0	79.5	150
Pb	1542	2313	7500	(31)[a]	(40)[b]	300	16950	25425	46700

[a]Cd value is below the detection limit (<BDL) and Pb presents a majority of non-detected values in monitoring datasets.
[b]estimated BACs from reliable limits of detection (BAC=1.5 x LOD) using analytical data and certified reference material information (DORM-2) (note liver tissues hould be recommended in fish for Cd and Pb as within OSPAR Convention). See UNEP(DEPI)/MED WG.427/Inf.3 for full details.
*EC/EU 1881/2006 and 629/2008 Directives for maximum levels for certain contaminants in foodstuffs
** Long et al. 1995 (idem OSPAR adopted values)

Table 4a. Sub-regional Mediterranean BCs and BACs (Med BACs) in *Mytilus galloprovincialis* (µg/kg d.w.) calculated for a purpose of this updated assessments in line with regional values

	Mediterranean Sea (regional)		Western Mediterranean (WMS)		Adriatic Sea (ADR)		Central Mediterranean (CEN)		Aegean-Levantine Seas (AEL)	
Trace metal	*MedBCs*	**Med BACs**	*WMS BCs*	**WMS BACs**	*ADR BCs*	**ADR BACs**	*CEN BCs*	CEN BACs	*AEL BCs*	**AEL BACs**
Cd	*730.0*	**1095.0**	*660.5*	**990.8**	*782.0*	**1173**	*Idem regional*		*942.0*	**1413**
HgT	*115.5*	**173.2**	*109.4*	**164.1**	*126.0*	**189**	*Idem regional*		*110.0*	**165**
Pb	*1542*	**2313**	*1585*	**2378**	*1381*	**2072**	*Idem regional*		*2300*	**3450**

Table 4b. Sub-regional Mediterranean BCs and BACs (Med BACs) in surface sediments (µg/kg d.w.) calculated for a purpose of this updated assessments in line with regional values, although the regional value was used (see text).

	Mediterranean Sea (regional)		Western Mediterranean (WMS)		Adriatic Sea (ADR)		Central Mediterranean (CEN)		Aegean-Levantine Seas (AEL)	
Trace metal	*Med BCs*	**Med BACs**	*WMS BCs*	**WMS BACs**	*ADR BCs*	**ADR BACs**	*CEN BCs*	CEN BACs	*AEL BCs*	**AEL BACs**
Cd	*85.0*	**127.5**	*91.2*	**136.8**	*92.3*	**138.5**	*Idem regional*		*56.0*	**84.0**
HgT	*53.0*	**79.5**	*60.0*	**90.0**	*106.8*	**(160.2)**	*Idem regional*		*31.2*	**46.8**
Pb	*16950*	**25425**	*20465*	**30697**	*13932*	**20898**	*Idem regional*		*4920*	**7380**

As mentioned above, it should be highlighted that solely the values in Tables 4 and 4b have been tested for the sub-regional and regional assessments in this document, whilst the sub-regional BACs for sediments are discussed but not used for spatial assessments and regional maps awaiting further confirmation when new reference datasets will be available.

2.3. Data compilation for IMAP EO9 (CI17)

The new data sets for the period 2014-2017 in the MED POL Database for each country and matrix are shown in Table 5. These datasets were received by the Secretariat in 2017 and 2018 and are used to replace or to add updated information on the regional heavy metals' assessments.

Table 5. Datasets from the MED POL Database in the updated contaminant assessment (heavy metals) for the Mediterranean Sea in this document.

MATRIX / COMPARTMENT	Online Med QSR 2017 and (UNEP(DEPI)/MED WG.444/8EcAp Coordination Meeting, September 2017, Athens)	Updated (in this document)
BIVALVES	Croatia (2009, 2011-2014)	*Idem*
	Egypt (2009-10)	*Idem*
	France (2012)	France (2015)
	Israel (2012-13, including 2011 for Pb)	Israel (2011 for Pb, 2013 and 2015)
	Italy (2009)	*Idem*
	Montenegro (2009-2011)	*Idem*
	Morocco (2015)	*Idem*
	Slovenia (2015)	Slovenia (2016)
	Spain (2011)	*Idem*
	Tunisia (2010-2013)	*Idem*
	Turkey (2009, 2011)	*Idem*
FISH	Cyprus (2014-2015)	*Idem*
	Greece (2005)	*Idem*
	Israel (2013)	Israel (2015, 2016 for one station)
	Spain (2006-08)	*Idem*
	Turkey (2013)	Turkey (2014-2015)
SEDIMENTS	Croatia (2011, 2013)	*Idem*
	Egypt (2006, 2009, 2010)	Egypt (2010 only)
	France (2009-2011)	France (2016)
	Greece (2005)	*Idem*
	Israel (2013)	Israel (2015)
	Italy (2009)	*Idem*
	Montenegro (2010-2011)	Montenegro (2016-2017)
	Morocco (2007 and 2015)	*Idem*
	Spain (2007-08, 2011)	*Idem*
	Tunisia (2012-13)	*Idem*
	Turkey (2013)	Turkey (2014-2015)

In brief, the added datasets characteristics are as follows:

France: biota and sediment monitoring results were reported for 2015 (*Mytilus galloprovincialis*) and 2016 (sediments), respectively. These datasets replaced the earlier stations assessed from 2012, including two new stations, for the areas in the southern French Mediterranean and Corsica. Datasets were submitted for heavy and trace elements, polycyclic aromatic hydrocarbons and organochlorinated compounds.

Slovenia: reported 2016 datasets for heavy metals in biota (*Mytilus galloprovincialis*) for historical station 00TM and the reference 0024 station, solely for Cd, HgT and OCs, and sediment datasets only for PAHs.

Montenegro: updated sediment data for heavy metals was available for 2014, 2016 and 2017 including OCs.

Israel: the coastal and hotspot stations for biota from 2011 for Pb were kept in the current assessment, namely, C18, C23,C39 and H8 as it was not further reported in 2013 or 2015; while the HgT was reported for 2015 in a number of other stations, as well as a lower number of data for Cd. In 2013 data was kept for stations H12 and C14 not reported in 2015. For sediments in 2015, the following stations were replaced with new values H1, H2, H8, H9, H10, H12 (hotspots) and C12, C18, C23 and C39 (coastal stations).

Turkey: new datasets for fish (*Mullus barbatus, MB*) were reported for the Mediterranean Sea and the Aegean Sea with an outstanding sampling strategy. In the Mediterranean Sea in 2015, samples were collected at five stations with five replicates for MB (each in pools of 6 individuals) taking into account their length (i.e. length averaged within the range 10.8 to 13.4 cm for the 25 sample pools; however, with a lower intra-pool variability at each station, namely, Tirtar/Mersin, Seyhan/Adana, Anamur/Mersin, Göksu/Mersin and Karataş/Adana). For 2014, solely two stations were selected from the datasets for the spatial assessment, thus, the rest of them were also included in 2015. The data was converted from dry to fresh weight using the reported ratio, otherwise using an arbitrary 0.25 value. For the Aegean Sea the sites were the same for 2014 and 2015, and the latter year was taken.

