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Athens, Greece, 11 September 2017

Agenda item 3: Review of Quality Status Report QSR (Pollution and Litter)

Quality Status Report (Pollution and Litter)

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UNEP/MAP
Athens, 2017

Note by the Secretariat

In line with the article 12 of the Barcelona Convention and several monitoring related provisions under different protocols, the 2017 Quality Status Report (QSR 2017) is the first report based on IMAP Common Indicators. It is prepared following the mandate given to Secretariat by the Decision IG.22/20 of the 19th Meeting of the Contracting Parties on the Programme of Work and Budget 2016-2017 (Athens, Greece, February 2016).

QSR 2017 follows a model that has been prepared by the Secretariat in cooperation with the Contracting Parties through the Ecosystem Approach Correspondence Groups on Monitoring (COR MONs) and the Ecosystem Approach Coordination Group. It also considered the approach taken by other Regional Seas (i.e. OSPAR), and work implemented at global level, such as the Regional Process on a second World Ocean Assessment(s) and the process on implementing the 2030 Agenda, especially in relation to oceans related Sustainable Development Goals (SDGs).

Given the fact that the IMAP implementation is still at an early phase, the approach for the preparation of the QSR 2017 accommodates the time limitations and data gaps on the IMAP Common Indicators. During the preparation of the QSR 2017, countries were still in the process of revising their national monitoring programmes as to align them with IMAP, and therefore, it has not been possible to compile a full set of data for IMAP indicators for the QSR 2017. Hence the approach followed was to use all available data for the IMAP Common Indicators and to complement and address data gaps with inputs from numerous sources where appropriate.

Apart of the MED POL monitoring database, QSR 2017 has the links to all information sources and case studies relevant for different IMAP Common Indicators, provided from the Contracting Parties and other partners. During the initial steps, additional sources of information were identified and mapped, including information related to national reports on implementation of Barcelona Convention and its protocols, implementation of the National Action Plans (NAPs), Coastal Area Management Programmes (CAMPs), as well as the results of regionally and nationally driven implementation of relevant policies, programmes and projects.

As the result, QSR 2017, through systematic compilation of the Assessment Factsheets for all IMAP Common Indicators, provides the findings on the status of implementation of the appropriate assessment methods, identifies the status of information availability that are necessary for evaluation of the IMAP Common Indicators, provides the findings related to the status of marine and coastal ecosystems and where possible, identifies the trends that are expressed through qualitative and quantitative assessment, including the graphics and animations as appropriate. It also determines the knowledge gaps and defines key directions to overcome them with the aim to enable success of the initial phase of IMAP (2016-2019). For each cluster it provides the case studies that have been submitted by Contracting Parties and Partners.

The QSR Assessment Factsheets for all IMAP Common Indicators were presented at and reviewed by the relevant meetings of the Ecosystem Approach Correspondence Groups (on biodiversity, pollution, marine litter and coast and hydrography), the Ecosystem Approach Coordination Group and the meetings of the respective MAP Components Focal Points (MED POL, SPA/RAC, REMPEC, PAP/RAC), and were revised accordingly.

In conclusion the delivery of this report is a unique MAP achievement based on a joint and integrated efforts of the Contracting Parties, Secretariat, MAP Components and Partners.

Ecological Objective 5 (EO5): Eutrophication

EO5: Common Indicator 13. Key nutrients concentration in water column

GENERAL

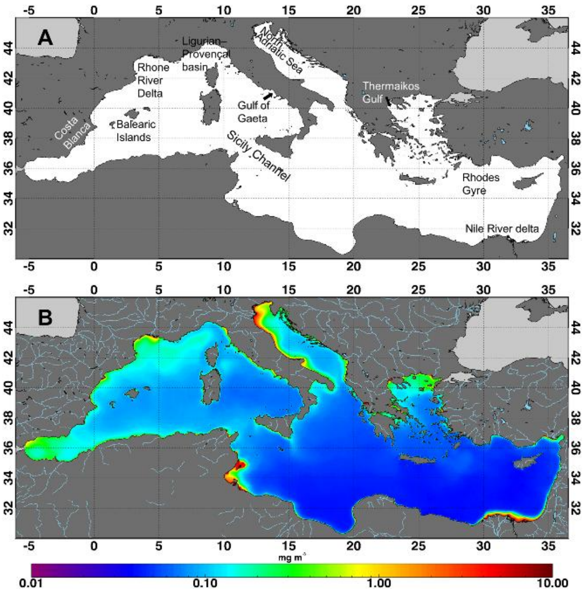
Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Morocco, Slovenia, Spain, Syria, Tunisia, Turkey
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO5. Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters
IMAP Common Indicator	CI13. Chlorophyll-a concentration in water column (EO5)
Indicator Assessment Factsheet Code	EO5CI13

RATIONALE/METHODS

Background (short)

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 (UNEP(DEPI)/MED, WG.411./3). 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). 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. In the Mediterranean Sea, the Barcelona Convention adopted in 1976 was the first legally-binding instrument for its environmental protection and included a number of protocols, such as the pollution land-based sources (LBS) Protocol. Since 2000, other international and national policies, such as the European Water Framework Directive and the European Marine Strategy Framework Directive are developing programmes, which sums to its environmental protection at sub regional levels and collaborate with UNEP/MAP. At the 19th Ordinary Meeting in 2016 of the Contracting Parties to the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols) adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Coast and Sea and Related Assessment Criteria, which includes the targets to achieve the Good Environmental Status

(UNEP/MAP, 2016). The initial targets of GES for IMAP Common Indicator 14 are reflecting the scope of the current MED POL Programme and the availability of suitable agreed assessment criteria.



The Mediterranean basin and its chlorophyll *a* concentration pattern. (A) Geographic regions (B) chlorophyll *a* concentration climatology over the Mediterranean Sea relative to 1998–2009 time period. Highest chlorophyll *a* concentrations are generally found in coastal water, in proximity of the river outflow, and are obviously conditioned by the nutrient of natural origin carried by rivers. From: Colella *et al.*, 2016.

Background (extended)

In the Mediterranean area eutrophication is caused by both regional sources such as urban effluents, industrial discharges, and aquaculture activities as well as transboundary components such as agricultural runoffs, riverine outflows, and airborne nutrient deposition. The variables related to eutrophication are influenced by water circulation and to regional sources of pollution including eutrophication (UNEP, 2003).

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). Eutrophication and oligotrophy in the Mediterranean is illustrated as chlorophyll *a* distribution in remote sensing imagery (Fig. 1)

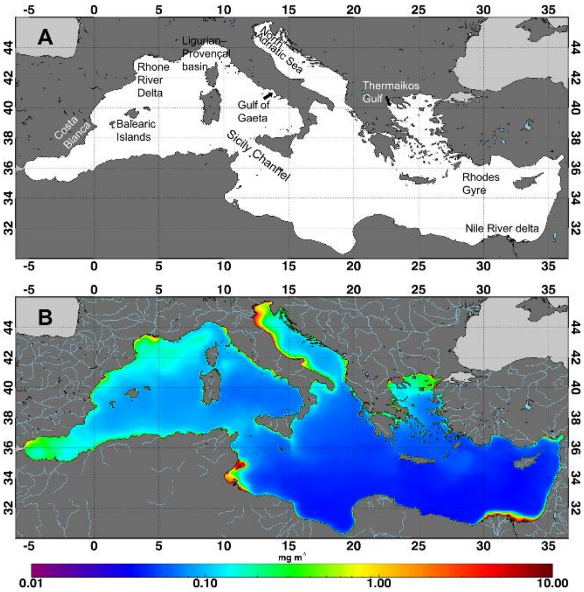


Figure 1. The Mediterranean basin and its chlorophyll a concentration pattern. (A) Geographic regions (B) chlorophyll a concentration climatology over the Mediterranean Sea relative to 1998–2009 time period. From: Colella et al., 2016.

At the moment only some of the countries developed boundary approach for the assessment of eutrophication and no general assessment criteria were accepted for the Mediterranean area for the key nutrient concentrations in the water column.

In the Mediterranean Sea, the Barcelona Convention adopted in 1976 was the first legally binding instrument for its environmental protection and included a number of protocols, such as the pollution land-based sources (LBS) Protocol. Since 2000, other international and national policies, such as the European Water Framework Directive and the European Marine Strategy Framework Directive are developing programmes, which sums to its environmental protection at sub regional levels and collaborate with UNEP/MAP. At the 19th Ordinary Meeting in 2016 of the Contracting Parties to the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols) adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Coast and Sea and Related Assessment Criteria, which includes the targets to achieve the Good Environmental Status (UNEP/MAP, 2016). The initial targets of GES for IMAP Common Indicator 13 are reflecting the scope of the current MED POL Programme and the availability of suitable agreed assessment criteria.