2.4. Updated regional and sub-regional assessments

The following maps show the spatial qualitative and quantitative assessments based on the latest MED POL datasets against IMAP assessment criteria (by Decision 23/6 from COP20) for biota and sediments at regional scale, including the sub-regional criteria for mussels (Table 4a).

Mussel matrix:

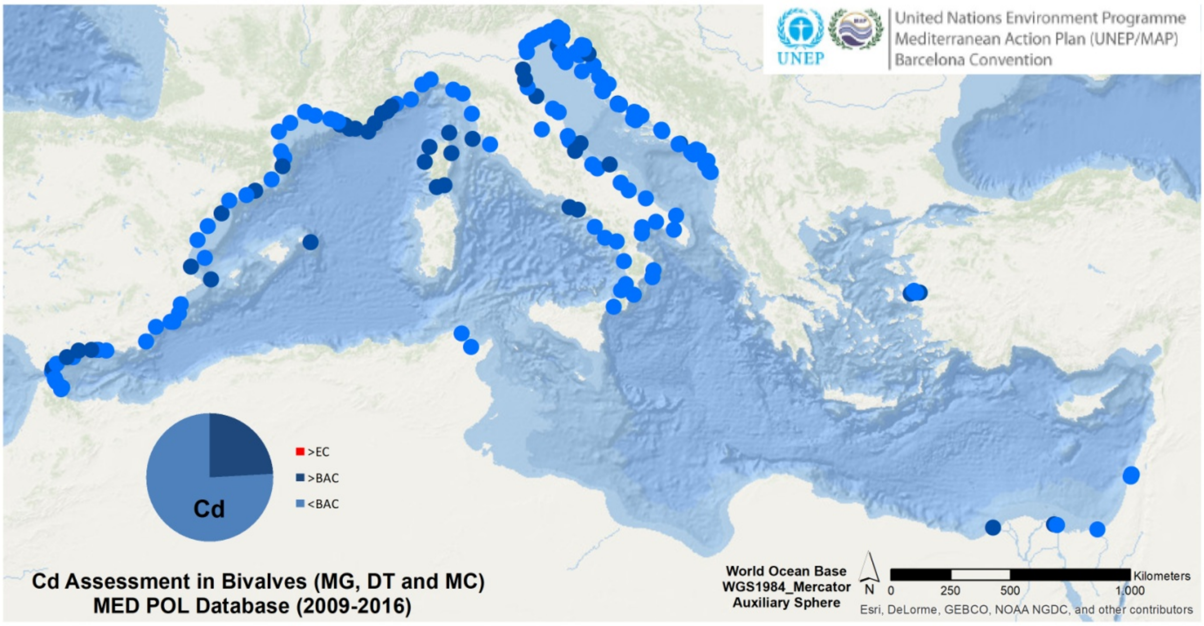


Figure 14. Sub-regional criteria for cadmium assessment in the Mediterranean basin. The concentration levels in bivalve sp. (*Mytilus galloprovincialis*, *Donaxtrunculus* and *Mactracorralina*) are assessed against IMAP BACs and ECs criteria for the Mediterranean Sea.

The spatial Cd distribution in bivalve species is similar to the earlier datasets assessed for the Med

QSR 2017, as well as the percentages of the data in each category of the assessment criteria, showing no concerns in terms of toxicological effects, thus all the concentrations assessed exhibit levels below the ECs proposed for establishing pollution effects. The cadmium data for Israel is shown here for 2015 in *Mactracorralina* species (Table 5), as a novelty thus in the earlier assessment no cadmium data was available. As a whole, more than the 75% of the datasets in this assessment are below the Background Assessment Criteria (BACs) but as stated above the entire dataset exhibits levels for cadmium below the established Environmental Assessment Criteria (namely, ECs), which in this case is defined as the seafood concentrations permitted for human consumption in this species. It should be observed that the time window expands seven years, as this is the data not earlier assessed until the Med QSR 2017 with the replacement or addition of the new datasets received by the Secretariat during 2017 and 2018 as mentioned.

The BACs have been assessed in a sub-regional approach (Table 4a), therefore whilst the new regional Med BAC for cadmium is 1095.0 in *Mytilus galloprovincialis* (μg/kg d.w.) instead of the earlier 1088μg/kg d.w.; for the Western Mediterranean Sea (WMS) the Cd BAC have been decreased to 990.8 μg/kg d.w., but increased to 1173 and 1413 (μg/kg d.w.) for the Adriatic Sea (ADR) and the Aegean and Levantine Seas (AEL) based on the Mediterranean reference stations estimations. This new Cd BAC for the WMS did not significantly changed the earlier assessment for any of the sub-regions, despite few more coastal stations show levels above the BACs in south of France and the levels in the island of Corsica, as usual, the latter continuously reporting higher levels compared to the continent, pointed out by different authors as potential atmospheric contributions of cadmium to the sea surface in this sub-region. As such, scaling down for the Western Mediterranean Sea assessment areas below sub-regions more refined criteria would be needed. In any case, the Cd concentrations exhibited by mussels and other bivalve species in the region are very far from the EC value for cadmium (Table 4) to infer potential pollution leading to biological effects or marine resources public health concerns by anthropogenic inputs of Cd.

In Figure 15, despite including the datasets for France, Israel and Slovenia for 2015 and 2016, the assessment is almost the same that the performed for the Med QSR 2107, meaning that the values reported for these recent years for *Mytilus galloprovincialis* in France and Slovenia and the values reported for *Mactracorralina* and *Donaxtrunculus* in Israel, do not pose a threat to the coastal environment and continue with the same trend showing values mostly below the Background Assessment Criteria (BACs) containing a 70% of the evaluated dataset; and therefore, a 30% above the BAC but below the EAC. In this case, the sub-regional criteria have been also applied and have slight differences between sub-basins being 164.1, 189 and 165 μg/kg d.w.for the WMS, ADR and AEL, respectively; whilst the Med BAC for HgT in bivalve is set to 173.1 μg/kg d.w. (*Mytilus galloprvincialis*), instead of the earlier 188 μg/kg d.w. at a regional scale. It is worth to mention that no concentrations are found above the EC values for mercury in bivalves (>2500 μg/kg d.w.), and thus, a situation of no concern for this element, despite this value could be to high for ecosystem assessment purposes.

The lead assessment in the Mediterranean Sea basin is also similar to the Med QSR 2017 assessment (Figure 16), despite few more data is assessed above the BACs values taking into account the new values for the sub-regions, being 2378, 2072 and 3450 μg/kg d.w. for the WMS, ADR and AEL, respectively, whilst the regional BAC, noticeably, decreased to 2313 μg/kg d.w. from and earlier 3800 μg/kg d.w.; and therefore, indicating that despite the significance decrease on this regional and sub-regional Med BACs, with the exception of AEL, the lead observations are well below or above its value and showing only some concern in already known sites. To this regard, the data above the EAC (>7500 μg/kg d.w.) for the Mediterranean Sea basin accounts a 9% compared to the earlier 8% reported for the Med QSR 2017 (red points Figure 16), however, due to a minor data volume effect rather than real environmental changes and with the same spatial distribution showing hotspot known areas in the south of Spain and Italy, despite for the later the data is from 2009. As mentioned, the same spatial distribution has been found with the inclusion of the three countries datasets (France, Slovenia and Israel).

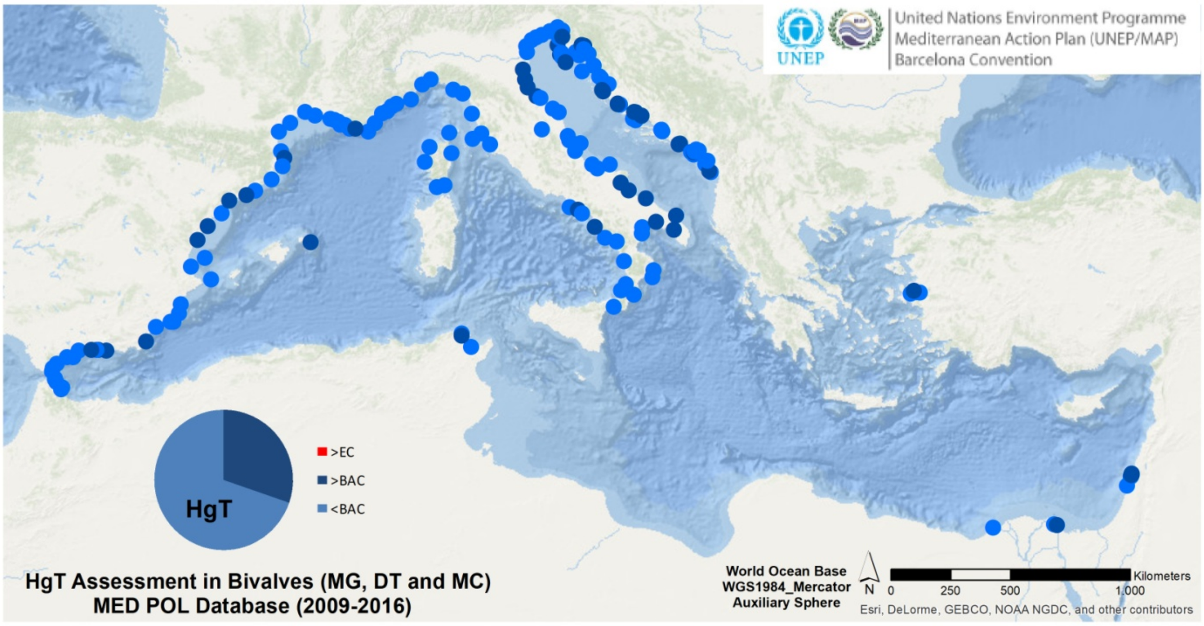


Figure 15. Sub-regional criteria for mercury assessment in the Mediterranean basin. The concentration levels in bivalve sp. (*Mytilus galloprovincialis*, *Donaxtrunculus* and *Mactracorralina*) are assessed against IMAP BACs and ECs criteria for the Mediterranean Sea.

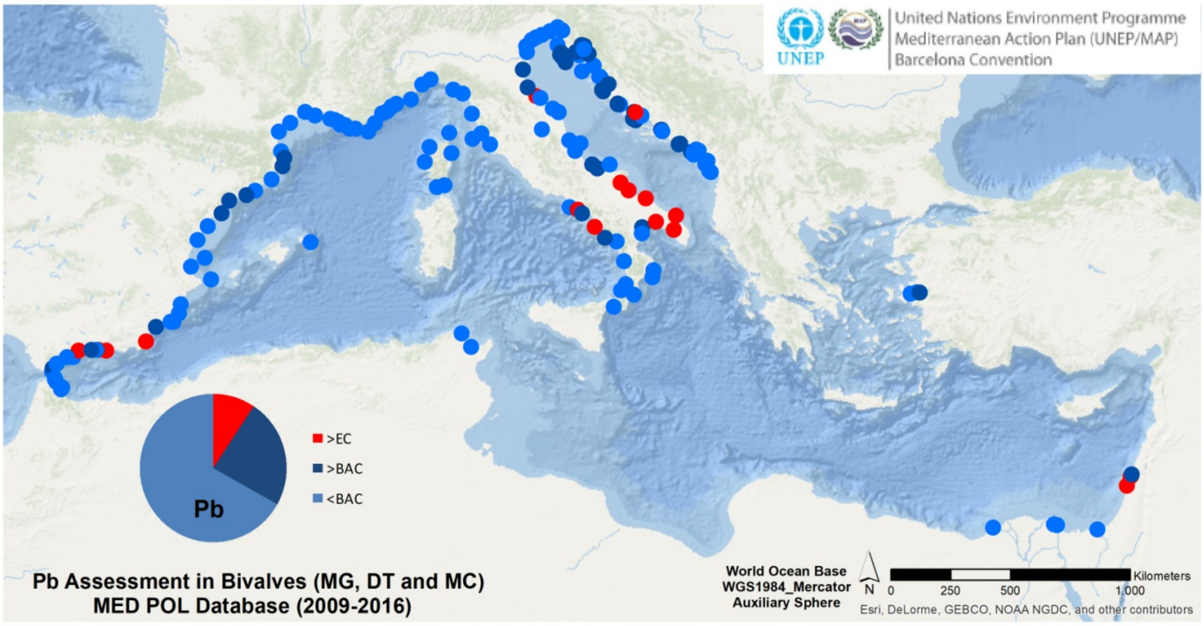


Figure 16. Sub-regional criteria for lead assessment in the Mediterranean basin. The concentration levels in bivalve sp. (*Mytilus galloprovincialis*, *Donaxtrunculus* and *Mactracorralina*) are assessed against IMAP BACs and ECs criteria for the Mediterranean Sea.

<u>Fish matrix:</u>

The addition of the new datasets submitted by Israel and Turkey (2014, 2015 and 2016) for *Mullus barbatus* species have not shown any significant differences compared to the earlier spatial distribution picture for the whole Mediterranean basin altogether with the earlier datasets assessed for Spain, Greece and Cyprus. Considering these new data sets, the updated spatial assessment and percentages of data observed between the assessment's categories are shown in Figures 17 to 19. It should be mentioned, in this case the assessment criteria used, both BACs and ECs, correspond to the regional Mediterranean criteria (Table 4).