Assessment methods

At the moment only some of the countries developed boundary approach for the assessment of eutrophication and no general assessment criteria were accepted for the Mediterranean area for the key nutrient concentrations in the water column. This assessment effort was only based on the presentation of the geographical variability of some key nutrients (DIN – dissolved inorganic nitrogen and TP- total phosphorous; μmol L^{-1}).

In this assessment, aware that for most of the northern Mediterranean countries data are available also in other databases (EEA, EIONET, EMODnet…), only datasets obtained from the MED POL Database for nutrients were used. Data availability by country were as follows:

Albania (2005-2006), Bosnia and Herzegovina (2006-2008) Croatia (2009, 2011-2014), Cyprus (1999-2015), Egypt (2009, 2010), France (2009, 2012), Greece (2004-2006), Israel (2001-2012), Montenegro (2008-2011), Morocco (2006,2007), Slovenia (1999-2013, 2015), Tunisia (2002-2013), Turkey (2005-2009, 2011, 2013)

RESULTS

Results and Status, including trends (brief)

The trophic status of the Mediterranean Sea is controlled by the highly populated coastal zone and the riverine input. Offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards, 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. The sewage effluents of Cairo and Alexandria mainly induce eutrophic conditions in the area. 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 a limited nutrient supply through the Strait of Gibraltar due to different nutrient concentrations between the Atlantic and Mediterranean waters.

The main coastal areas in the Mediterranean with permanent eutrophic trends are the Gulf of Lions, the Adriatic, Northern Aegean, and the SE Mediterranean (Nile–Levantine).

The available data show that in areas were assessment is possible the key nutrient concentrations are in ranges characteristic for coastal areas and in line with the main processes undergoing in the interested area. The result also confirm the validity of this indicator 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. In this effort greatly will help the implementation of a clear sampling strategy with a simplified approach in monitoring design and data handling.

Results and Status, including trends (extended)

The trophic status of the Mediterranean Sea is controlled by the highly populated coastal zone and the riverine input from a draining area of 1.5 million km^2 (Ludwig *et al.* 2009) that induce eutrophic trends in coastal areas. The blue offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards (Turley 1999). Eutrophication and oligotrophy in the Mediterranean is illustrated as chlorophyll *a* distribution in remote sensing imagery (Fig. 1). It is observed that the Eastern Mediterranean Sea (EMS) is still the most oligotrophic area of the whole Mediterranean basin. This is due to the low nutrient content of EMS; the maximum concentrations recorded for nitrate were about 6 μM, 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 southeastern part of the Mediterranean shows clearly eutrophic trends. Although the River Nile is the major water resource in the area, its freshwater fluxes are getting 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 Kairo 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 μM, 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 with permanent eutrophic trends are the Gulf of Lions, 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 sea of Levantine. 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 mg L^{-1}.

The results of assessment and status of the key nutrients concentration in the water column are presented on Figs 3-5 showing a rather limited figure of the Mediterranean region. The main reason is the data availability and quality. On the Fig. 2 are clearly visible that for the great part of the region data are missing. The implementation of water type criteria for the purpose of IMAP are also limited. Even a rather weak criteria (10 samples in 10 years in surface layer - <= 10 m) were adopted the data availability for assessment were low.

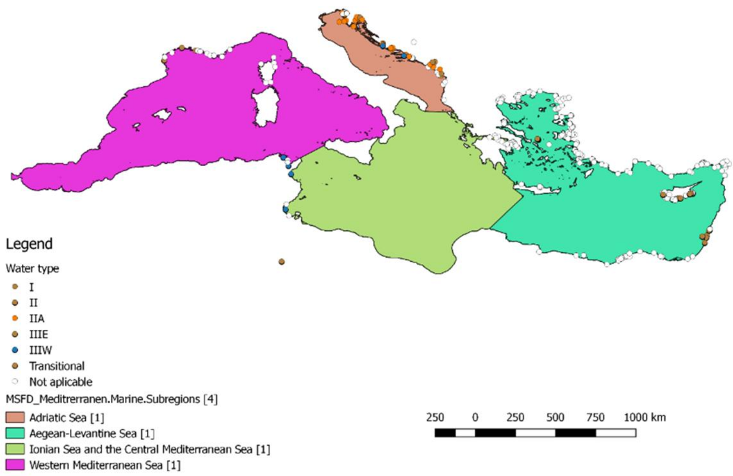


Figure 2. Stations in the Mediterranean region for which nutrient concentrations were sampled. Also are shown the water types (applicable for phytoplankton; IMAP. 2017) were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

On Figs 3-5 data for the Adriatic and Aegean-Levantine subregions for dissolved inorganic nitrogen (DIN) and total phosphorus (TP) were presented. DIN and TP concentration show a characteristic variability for both coastal sea (Adriatic and Aegean-Levantine Sea) indicating that no hotspot is present for DIN and TP.

When harmonised reference and boundary criteria for key nutrients concentration in the water column will be accepted, no meter the level is, regional, subregional or country based, through a such simplified approach (Box and whisker plot) assessment can be performed efficiently, on both the geographical or time scale. Taking in account the fact that a great part of the Mediterranean countries have undergoing eutrophication monitoring programmes and are contributing to other databases, the IMAP goals can be maintained.

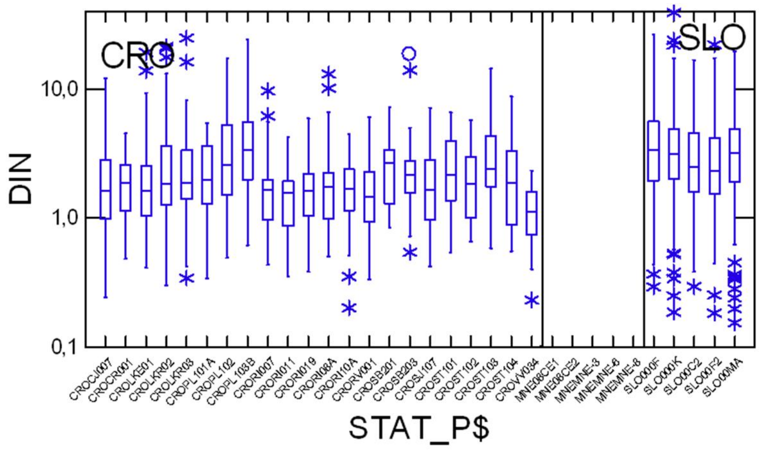


Figure 3. Box and whisker plot for dissolved inorganic nitrogen (DIN) concentration (µmol L^{-1}) in the Adriatic Sea subregion (water type IIA)

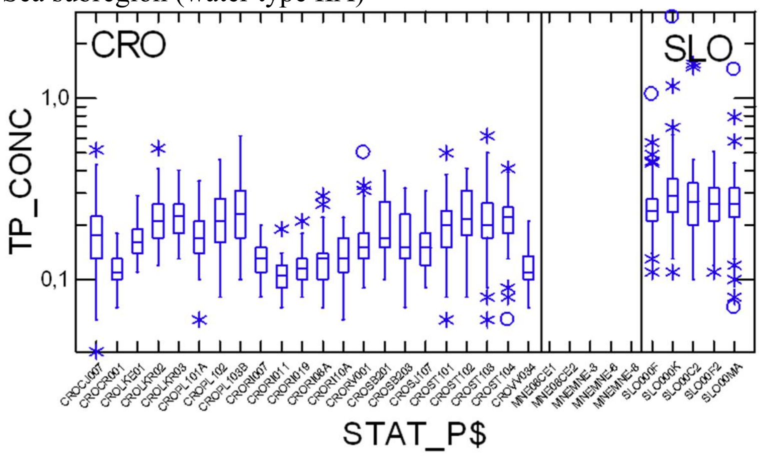


Figure 4. Box and whisker plot for Total Phosphorous (TP) concentration (µmol L^{-1}) in the Adriatic Sea subregion (water type IIA)

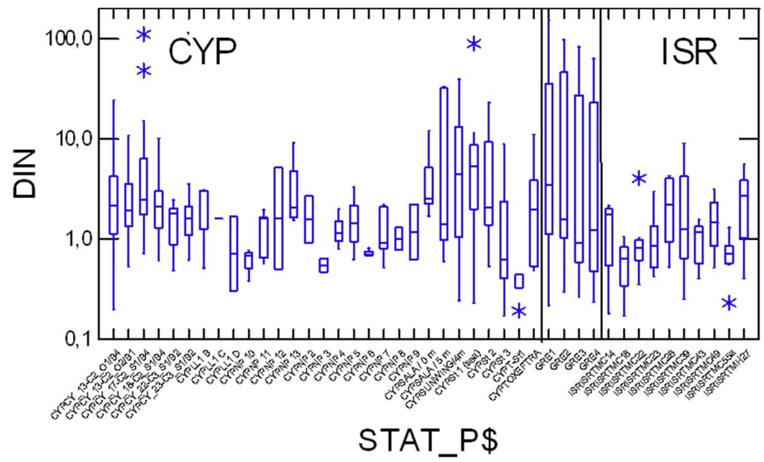


Figure 5. Box and whisker plot for dissolved inorganic nitrogen (DIN) concentration (µmol L^{-1}) in in the Aegean-Levantine Sea subregion (water type IIIE)

The available data show that in areas were assessment is possible the key nutrient concentrations are in ranges characteristic for coastal areas and in line with the main processes undergoing in the interested area. The result 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. In this effort greatly will help the implementation of a clear sampling strategy with a simplified approach in monitoring design and data handling.