In Figure 17 it can be observed that the reported datasets in this occasion, compared to the earlier Med QSR 2017 assessment, shows 100% concentrations below the established regional BAC for cadmium, despite this fact should be interpreted with caution. It should be noted that the data values reported for all the countries (Table 5) are below the BC (Background Concentration) estimated for fish fillet tissue from reliable detection limits for cadmium analytical determinations (Table 4) rather than from reference stations, thus, almost all the values monitored for cadmium in fish fillet tissue gives non-detectable Cd values and liver tissue should be recommended for analysis for this element, such as recommended in OSPAR convention. Therefore, little information can be inferred from Figure 17, despite the fact that the concentrations levels in fish fillet tissue (*Mullus barbatus*) might not reflect the real situation in terms of cadmium pollution levels in biota.

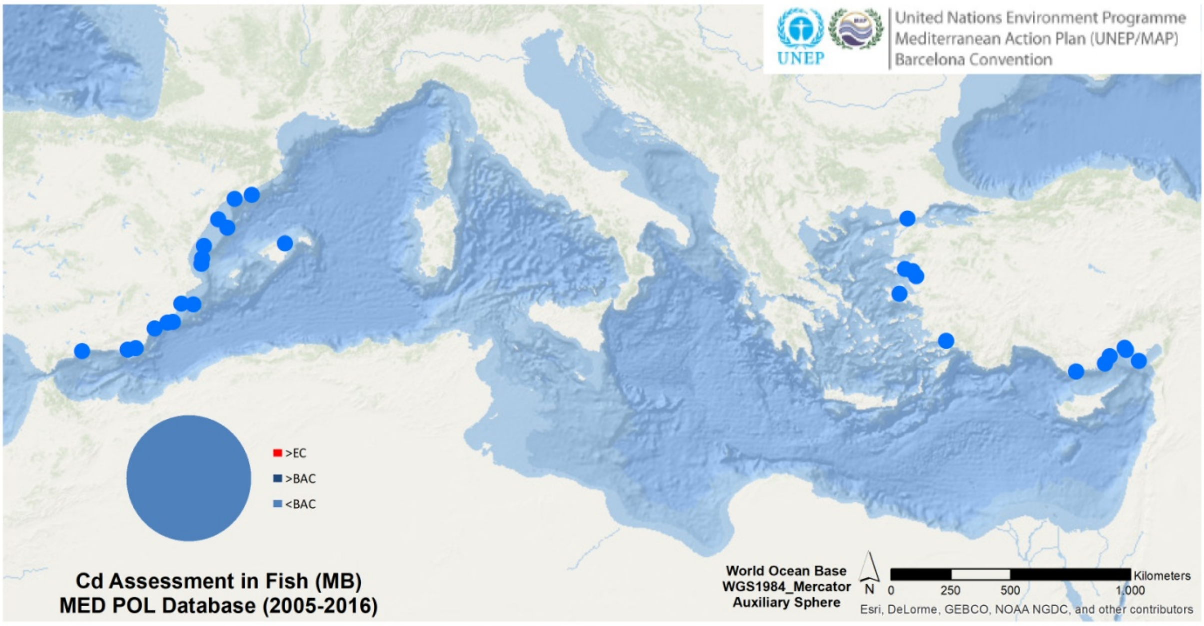


Figure 17. Regional cadmium assessment for the Mediterranean basin. The concentration levels in fish sp. (*Mullus barbatus*) are assessed against IMAP BACs and ECs criteria for the Mediterranean Sea.

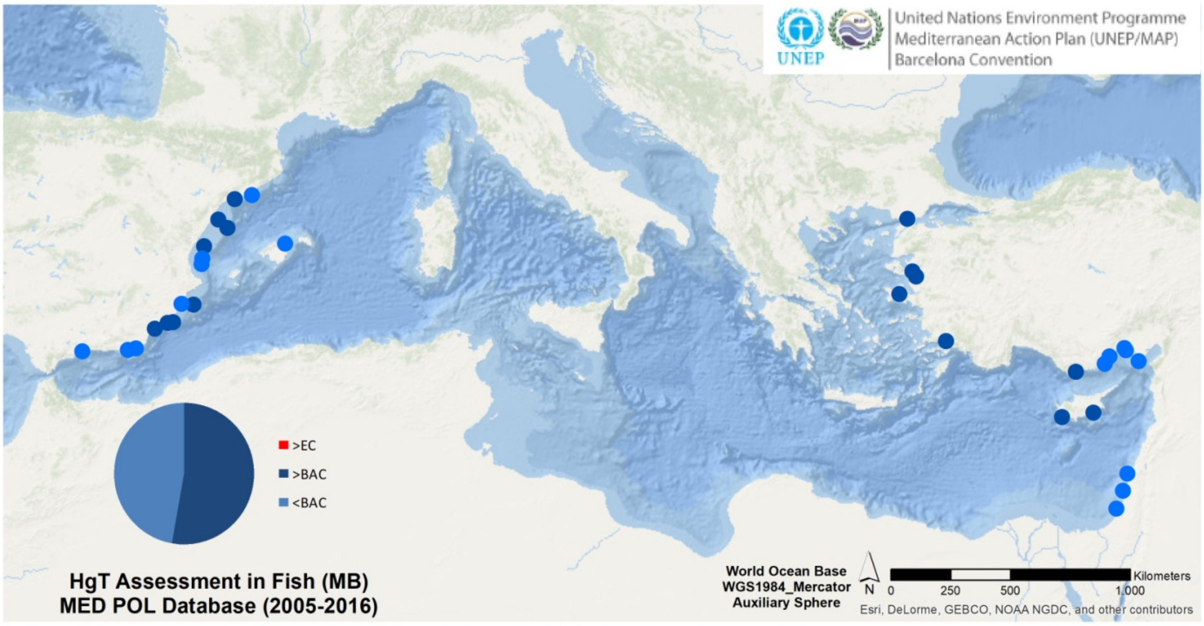


Figure 18. Regional mercury assessment for the Mediterranean basin. The concentration levels in fish

sp. (*Mullus barbatus*) are assessed against IMAP BACs and ECs criteria for the Mediterranean Sea.

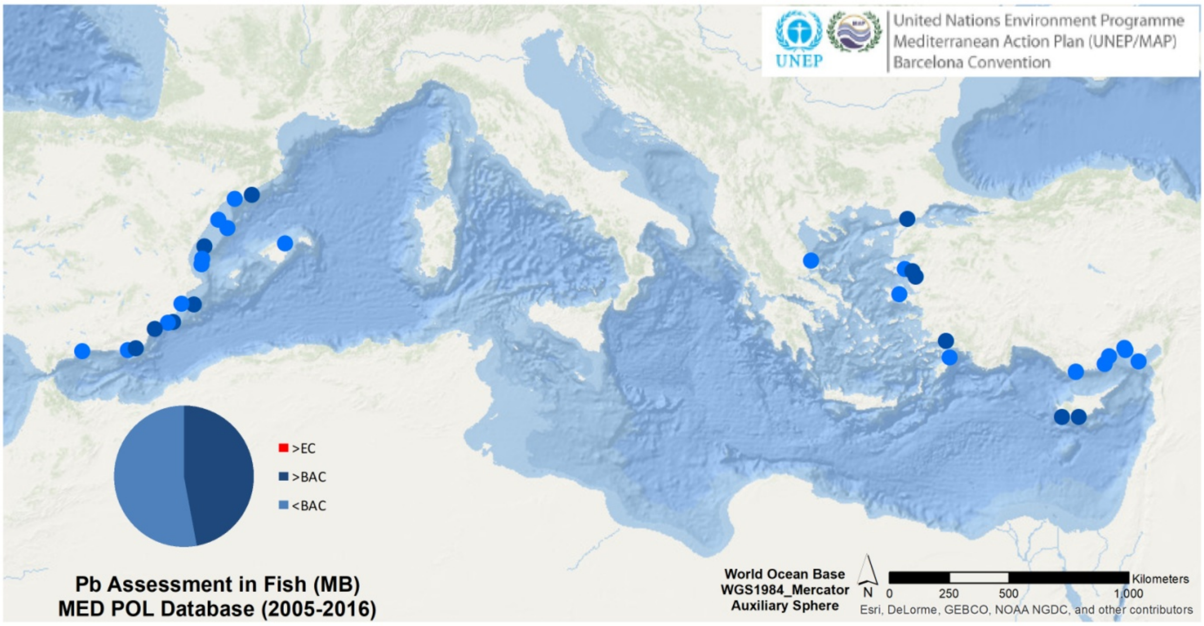


Figure 19. Regional cadmium assessment for the Mediterranean basin. The concentration levels in fish sp. (*Mullus barbatus*) are assessed against IMAP BACs and ECs criteria for the Mediterranean Sea.

Figures 18 and 19, show a similar situation as well compared to the earlier Med QSR 2017 assessment, despite higher number of stations with values above BACs for the Mediterranean basin. The Med BACs for HgT and Pb in fish (*Mullus barbatus*) are established to 101.2 and 40 µg/kg fresh weight (f.w.), respectively, whilst the ECs are 1000 and 300 µg/kg f.w., respectively. As it can be observed, there are no reported concentrations above the ECs set for these elements, but as mentioned earlier, an increase on the number of data above BACs, with a 53% and 47% compared to the earlier 17% and 6% (Med QSR 2017), for HgT and Pb, respectively. It should be also noticed, that the submissions received by the Secretariat are scarce for this matrix, however, within the IMAP national monitoring, and particularly for CI20 (seafood contaminants) the determination of contaminants in commercial fisheries and shellfish should be enlarged in the near future.

<u>Sediment matrix:</u>

The inclusion of datasets from France, Israel, Montenegro and Turkey for the years between 2014 and 2017 (Table 5) have depicted a similar situation than for the evaluation of the Med QSR 2017, except for mercury which has changed to some extent and is discussed below. For the assessment of sediments, the recommended regional BACs have been tested (Table 4), instead of the earlier values used in the Mediterranean assessment for the Med QSR 2017.Considering these new data sets, updated spatial assessment and percentages of data observed between the assessment's categories are shown in Figures 20 to 22.

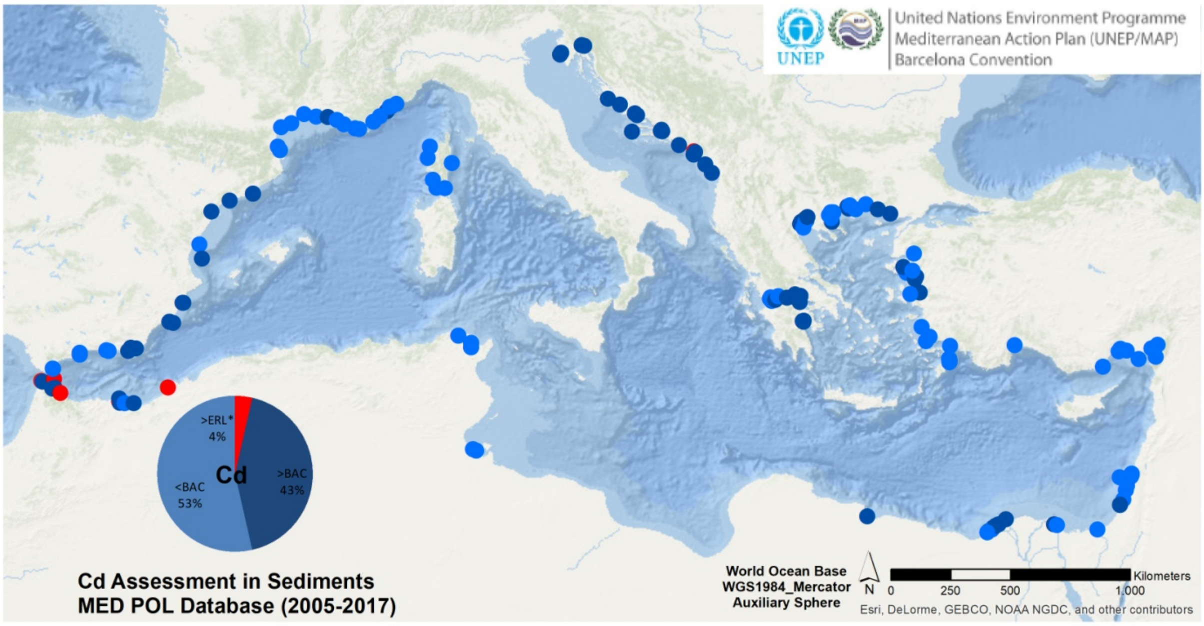


Figure 20. Regional cadmium assessment for the Mediterranean basin. The concentration levels in surface sediments are assessed against IMAP BACs and ERLs criteria for the Mediterranean Sea.

In Figure 20, Cd shows a 4% and 43% of stations with concentrations above the ERL and BAC, respectively, compared to the earlier assessment with a 2% and 55% respectively (Med QSR 2017). However, the number of data volume assessed is responsible for these slight variations rather than the new tested value of the revised Med BAC for cadmium, 127.5 µg/kg d.w. instead of 150 µg/kg d.w. as used previously. The data above ERL corresponds to the Moroccan datasets from 2015, early assessed, and poses the only potential threat to contamination from elevated levels of cadmium in coastal sediments so far reported in the Mediterranean (>1200 µg/kg d.w.).