At the eutrophication hot spots in the Mediterranean Sea a comprehensive key nutrient concentrations in the water column trend analysis would be beneficial. Significant trends need to be detected from long time series that are able to capture nutrient concentrations changes in coastal waters as the analysis of short time series can erroneously lead to interpret some spatial patterns produced by random processes nutrients concentration trends. For that reason data availability have to be improved. A possible approach is to use data stored in other databases were some of the Mediterranean countries regularly contribute.

CONCLUSIONS

Conclusions (brief)

The available data show that in areas were assessment is possible the key nutrient concentrations are in ranges characteristic for coastal areas and in line with the main processes undergoing in the interested area. The result 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. In this effort greatly will help the implementation of a clear sampling strategy with a simplified approach in monitoring design and data handling.

Conclusions (extended)

The available data show that in areas were assessment is possible the key nutrient concentrations are in ranges characteristic for coastal areas and in line with the main processes undergoing in the interested area. The result 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. In this effort greatly will help the implementation of a clear sampling strategy with a simplified approach in monitoring design and data handling.

Key messages

- Criteria for reference condition and boundaries for key nutrients in the water column have to be built and harmonised through the Mediterranean region.

Knowledge gaps

Criteria for reference condition and boundaries for key nutrients in the water column have to be built and harmonised through the Mediterranean region. Data availability have to be improved. A possible approach is to use data stored in other databases were some of the Mediterranean countries regularly contribute.

List of references

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Ecological Objective 5 (EO5): Eutrophication

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

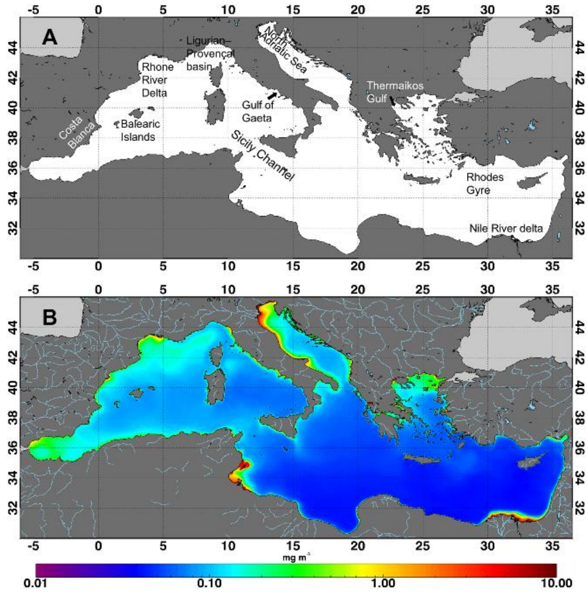
GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Morocco, Slovenia, Spain, Syria, Tunisia, Turkey
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO5. Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters
IMAP Common Indicator	CI14. Chlorophyll-a concentration in water column (EO5**)**
Indicator Assessment Factsheet Code	EO5CI14

RATIONALE/METHODS

Background (short)

Eutrophication may be defined as the nutrient enrichment of the marine environment with nutrients primarily nitrogen and phosphorus that stimulate primary production and algal growth (Vollenweider, 1992). 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). 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. In the Mediterranean Sea, the Barcelona Convention adopted in 1976 was the first legally binding instrument for its environmental protection and included a number of protocols, such as the pollution land-based sources (LBS) Protocol. Since 2000, other international and national policies, such as the European Water Framework Directive and the European Marine Strategy Framework Directive are developing programmes, which sums to its environmental protection at sub regional levels and collaborate with UNEP/MAP. At the 19th Ordinary Meeting in 2016 of the Contracting Parties to the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols) adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Coast and Sea and Related Assessment Criteria, which includes the targets to achieve the Good Environmental Status (UNEP/MAP, 2016). The initial targets of GES for IMAP Common Indicator 14 are reflecting the scope of the current MED POL Programme and the availability of suitable agreed assessment criteria.



The Mediterranean basin and its chlorophyll *a* concentration pattern. (A) Geographic regions (B) chlorophyll *a* concentration climatology over the Mediterranean Sea relative to 1998–2009 time period. Highest chlorophyll *a* concentrations are generally found in coastal water, in proximity of the river outflow, and are obviously conditioned by the nutrient of natural origin carried by rivers. From: Colella *et al.*, 2016.

Background (extended)

In the Mediterranean area, eutrophication is caused by both regional sources such as urban effluents, industrial discharges, and aquaculture activities as well as transboundary components such as agricultural runoffs, riverine outflows, and airborne nutrient deposition. The variables related to eutrophication are influenced by water circulation and to regional sources of pollution including eutrophication (UNEP, 2003).

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). Eutrophication and oligotrophy in the Mediterranean is illustrated as chlorophyll *a* distribution in remote sensing imagery (Fig. 1).

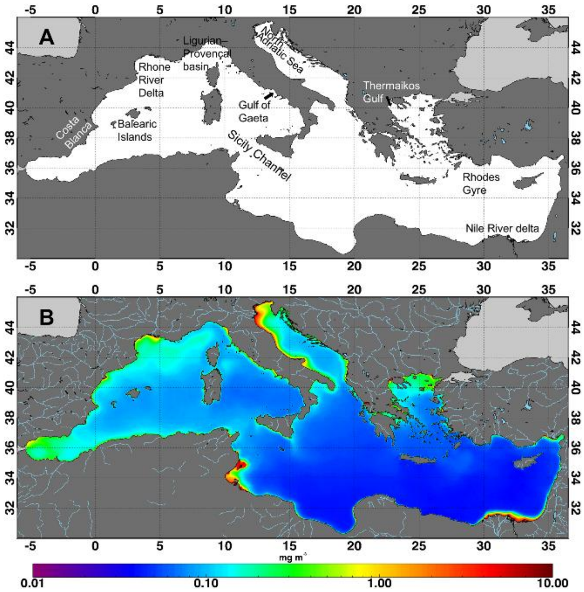


Figure 1. The Mediterranean basin and its chlorophyll *a* concentration pattern. (A) Geographic regions (B) chlorophyll a concentration climatology over the Mediterranean Sea relative to 1998–2009 time period. From: Colella *et al.*, 2016.

The assessment of eutrophication face a fairly complex matter, since, in the case of coastal environments, "abundance and composition of phytoplankton are characterized by a high degree of space-time variability: the complexity of these areas, due mainly to the high variability of environmental factors and to the responses of the communities, make it difficult to define a regular annual cycle of phytoplankton" (Pugnetti *et al*., 2007. In Italian). This statement clearly show that in the field of eutrophication the statistical requirement are essential for an acceptable assessment strategy. The applied WFD requirements in regards of Coastal Water types reference conditions and boundaries in the Mediterranean now is the best compromise.

In the Mediterranean Sea, the Barcelona Convention adopted in 1976 was the first legally binding instrument for its environmental protection and included a number of protocols, such as the pollution land-based sources (LBS) Protocol. Since 2000, other international and national policies, such as the European Water Framework Directive and the European Marine Strategy Framework Directive are developing programmes, which sums to its environmental protection at sub regional levels and collaborate with UNEP/MAP. At the 19th Ordinary Meeting in 2016 of the Contracting Parties to the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols) adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Coast and Sea and Related Assessment Criteria, which includes the targets to achieve the Good Environmental Status (UNEP/MAP, 2016). The initial targets of GES for IMAP Common Indicator 14 are reflecting the scope of the current MED POL Programme and the availability of suitable agreed assessment criteria.

Assessment methods

At the moment only some of the countries developed boundary approach for the assessment of eutrophication and this effort is integrated in the Coastal Water types reference conditions and boundaries in the Mediterranean (applicable for phytoplankton; IMAP, 2017). These criteria were for the first time applied on the data available for the Mediterranean through the MED POL Database.

For eutrophication, it is accepted that surface density is adopted as a proxy indicator for static stability of a coastal marine system. More information on typology criteria and setting 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).

Coastal water type III was split in two different sub basins, the western and the Eastern Mediterranean ones, according to the different trophic conditions and is well documented in literature.

It is recommended to define the major coastal water types in the Mediterranean for eutrophication assessment (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

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

In this assessment, aware that for most of the northern Mediterranean countries data are available also in other databases (EEA, EIONET, EMODnet…), only datasets obtained from the MED POL Database for chlorophyll *a* were used. Data availability by country were as follows:

Albania (2005-2006), Bosnia and Herzegovina (2006-2008) Croatia (2009, 2011-2014), Cyprus (1999-2015), Egypt (2009, 2010), France (2009, 2012), Greece (2004-2006), Israel (2001-2012), Montenegro (2008-2011), Morocco (2006,2007), Slovenia (1999-2013, 2015), Tunisia (2002-2013), Turkey (2005-2009, 2011,2013).

RESULTS

Results and Status, including trends (brief)

The trophic status of the Mediterranean Sea is controlled by the highly populated coastal zone and the riverine input. Offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards, the EMS has been characterized as the largest phosphorus-limited body of water in the global ocean.

The coastal area of the southeastern part of the Mediterranean shows clearly eutrophic trends. Eutrophic conditions in the area are mainly induced by the sewage effluents of Kairo 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 a limited nutrient supply through the Strait of Gibraltar due to different nutrient concentrations between the Atlantic and Mediterranean waters.

The main coastal areas in the Mediterranean with permanent eutrophic trends are the Gulf of Lions, the Adriatic, Northern Aegean, and the SE Mediterranean (Nile–Levantine).

The available data show 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.

Coastal Water type reference condition and boundaries for CI14 (Chlorophyll *a* concentration in the water column) have to be harmonised through the south Mediterranean region which has not yet participated in the assessment effort. The assessment can also help to identify areas were the criteria have to be improved. Of great help will be the implementation of a sampling strategy with simplified approach in monitoring design and data handling.

Results and Status, including trends (extended)

The trophic status of the Mediterranean Sea is controlled by the highly populated coastal zone and the riverine input from a draining area of 1.5 million km^2 (Ludwig *et al.* 2009) that induce eutrophic trends in coastal areas. The blue offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards (Turley 1999). Eutrophication and oligotrophy in the Mediterranean is illustrated as chlorophyll *a* distribution in remote sensing imagery (Fig. 1). This is due to the low nutrient content of EMS; the maximum concentrations recorded for nitrate were about 6 μM, for phosphate 0.25 μM, and for silicate 10–12 μM, 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 southeastern part of the Mediterranean shows clearly eutrophic trends. Although the River Nile is the major water resource in the area, its freshwater fluxes are getting 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 Kairo 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 μM, the nitrogen (nitrate) concentrations being about 1–4 μM, and the silicon (silicate) concentration is about 1.2 μM (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 with permanent eutrophic trends are the Gulf of Lions, 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 sea of Levantine. Phosphate maxima ranged from 0.05 to 0.26 μM, nitrate from 1.87 to 4.04 μM, chlorophyll *a* (chl*a*) from 0.39 to 0.96 mg L^{-1}.

The results of assessment and status of chlorophyll *a* concentration in the water column are presented on Figs 2-8 showing a rather limited figure of the Mediterranean region. The main reason is the data availability and quality. On the Fig. 2 are clearly visible that for the great part of the region data are missing. The implementation of water type criteria for the purpose of IMAP are also limited. Even a rather weak criteria (10 samples in 10 years in surface layer - <= 10 m) were adopted the data availability for assessment were low.

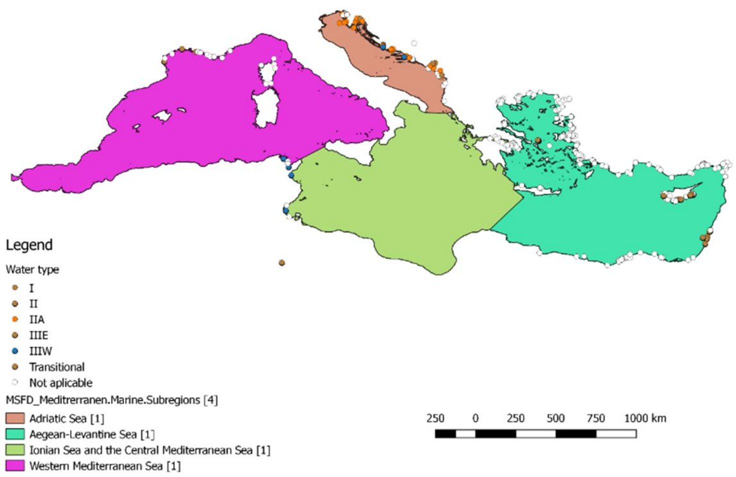


Figure 2. Stations in the Mediterranean region for which eutrophication parameter were sampled. Also are shown the water types (applicable for phytoplankton; IMAP. 2017) were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

On Figs 3-8 assessment data for all four subregions applying the Coastal Water types reference conditions and boundaries in the Mediterranean (applicable for phytoplankton; IMAP. 2017) are presented. For the Western Mediteranean Sea subregion (Fig. 3) only a limited set of data for France (from 2009 and 2012) were assessed indicating that none of the stations in the Golf of Lyon were in moderate state.

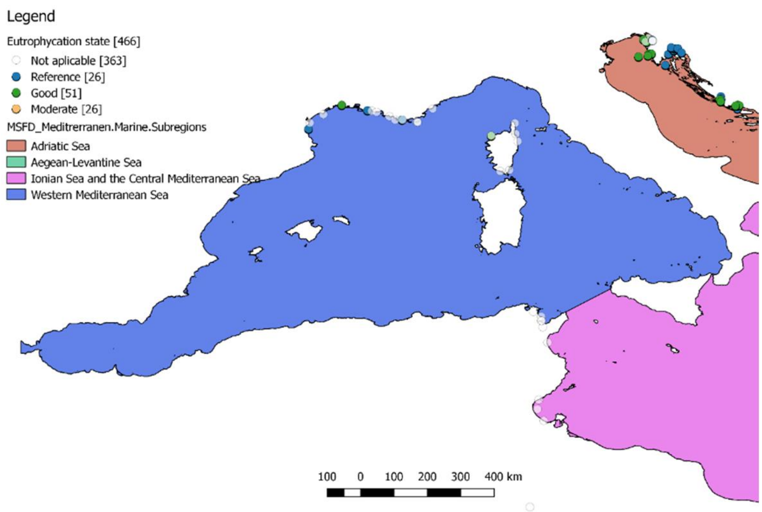


Figure 3. Stations in the Western Mediterranean Sea subregion for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017) for were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

In the Adriatic Sea subregion (Figs 4-5) only the eastern part were assessed (Slovenia, Croatia and Montenegro). The applied criteria showed that all the stations in the assessed area are at list in good status. The Box and Whisker plot (Fig. 5) 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.

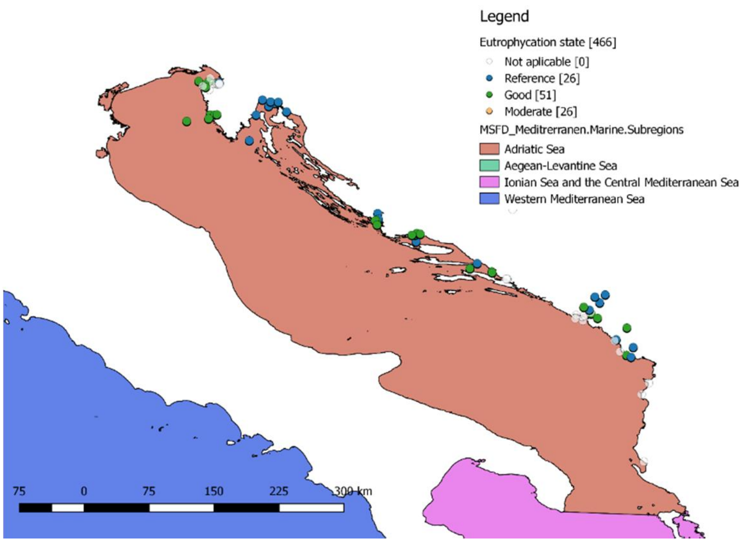


Figure 4. Stations in the Adriatic Sea subregion for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017) for were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

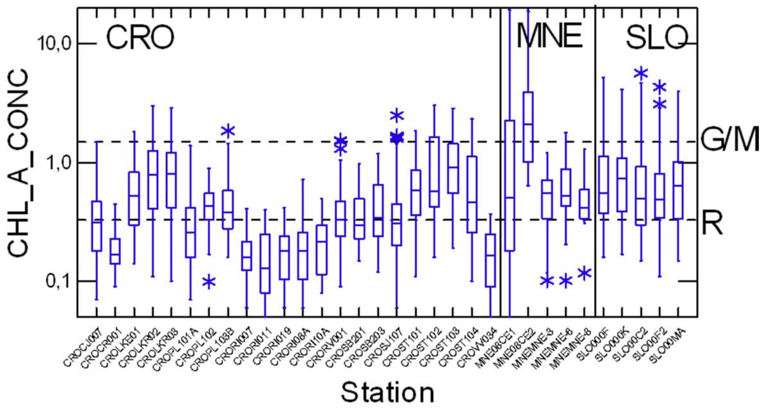


Figure 5. Box and whisker plot for chlorophyll *a* concentration in the Adriatic Sea subregion (water type IIA) for which coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017)

For the Ionian Sea and the Central Mediterranean Sea subregion (Fig 6) the assessment was not performed as no data were available.