In Figure 21, the percentages of stations with HgT values above ERL or BAC and below BAC are 38%, 21% and 41%, respectively. The earlier assessment resulted in 51%, 40% and 9%, respectively (Med QSR 2017). Here, the Med BAC revised for mercury in sediments increased to 79.5 µg/kg d.w. from an earlier estimation of 45µg/kg d.w. initially based on core samples from the deep Mediterranean areas. The increase on the tested Med BAC value produced an increase of sites under this new value changing from about a 9% to a 41% of data despite the slight differences in the number of data assessed (Figure 21). On the other hand, the known hotspots of mercury above the ERL value in coastal sediments have not changed (ERL HgT>150 µg/kg d.w.) in areas from Spain, Italy, the Northern Adriatic and Greece, with the exception of Turkey where the newest datasets show a decrease in HgT concentrations, as well as a lower number of stations. This situation in the AEL sub-region compared to the previous Med QSR 2017 assessment is the reason that the percentage of data have decreased from a 51% to a 38%.It should be mentioned that the dataset from Greece date from 2005, and probably, is too old to reflect the current situation in the area (but unfortunately no other routine monitoring data is available) and might capsize this situation.

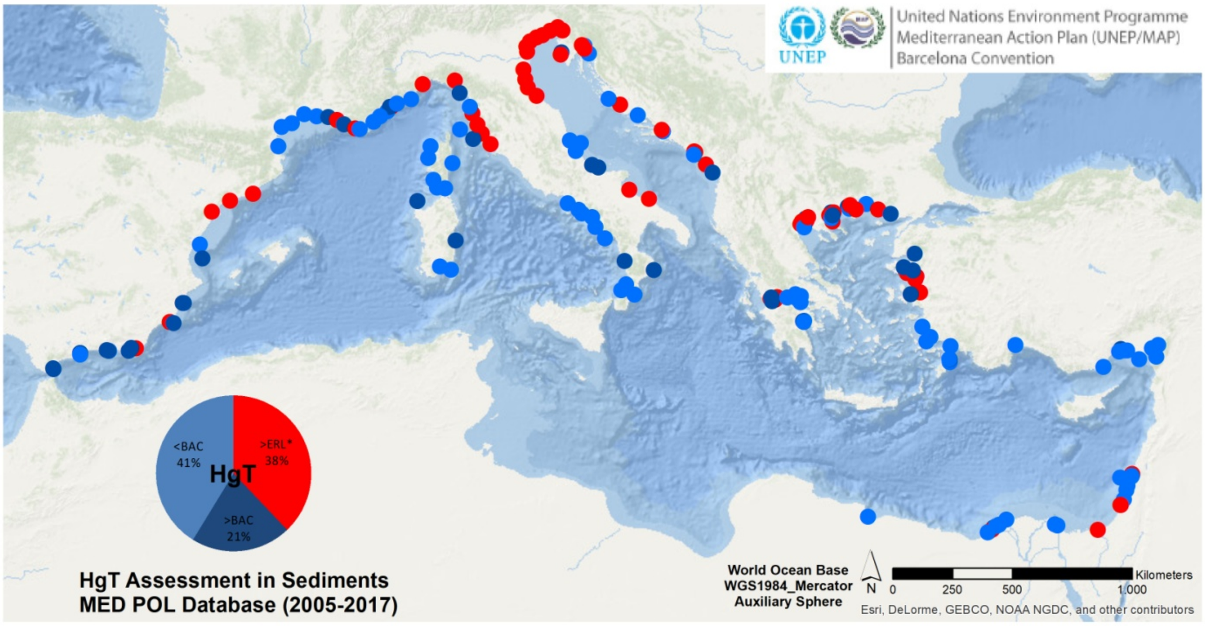


Figure 21. Regional mercury assessment for the Mediterranean basin. The concentration levels in surface sediments are assessed against IMAP BACs and ERLs criteria for the Mediterranean Sea.

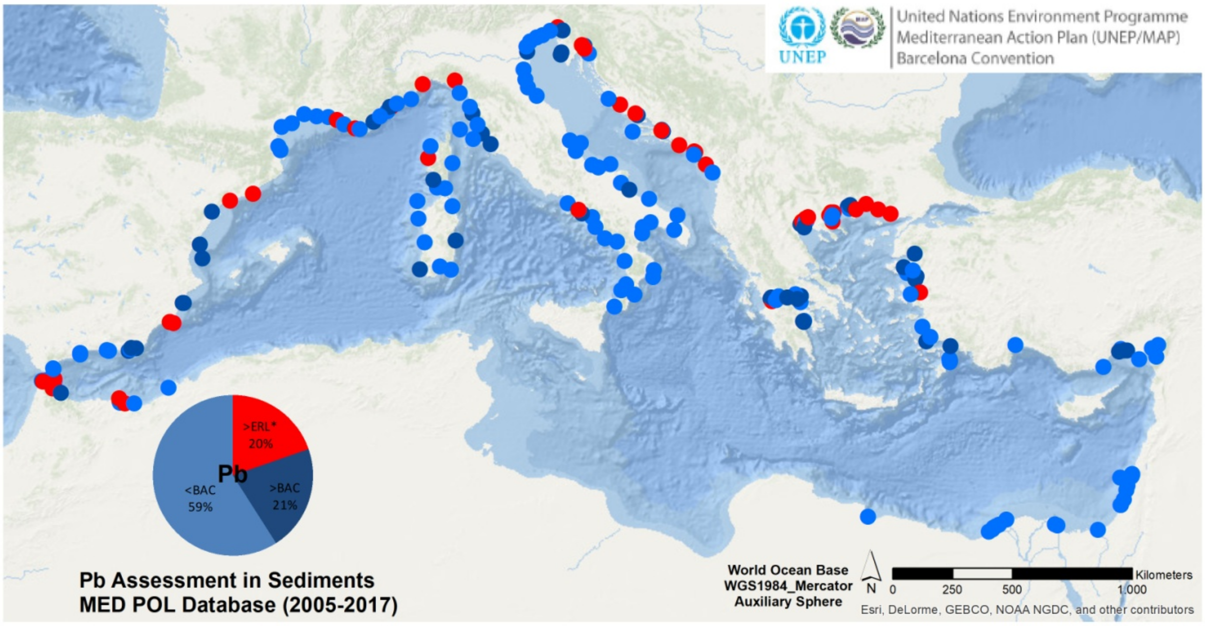


Figure 22. Regional lead assessment for the Mediterranean basin. The concentration levels in surface sediments are assessed against IMAP BACs and ERLs criteria for the Mediterranean Sea.