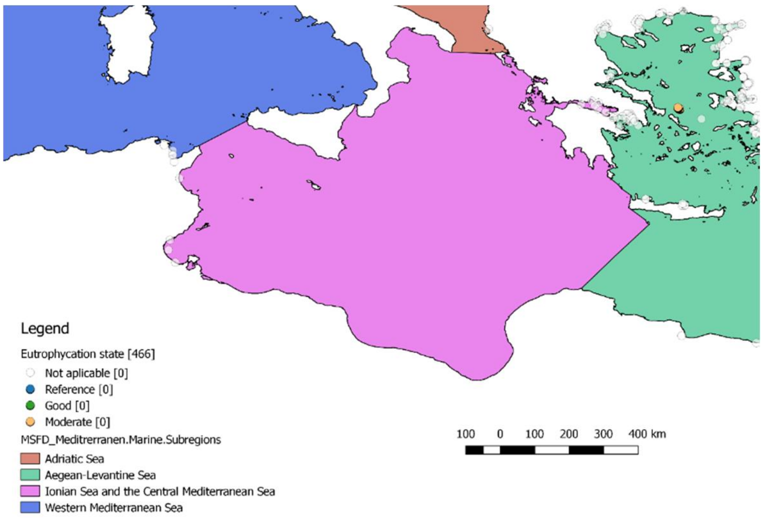


Figure 6. Stations in the Ionian Sea and the Central Mediterranean Sea subregion for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017) for were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

In the Aegean-Levantine Sea subregion (Figs 7-8) the assessed country were Cyprus and Israel. Partially data for Turkey (Mersin area) were also used the applied criteria (Water type IIIE) showed that practically all the stations in the Cyprus area are at list in good status. The Box and Whisker plot (Fig. 8) shows even more details. The data for Israel and Mersin area (Turkey) indicate that the areas were in moderate state. Probably the criteria for Water type IIIE in this area are too rigorous due to the fact that this area a close to the coast and ports.

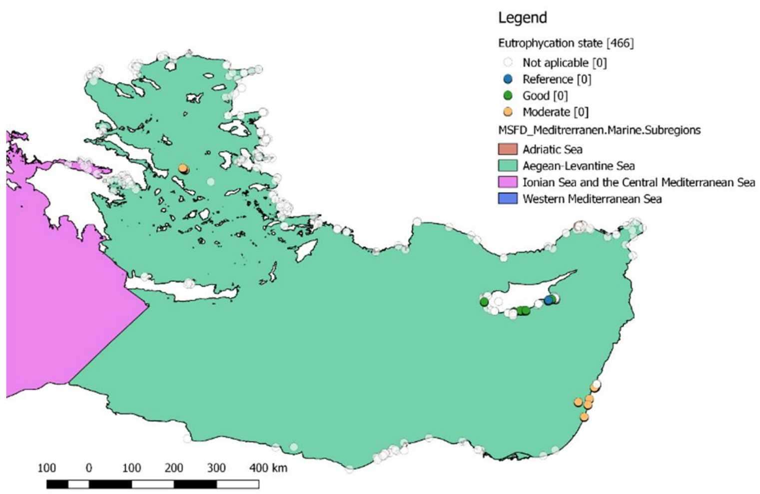


Figure 7. Stations in the Aegean-Levantine Sea subregion for which eutrophication were assessed. Coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017) for were minimal statistical requirements were satisfied (10 samples in the last 10 years and in the surface layer, <= 10 m)

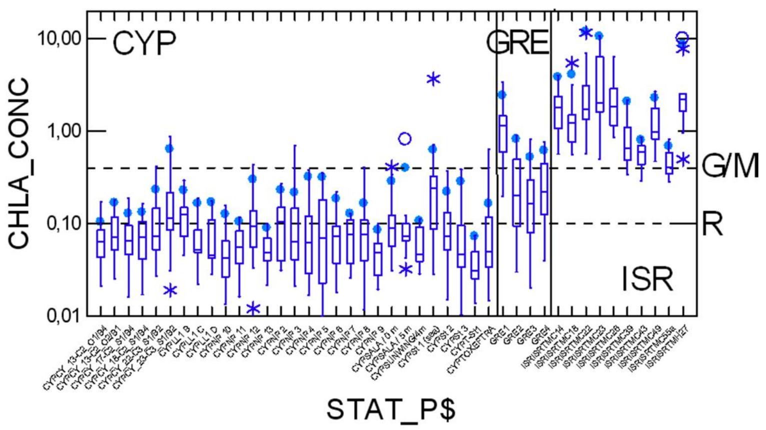


Figure 8. Box and whisker plot for chlorophyll *a* concentration in the Aegean-Levantine Sea subregion (water type IIIE) for which coastal Water types reference conditions and boundaries in the Mediterranean were applied (applicable for phytoplankton; IMAP. 2017). The blue dots represent the 90-percentile value

At the eutrophication hot spots in the Mediterranean Sea a comprehensive chlorophyll *a* trend analysis would be beneficial. Significant chlorophyll *a* trends need to be detected from long time series that are able to capture biomass changes in coastal waters as the analysis of short time series can erroneously lead to interpret some spatial patterns produced by random processes as chlorophyll *a* concentration trends.

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 applications of environmental regulations. Recent use of this data (Colella *et al.*, 2016) allowed for a consistent monitoring of biogeochemical issues in the Mediterranean basin. 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 problems is welcome, 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.

CONCLUSIONS

Conclusions (brief)

The trophic status of the Mediterranean Sea is controlled by the highly populated coastal zone and the riverine input from a draining area. Offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards.

The main coastal areas in the Mediterranean with permanent eutrophic trends are the Gulf of Lions, the Adriatic, Northern Aegean, and the SE Mediterranean (Nile–Levantine).

The available data show 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 term of GES achievement in these areas (Eastern Adriatic and Cyprus) it is maintained.

Conclusions (extended)

The trophic status of the Mediterranean Sea is controlled by the highly populated coastal zone and the riverine input from a draining area. Offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards. The Eastern Mediterranean Sea (EMS) is still the most oligotrophic area of the whole Medirerranen basin, and the largest phosphorus-limited body of water in the global ocean.

The coastal area of the southeastern part of the Mediterranean shows clearly eutrophic trends. Although the River Nile is the major water resource in the area, its freshwater fluxes are getting 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 Kairo and Alexandria. The Northern Aegean shows mesotrophic to eutrophic trends 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. 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 with permanent eutrophic trends are the Gulf of Lions, the Adriatic, Northern Aegean, and the SE Mediterranean (Nile–Levantine).

The available data show 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 term of GES achievement in these areas (Eastern Adriatic and Cyprus) it is manteined.

Coastal Water type reference condition and boundaries for CI14 (Chlorophyll *a* concentration in the water column) have to be harmonised through the south Mediterranean region which has not yet participated in the assessment effort. The assessment can also help to identify areas were the criteria have to be improved. Of great help will be the implementation of a sampling strategy with simplified approach in monitoring design and data handling.

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 applications of environmental regulations.

Key messages

- offshore waters of the Mediterranean have been characterized as extremely oligotrophic with an increasing tendency for oligotrophy eastwards,

- the main coastal areas in the Mediterranean with permanent eutrophic trends are the Gulf of Lions, the Adriatic, Northern Aegean, and the SE Mediterranean (Nile–Levantine), and
- the available data show 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.

Knowledge gaps

There are no main gaps identified in the Mediterranean Sea concerning the assessment of the Common Indicator 14. However, significant chlorophyll *a* trends need to be detected from long time series that are able to capture biomass changes in coastal waters, and for that purpose data availability have to be improved. A possible approach is to use data stored in other databases were some of the Mediterranean countries regularly contribute. 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 applications of environmental regulations.