In Figure 22, the spatial assessment of lead in the coastal sediments does not differ significantly from the previous assessment undertaken for the Med QSR 2017; however, there is a slight increase in the categories above Med BAC and ERL due to the effect of a lower number of datasets. A new site in the western coast of Corsica close to Marine de Porto (122-P-094) shows a significant value above ERL. The addition of recent lead datasets in sediments shows the same distributions, despite the decrease of the earlier gross regional value of 30000 μg/kg d.w. for the Med BAC to the revised 25425 μg/kg d.w. In any case, the Eastern Mediterranean Sea datasets, such as for Israel, are well below 7380 μg/kg d.w. in practically all the stations reported (the estimated sub-regional AEL Pb BAC, Table 4b), confirming the lower background for Pb in sediments in the sub-region, as well as very low anthropogenic inputs on the sites reported. As shown earlier in UNEP(DEPI)/MEDWG.427/Inf.3, there is a decreasing gradient of lead in sediments from the Western to the Eastern Mediterranean basin with sub-regional Med BAC values as show in Table 4b, whilst the Med BAC tested in this assessment at a regional scale has been solely the revised value of 25425 μg/kg d.w.

2.5. Conclusion

The updated assessment of heavy metals in biota species of the Mediterranean Sea, through national coastal and marine monitoring networks under MED POL Programme in the northern part of the Mediterranean Sea, show no increasing concentrations of Cd, HgT and Pb nor significant environmental concerns, despite the historical known hotspots. In fact, there are a slightly major number of stations under the IMAP Background Assessment Criteria (Med BACs) for Cd, for example, with the latest data reported to the MED POL up to 2017 (during the period 2016-2018). As well, mercury and lead concentrations show constant and coherent levels in line with the earlier assessment (i.e. Med QSR 2017 Report), despite for the latter, the 9% of the total stations assessed in this update and reported by different countries shown Pb levels above the EC in known impacted sites in the Western Mediterranean Sea (WMS), the Adriatic Sea (ADR) and the Aegean and Levantine Seas (AEL) related to mining and other anthropogenic industrial sources (Figure 16).

With regard to organic contamination in this species, the datasets available does not allow to perform a regional or sub-regional assessment in the Mediterranean, including the fact that observed levels of major organic synthetic compounds are declining in historical monitoring stations. A recent review monitoring study published in the Western Mediterranean coast of Spain (Campillo et al., 2017) for organochlorinated compounds (OCLs) with datasets for the period 2000-2013, confirmed decreasing trends and no-trends or weak downtrends for DDTs and PCBs, a similar environmental situation already seen in the French Mediterranean coast (UNEP/MAP/MED POL 2011a, 2011b, 2012) whilst some concerns still near urban and industrial areas, ports and river mouths in terms of organic contaminants.

In the southern part of the Mediterranean Sea, the geographical distribution of the common mussel (*Mytilus galloprovincialis*) is not sufficient to be used as long-term monitoring bioindicator, and alternatively, other bivalve species are used (*Donaxtrunculus, Mactracorralina, Ruditapesducussatus*), despite the fact that the implementation of routine monitoring has some important temporal gaps within MED POL Programme. A recent published research covering large parts of the Libyan coastline assessed no concerns for those heavy metals in biota (i.e. caged mussels) mussels, rather than high Cd values (Galgani et al., 2015), which might be related to the local geochemical characteristics of the region, and similarly, a hotspot site for HgT and arsenic near a petrochemical industrial site with the potential to impact the food webs (ca. fish sp.) (Bonsignore et al., 2018).

A second bioindicator species, a fish species (*Mullus barbatus*), monitored in the Western and Eastern parts of the Mediterranean Sea indicates the levels of Cd, HgT and Pb are below the environmental assessment criteria set for the species (i.e ECs), through the latest datasets reported to the MED POL Database (Figures 17 to 19), with similar proportions of sites below and above Med BACs with no relevant concern through the Mediterranean region than previously reported up to 2017 (i.e. Med QSR 2017). It should be mentioned here, that fish fillet tissue analysis might not be a complete proxy for Cd and Pb for environmental assessments (UNEP(DEPI)/MED WG.427/Inf.3).

Therefore, the awareness and national measures taken over the last two decades in the Mediterranean Sea, guided by the UNEP/MAP/ MED POL within framework of the Barcelona Convention, have produced fruitful outcomes and today the levels of the so called ‘legacy pollutants’ have decreased as observed in the bioindicator (i.e. bivalves) national networks, in line with the international demands of the Stockholm Convention on persistent organic pollutants (POPs) (UNEP/MAP/MED POL 2011a, 2011b, 2012). However, some of these have been replaced by new and emerging chemicals and their occurrence in the marine environment have been confirmed (both halogenated and non-halogenated compounds) and monitoring and assessment of those chemicals will be needed as well to be followed with implementation of policy and reduction targets.

On the other hand, the sediment national monitoring activities within the MED POL Programme, have revealed the informative fact that the marine compartment that continues to show a major concern in term of contaminants concentrations (Cd, HgT and Pb) potentially giving rise to pollution effects are the coastal sediments in many parts of the Mediterranean region assessed with the IMAP Med BACs and ERLs criteria (ca. Effects Range Low, ERL criteria). From Figures 20-22 it can be observed that in the northern part of the Mediterranean, were most MED POL recent datasets are available, a similar situation since the earlier assessment in 2017 (i.e. Med QSR 2017) have been found. Despite including new datasets for the period up to 2017 received by the Barcelona Convention Secretariat during the period 2016-2018 and this assessment performed by using the sediment recommended Med BACs and ERLs by Decision 23/6 (Table 4), have not changed significantly. There are a major number of coastal sites under the HgT Med BAC, as it has increased from 45 to 79.5 µg/kg d.w. its value, whilst for Cd and Pb the general situation has not changed, as well as some known historical locations (ca. hotspots) still active. To this regard, it should be mentioned here that new information (i.e. monitoring datasets) have not been yet updated by all Contracting Parties in the MED POL Database and the spatial assessment is performed within a too wide period of time window and should be interpreted with caution in a sub-regional and regional basis.