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Ecological Objective 9 (EO9): Chemical pollution

EO9: Common Indicator 17: Concentration of key harmful contaminants measured in the relevant matrix (EO9, related to biota, sediment, seawater)

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Morocco, Slovenia, Spain, Syria, Tunisia, Turkey
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO9. Contaminants cause no significant impact on coastal and marine ecosystems and human health
IMAP Common Indicator	CI17. Concentration of key harmful contaminants measured in the relevant matrix (EO9, related to biota, sediment, seawater)
Indicator Assessment Factsheet Code	EO9CI17

RATIONALE/METHODS

Background (short)

The status of the chemical contamination in the marine environment is the result of the human activities (drivers and pressures) that take place all around the coastal and marine areas of the Mediterranean Sea and puts it away from the natural steady-state conditions. Primarily, harmful contaminants enter the marine ecosystem through different routes, such atmospheric deposition or inputs from land-based sources. For example, in the Mediterranean coasts, from small recreational marinas up to major commercial ports, which count thousands, have created a number of different pressures in terms of chemical pollution. At present, there are still old threats and new pressures, although the trends and levels of the so called legacy pollutants (e.g. heavy metals, persistent organic pollutants and pesticides), have decreased significantly in the most impacted areas in the Mediterranean Sea after the 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). Today, there are still point and diffuse pollution sources releasing both priority and emerging chemical contaminants (e.g. pharmaceuticals, personal care products, flame retardants) in the Mediterranean Sea. The land-based sources (LBS) of contaminants impacting the coastal environment enter both via treated (or non-treated) wastewater discharges and represent a major input. In terms of diffuse pollution sources, land based run-off and atmospheric deposition (wet/dry deposition and diffusive transport) are the two major contributors to the coastal areas. The sea-based sources themselves are also accounted (i.e. direct inputs from maritime and industrial activities, such as shipping, fishing, oil refining oil and gas exploration and exploitation) which could be permanent chronic sources of pollution in the marine environment, including the potential for acute pollution events.

Good Environmental Status (GES) for Common Indicator 17 (CI 17) can be accomplished when levels of pollution would be below a determined threshold (e.g. Environmental assessment Criteria, EACs), defined for the area and species. To this regard, the concentrations of specific harmful chemicals should be maintained below EACs or reference concentrations without deterioration trends, as well as, the reduction of contaminant emissions form land-based sources should be achieved (UNEP/MAP, 2013, 2015).

Figure 1: Muddy sediment sample taken with a large grab sampler. The top 1 cm layer is collected for chemical pollution analyses. The oxic and anoxic layers can be clearly observed, Image provided: Mudsedimentsample_CGuitart.jpg

Background (extended)

In the Mediterranean Sea, the Barcelona Convention adopted in 1976 was the first legally-binding instrument for its environmental protection and included a number of protocols, such as the pollution land-based sources (LBS) Protocol. The MAP/MED POL (Programme for the Assessment and Control of Marine Pollution) was implemented and the coastal long-term monitoring networks developed. Its NBB/PRTR component (National Baseline Budget/ Pollutant Release and Transfer Register) allows the Contracting Parties of the Barcelona Convention to submit the data related to national loads of pollutants discharged directly or indirectly into the Mediterranean Sea for whom it is worth marine monitoring. Since 2000, other international and national policies, such as the European Water Framework Directive and the European Marine Strategy Framework Directive are developing strategies in the Mediterranean Sea which aims to its environmental protection at sub-regional levels and collaborate with UNEP/MAP. At the 19th Ordinary Meeting in 2016 of the Contracting Parties to the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols) adopted the Integrated Monitoring and Assessment Programme (IMAP) of the Mediterranean Coast and Sea and Related Assessment Criteria, which includes the targets to achieve the Good Environmental Status (UNEP/MAP, 2016). The initial targets of GES for IMAP Common Indicator 17 are based upon data for a relatively small number of chemicals, reflecting the scope of the current MED POL Programme and the availability of suitable agreed assessment criteria.

Assessment methods

The method for the assessment of the CI 17 has been undertaken by evaluating the latest and available MED POL datasets of levels of chemical contaminants against set environmental criteria (for different matrices) at a regional scale. Heavy metals (Cadmium, Mercury and Lead), petroleum hydrocarbons and persistent organic pollutants (POPs) -from the national coastal monitoring networks reported to the MEDPOL Database- were initially evaluated. However, petroleum hydrocarbons and POPs show a data scarcity, a lack of regional coverage and mostly non-detected concentrations, and therefore, this assessment focus on heavy metals at a regional scale. Three different matrices have been considered, bivalves, fish and sediments, and their contaminant levels compared against background and environmental assessment criteria (BACs and EACs), as adopted by the COP19 in February 2016 for the Mediterranean Sea (Annex to the UNEP(DEPI)/MED IG. 22/7 Decision). The current EACs defining acceptable or non-acceptable environmental chemical status are based on European policy for biota (EC/EU 1881/2006 and 629/2008 Directives for maximum levels for certain contaminants in foodstuffs) and US ERL values (Effects Range Low toxicological criteria) for sediments (see the table below).

Table1: IMAP Assessment Criteria for Heavy Metals

Trace metal	[a]Mussel (MG) µg/kg d.w.			[b]Mussel µg/kg d.w.	[c]Fish (MB) µg/kg d.w.[f]			Sediment µg/kg d.w.		
	BC	Med BAC	EC	BAC	BC	Med BAC	(EC)	BC	[e]Med BAC	ERL
Cd	725	1088	5000	1000	4	8/16[d]	207	-	150	1200
Hg	125	188	2500	170	296	600	4150	-	45	150
Pb	2500	3800	7500	1000	279	558	1245	-	30000	46700

[a] preliminary data for the NW Mediterranean (Spain);
[b] additional BAC data provided by Lebanon for *Brachidontes variabilis* species;
[c] preliminary data for the NW Mediterranean (Spain);
[d] earlier estimation wet weight;
[e] estimated from sediment cores (UNEP(DEPI)/MED WG.365/Inf.8, 2011);
[f] a dry/wet ratio of 20 should be used to convert units for MG (f.w. units = d.w. units / 5)

The species of bivalves (*Mytilus galloprovincialis, MG; Mactra corralina, MC and Donax trunculus, DT)*) and fish (*Mullus barbatus MB)* were evaluated, as well as levels reported in coastal sediment samples. The methodology is based on the calculation of the percentages of stations (units) with levels below or above the BACs and above the EACs criteria (two thresholds and three groups, see graph), and plotted spatially (see GIS maps in Results Section).

In brief, tthe latest relevant year (or years) of non-evaluated MED POL datasets allowing a maximum spatial coverage were selected for each country and matrix in order to construct a regional state assessment integrated over time (*ca*. reflecting the temporal availability of the datasets). The datasets from countries reporting consecutive years were examined to evaluate their consistence (i.e. coordinates, values, methods, DLs) before the selection of the latest dataset for evaluation. Alternatively, the yearly datasets from CPs were mixed to provide a greater spatial coverage when locations changed over years. The data was also averaged when necessary (e.g. when reported yearly replicate samples for the same station).

The biota metrics employed for the assessment was µg/kg dry weight (ppb) for mussel samples (whole soft tissue) and µg/kg fresh weight (ppb) for fish (fillet tissue), for whom the methodologies and data format is harmonized through the MED POL countries. For sediments (in µg/kg dry weight), the data by stations was averaged (or by area when close stations were reported) when necessary, in line with the regional scale of the assessment and the volume of data available. The levels of contaminants in sediment samples includes different fractions as available at the MED POL Database submitted by the CPs and these were combined spatially for the evaluation (ranging from >60µm up to the whole sample).

The datasets used from the MED POL Database for each country and matrix were as follows:

- Bivalves: Croatia (2009, 2011-2014), Egypt (2009-10), France (2012), Israel (2012-13, including 2010 and 2011 for Pb), Italy (2009), Montenegro (2009-2011), Slovenia (2015), Spain (2011), Tunisia (2010-13), Turkey (2009, 2011)
- Fish: Cyprus (2014-2015), Greece (2005), Israel (2013), Spain (2006-08), Turkey (2013)

- Sediments: Croatia (2011, 2013), Egypt (2006, 2009, 2010), France (2009-2011), Greece (2005), Israel (2013), Italy (2009), Montenegro (2010-2011), Morocco (2007), Spain (2007-08, 2011), Syria (2007), Tunisia (2012-13), Turkey (2013).

The quality of the major MED POL legacy contaminant groups datasets were considered, in particular, for heavy metals were a major number of quality assured datasets were available.

In the course of preparing these assessments, several CPs provided new additional data that will be used to perform future assessments (e.g. Tunisia, Turkey, Cyprus, Croatia, Egypt, Israel, Morocco, Montenegro and Slovenia).

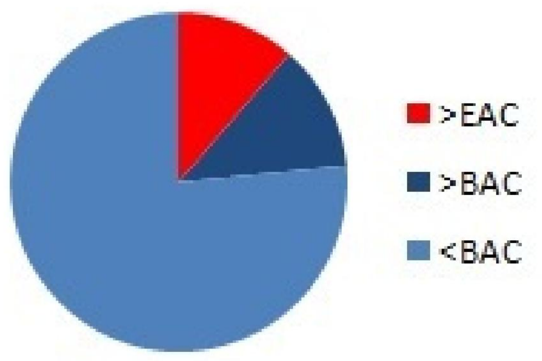

Figure 2. Graph showing the percentage of stations with contaminant concentrations below and above Background Assessment Criteria (BACs), and above Environmental Assessment Criteria (EACs that is either ECs or ERLs for biota and sediment, respectively).

RESULTS

Results and Status, including trends (brief)

The latest available datasets of contaminants reported to the MED POL Database continues to indicate lower levels of legacy pollutants and contaminants in the Mediterranean Sea biota (mainly bivalves), despite known hotspots, similarly to the previous assessment reports (UNEP/MAP, 2009; UNEP/MAP/MED POL, 2011a; UNEP/MAP, 2012a, 2012b) and temporal trends report (UNEP/MAP/MED POL, 2011b, 2016b), whilst chemicals show their accumulation and persistence in the coastal sediments. The monitored chemical contaminants in different matrices, namely mussel, fish and sediments and their assessment against Background Assessment Criteria (BACs) and Environmental Assessment Criteria (namely, ECs and ERLs, for biota and sediment) also point to this conclusion. In general terms, for biota (mussels and fish), the percentage of stations with acceptable environmental conditions, that is below the EC threshold criteria, range from 90% to 100% for Cd, Pb and HgT. Solely some stations assessed for Pb in mussels shows levels above Pb EC for a 10% of the stations at a regional scale. Therefore, all the MED POL assessed stations for biota show acceptable marine environmental conditions except a 10% of them for Pb. On the contrary, the calculated percentages of the monitored levels in the coastal sediments above the assessment criteria (ca. >ERLs), that is non-acceptable environmental conditions, are a 6%, 53% and 13% for Cd, HgT and Pb respectively. Mercury with a 53% of the monitored stations above the ERL in the coastal Mediterranean Sea sediments reflects the need of sub-regional assessment criteria, thus a mixture of natural and anthropogenic known sources might influence this result, especially in the Adriatic Sea and the Aegean and Levantine Seas.

To this regard, a revision of the current assessment criteria has been undertaken (UNEP/MAP/MED POL, 2016a) which should further refine these findings in future assessments. Figures 1 to 9 show the spatial results of the assessment performed at regional scale for the whole Mediterranean basin. The matrices evaluated were coastal populations of marine bivalves (such as *Mytilus galloprovincialis*), fish (such as *Mullus barbatus*) and sediments. Overall, both the calculations and spatial plots assessments reflect few non-acceptable environmental conditions, particularly, for Pb in mussels in some locations and both Pb and HgT in coastal sediments as mentioned (although some are known Mediterranean Sea hotspots and natural input areas); whilst for the rest of matrices and heavy metals evaluated the assessment could conclude acceptable environmental conditions. Clearly, to guarantee the control and achievement of targets (for example, with regard current acceptable conditions for Cd and HgT in biota), and to avoid future deteriorations of the environmental conditions the coastal marine environment needs continuous monitoring and assessment of levels and temporal trends.

Results and Status, including trends (extended)

Cadmium, mercury and lead in Mediterranean bivalves

The Figures 3 to 5 shows the distribution of the assessment performed for heavy metals in the Mediterranean Sea in bivalves. The stations are located mostly in the Western Mediterranean Sea and the Adriatic Sea sub-regions. The assessment primarily shows that Cd and HgT levels are not above the Environmental Assessment Criteria (*ca*. ECs), except for one station for HgT, thus indicating acceptable environmental conditions, which is an improvement of the earlier situation reported (UNEP/MAP/MEDPOL 2011a). A 80% and 69% of the monitored data for Cd and HgT in mussel, respectively, are also below the Background Assessment Criteria (BACs) which further indicates natural background levels. In the same way, the Pb assessment shows the environmental status situation in the Mediterranean basin, despite major mining and industrial activities with levels above the set ECs in the coasts of Spain, Italy and Croatia still known hotspots. A 90% of the stations below the EC value shows acceptable environmental Pb levels (72% below BAC and 18% above BAC), whilst a 10% above the EC indicates that the environmental situation should improve in these areas.

Cadmium, mercury and lead in Mediterranean fish

The new assessment for the pilot projects implemented by some Contracting Parties with regard the monitoring of levels of contaminants in fish shows an acceptable environmental situation (Figures 6 to 8). The assessment of the heavy metals indicates an acceptable environmental status with very few stations above the BACs and none above the ECs. Particularly, the 91%, 83% and 94% of the evaluated stations in both Western and Eastern geographical areas shows values below the BACs for Cd, HgT and Pb indicating naturally occurring levels in fish.

Cadmium, mercury and lead in Mediterranean coastal sediments

The Figures 9 to 11 show the assessment for coastal sediments against BACs and ERLs for the latest information available in the Mediterranean Sea. The concentrations of heavy metals in the coastal sediments show a different picture with respect the environmental information for biota, in particular for HgT and Pb. The number of samples over the ERLs values are higher in this matrix, which responds to the known environmental processes for chemical contaminants in the marine environment were the final compartment is known to be the coastal sediment. Cd shows only 6% and 49% of the evaluated stations above the ERL and BAC, respectively, therefore a 94% of sediment stations with acceptable environmental levels of cadmium. However, few of these 6% of stations are known to be impacted by anthropogenic sources, whilst others respond to different natural input processes, such as the input of Cd from the Atlantic waters through the Gibraltar Strait, the upwelling inputs in the Gulf of Lions or the atmospheric deposition processes in the Mediterranean island of Corsica.

Contrarily, HgT concentrations in coastal sediments reflect a situation far from a good environmental status (GES), according to the current regional assessment criteria, particularly in the NW

Mediterranean, the Adriatic Sea, the Aegean Sea and the Levantine Sea basins. All the data assessed in the different sub-regions shows a 53% of the stations above the ERL. Thus, a 30% above the BAC and 17% below BAC in the coastal sediment, sums a limited 47% of the monitored stations with acceptable environmental conditions. The main sources of this mercury in the marine environment are due to the industrial exploitation of mines of the Hg-rich natural land resources in these areas. It should be pointed out that the reference values agreed are based on information from core sediments collected in the Mediterranean Sea and the revision of these values has been proposed (UNEP/MAP MED POL, 2016a) to include sub-regional criteria to balance the potential geological background differences through the Mediterranean basins in future assessments. On the contrary, for Pb, a, different geographical composition between the Western and Eastern Mediterranean coastal sediments composition might overestimate the acceptable environmental conditions for the latter, if a single set of regional assessment criteria is used (UNEP/MAP/MED POL (2016a) In the Western Mediterranean a 11% of the stations are above the ERL, thus a 89% of stations with acceptable natural environmental conditions (only a 12% above the BAC). As mentioned above, however, none of the stations evaluated in the Eastern Mediterranean coasts show values above the ERL, and for the Levantine Sea none of the stations show even values above the BAC criteria, therefore, reflecting that different assessment criteria for Pb at sub-regional scales in the Mediterranean Sea should be considered, thus some known hotspots for Pb inputs are known in the Eastern Mediterranean Sea. As for the case of HgT, the Pb criteria, BACs and ERLs, for sediments are under proposal to refine the future assessments at a sub-regional scales (UNEP/MAP MED POL, 2016a).

Persistent Organic Pollutants (POPs) and Non-halogenated compounds

Persistent organic pollutants (POPs) include certain legacy chlorinated pesticides and industrial chemicals, such as the so called polychlorinated biphenyls (PCBs), most of which have already been prohibited at global scale under the Stockholm Convention. These chemical substances are resistant to environmental degradation processes, and therefore persistent and prone to long-range transport. In the marine environment the bioaccumulation and biomagnification in organisms have been largely investigated, as well as their implications for human health. The scarcity of recent POPs quality assured datasets in the MED POL Database and the fact that most of these show non-detectable levels, mainly in biota matrices, is in accordance with the earlier lowering levels and trends observed in previous reports (UNEP/MAP/MED POL 2011a, 2011b, 2012) and no further updates could be performed at present.

Similarly, the historical levels of petroleum hydrocarbons from a number of urban, industrial and sea activities in the marine environment have been reduced, probably the most significant example is the reduction of the spilled oil in the Mediterranean Sea (i.e. acute pollution) compared to previous decades. However, continuous chronic oil petroleum pollution continues associated to main harbors, sea-based sources and atmospheric inputs. Oil is composed of thousands of compounds and includes the group of the Polycyclic Aromatic Hydrocarbons (PAHs) which some of them are the current targeted compounds. . Further, it is interesting to point out the overlooked importance of inputs from particular marine operations, such as the oil exploitation, due to the introduction of PAHs in the marine environment but also of other chemicals (e.g. phenols) along with the produced-water from these installations.