Through a literature survey for the last decade some monitoring studies or scientific reviews have been performed in these areas (Greece, Spain); particularly, in the southern Mediterranean (Algeria, Tunisia, Libya, Egypt) which sufficient spatial coverage to complement the current discussion for heavy metals and organic contaminants as well. A work published (Tsangaris et al., 2010 and references therein) which includes eighteen locations revision of sediment data (2001-2008), both from research studies and local monitoring activities, including data beyond the last year reported to MED POL Database (ca. 2005), shows some locations exhibiting Pb values in sediment above the ERL (>46700 µg/kg d.w.), such as urban and industrial areas in the Thermaikos Gulf, Korinthiakos Gulf and the Nestos River Estuary, with concentrations up to 369000 µg/kg d.w. and 91000 µg/kg d.w., respectively, whilst the other scattered sites are reported to be below the ERLs. A similar situation for Pb and other heavy metals and trace elements have been also identified in the Alexandroupolis Gulf (Karditsa et al., 2014). In contrast, within the mentioned sites (Tsangaris et al., 2010) the organic contamination (e.g. PAHs, DDTs and PCBs) reviewed levels of low concern (with respect BACs and ERLs) and occurrences seems to be more equally distributed among the sites, despite differences in anthropogenic pressures. In the Aegean Sea, however, hotspot areas need to be continuously monitored (and searched for) due to its impact in the surrounding marine environment, such as industrial, harbor and port facilities, as revealed by an study of six potential hotspots in Turkey were PAHs in sediments were up to 79674 µg/kg d.w. and orgachlorinated pesticides up to 53.7 µg/kg d.w., exceeding environmental assessment criteria (Okay et al., 2014). In the Western part of the Mediterranean, a recent study also reported a review with data from 2006-2008 for 13 PAHs in sediments along the Spanish Mediterranean coast (León et al., 2014) concluding low concerns (i.e. data below environmental criteria), except for some individual congeners, such as Benzo(g,h,i)perylene and others in Barcelona and Sagunto areas.

In the southern Mediterranean, a number heavy metals and organic contaminant studies in coastal sediments have been reported in the literature over the last ten years which covers large parts or complete national coastlines, despite the majority of them have been a one-off monitoring rather than routine, however, it is of interest to understand occurrences and distributions of contaminants and pollution effects in the Mediterranean basin. In Egypt, a reference study (Barakat et al., 2011) covering all the Egyptian coastline reported contamination by PAHs ranging up to 22600 µg/kg d.w. for the sum of 39 PAHs, as well as their origin (petrogenic vs. pyrolitic) and potential for toxicological effects on organisms based on the US Sediment Quality Guidelines under Effects Range Medium (ERMs) and ERLs (ca. IMAP Assessment Criteria). The Alexandria Eastern Harbour exhibit concerns for two individual PAH congeners above ERMs (Effects Range Medium), Benzo(g,h,i)perylene and Dibenz(a,h)anthracene, whilst for few others above ERLs, but were environmentally acceptable for the remaining 26 coastal sites evaluated, whilst regarding heavy metal pollution a similar study found generally unpolluted coastal sediments assessed with contamination indices, except for hotspots and related to Cd and Pb (El Baz and Khalil, 2018). In the Libyan coastline, the only metal found exceeding known reference levels was Cd and evaluated as a potential threat using a number of reference indexes and guidelines (Souliman and Nasr, 2015), however, high levels of Cd have been also found distributed homogeneously in the more than 1000 km Libyan coastline, as well as higher concentrations measured up to the Corsica Island latitude in biota samples (Figure 14) and reported (Galgani et al., 2015), and therefore pointing to a natural contribution from atmospheric inputs in this sub-region. In Tunisia, an spatial study of heavy and trace elements in the central area of the Gulf of Gabes around an industrialized area, including Cd, HgT and Pb, found ranges from 6 to 93 μg/kg d.w. for HgT (<ERL), ranges from 110 up to 950000 μg/kg d.w. for Cd (with extremely high values associated to three coastal sites) and Pb ranges from 3800 to 13900 μg/kg d.w. (<Med BACs); thus indicating a significant point-source of Cd pollution concern in the Guld of Gabes (El Zrelli et al., 2015). Finally, in Algeria, a risk assessment study at 51 stations along fishing grounds in the Algerian coastline shown levels of concern above ERLs, primarily for arsenic, but low levels of cadmium and lead (Ahmeda et al., 2018).

To conclude, this updated assessment which includes an spatial qualitative and quantitative evaluation against IMAP assessment Criteria (Decision 23/6) of the Contracting Parties monitoring network stations using latest received datasets in the period 2016-2018 through the MED POL Programme combined with recent relevant scientific literature available covering, primarily, the southern Mediterranean continues to confirm that in terms of chemical pollution the major concerns are currently found in coastal sediments close to industrial, urban, harbors and ports locations rather than from uncontrolled or ubiquitous inputs from land-based activities into the sea, as reflected by the lower levels found in bioindicator species exhibiting in general no environmental concerns and the high levels found in hotspot areas, respectively. If the situation is compared with the 80' and 90', the Mediterranean Sea is improving its environmental chemical pollution status as a consequence of the national implementation of diverse environmental measures which are protecting directly or indirectly the marine and coastal environment as a whole driven by the pioneering Barcelona Convention, as well as the efforts of the European Union. However, continued science and policy national and as emerging chemical pollutants. In any case, under an ecosystem-based management the weight of the concerns about chemical pollution should be balanced with other contemporary threats challenging the sustainability and conservation of the Mediterranean marine environment.

3. Key messages

Key messages for EO5:

- The available and new submission data to the Secretariat shows that in areas were assessment is possible the IMAP assessment criteria for eutrophication based on CI14 (Chlorophyll *a* concentration in the water column) are applicable and confirm the main status of eutrophication in the coastal area.
- In terms of eutrophication GES achievement in the coastal areas of France, Eastern Adriatic and Cyprus it is maintained.
- Criteria for reference condition and boundaries for key nutrients in the water column, namely CI14, have to be built and harmonised through the Mediterranean region, which will greatly help the implementation of improved sampling strategy, with a simplified approach in monitoring design and data handling, for the future implementation of IMAP.

Key messages for EO9:

- The updated assessment for heavy metals, including the new datasets (received during 2016-2018), in biota species in the northern part of the Mediterranean Sea, show no increasing concentrations of Cd, HgT and Pb nor significant environmental concerns, despite the historical known hotspots.
- In the southern part of the Mediterranean Sea, the geographical distribution of the common mussel (*Mytilus galloprovincialis*) is not sufficient to be used as long-term monitoring

bioindicator, and alternatively, other bivalve species are used (*Donaxtrunculus, Mactracorralina, Ruditapesducussatus*), despite the fact that the implementation of routine monitoring has some important temporal gaps.

- The sediment monitoring reveals the fact that the marine compartment that continues to show a major concern in term of contaminants concentrations (Cd, HgT and Pb) potentially giving rise to pollution effects are the coastal sediments in many parts of the northern Mediterranean region, as well as some hotspots in the sourthern part; assessed with the IMAP Med BACs and ERLs criteria (ca. Effects Range Low, ERL criteria).
- In the southern Mediterranean, a number of heavy metals and organic contaminant studies in coastal sediments have been reported in the literature over the last ten years which covers large parts or complete national coastlines, despite the majority of them have been a one-off monitoring rather than routine, however, have been combined to complete this assessment.

Annex I
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