Emerging chemical compounds

The occurrence of emerging compounds in the Mediterranean Sea has gained relevance over the last decade both in the northern and southern coasts. Different groups of chemicals, such as environmental phenols, pharmaceutical compounds, personal care products, polycyclic fragrances and many others are currently under investigation. Particularly, it is worth to mention as well, the recent focus on the occurrence of marine litter from nano to macro sizes in the marine ecosystems, a new major treat for the Mediterranean Sea.

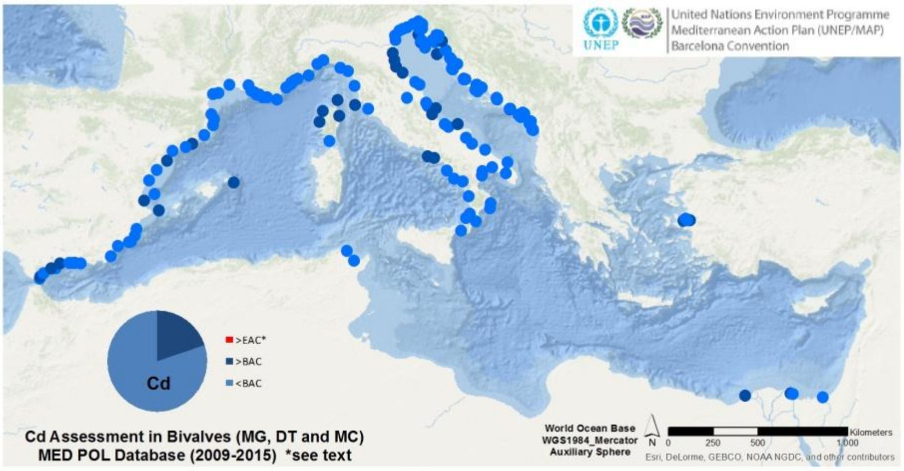

Figure 3. Regional Cadmium levels assessment against BAC/EAC (EC) criteria in bivalve sp. (*Mytilusgalloprovincialis, Donax trunculus and Mactra corralina*) for the Mediterranean Sea, Bivalve Cd.jpg

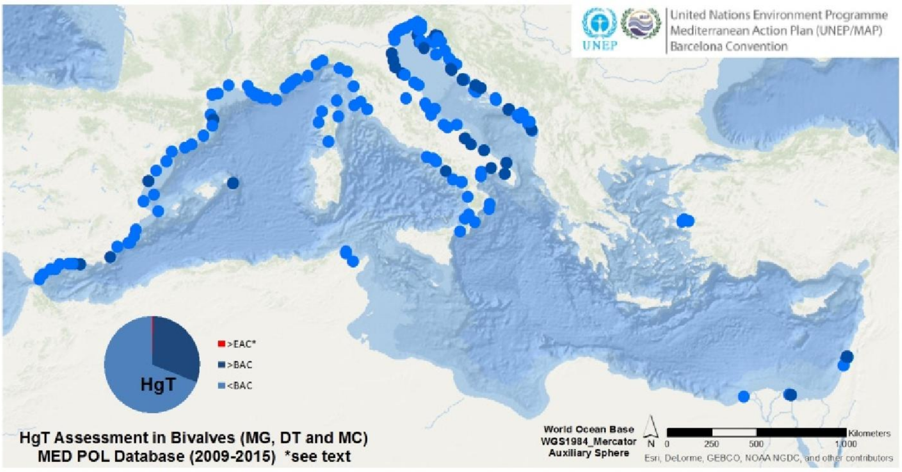

Figure 4. Regional Mercury levels assessment against BAC/EAC (EC) criteria in bivalve sp. (*Mytilusgalloprovincialis, Donax trunculus and Mactra corralina*) for the Mediterranean Sea, Bivalve HgT.jpg

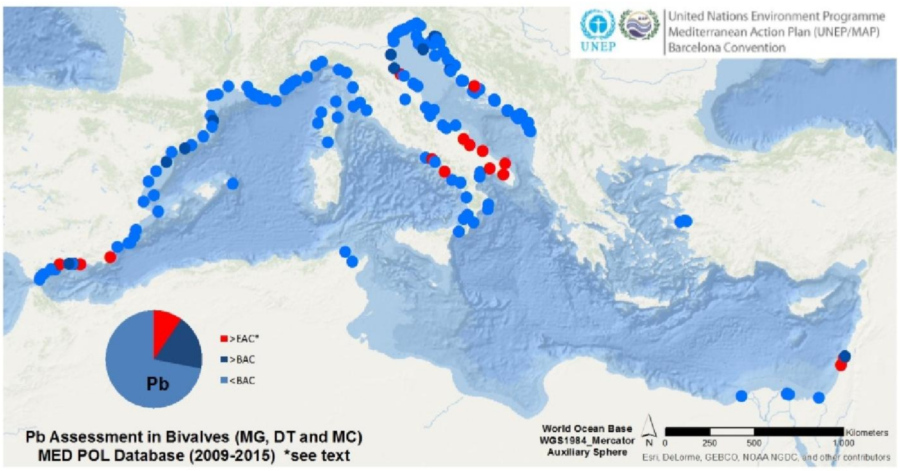

Figure 5. Regional Lead levels assessment against BAC/EAC (EC) criteria in bivalve sp. (*Mytilusgalloprovincialis, Donax trunculus and Mactra corralina*) for the Mediterranean Sea, Bivalve Pb.jpg

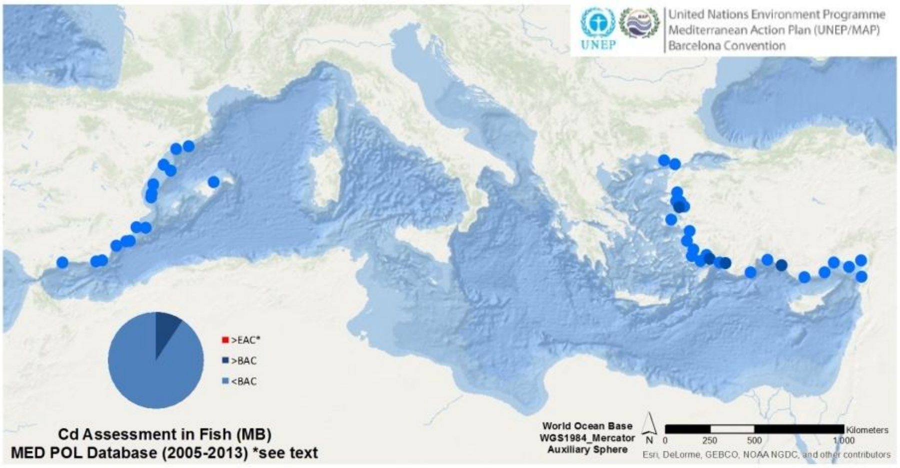

Figure 6. Regional Cadmium levels assessment against BAC/EAC (EC) criteria in fish sp. (*Mullus barbatus*) for the Mediterranean Sea, Mullus Cd.jpg

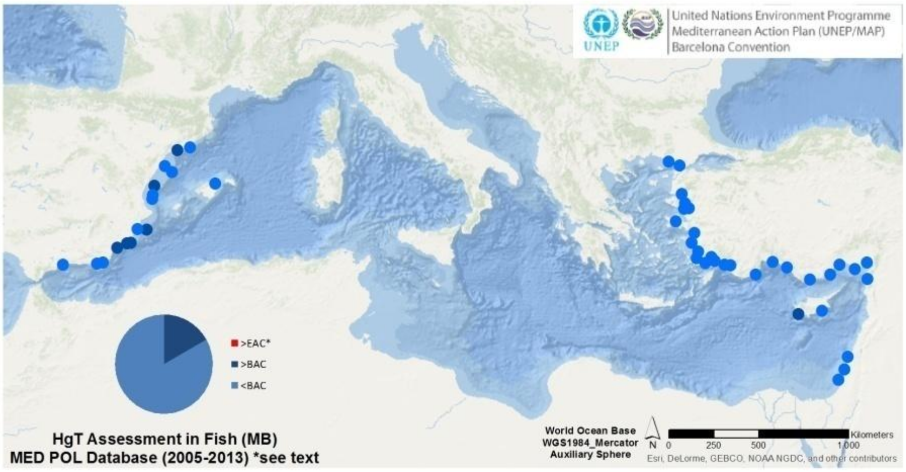

Figure 7. Regional Mercury levels assessment against BAC/EAC (EC) criteria in fish sp. (*Mullus barbatus*) for the Mediterranean Sea, Mullus HgT.jpg

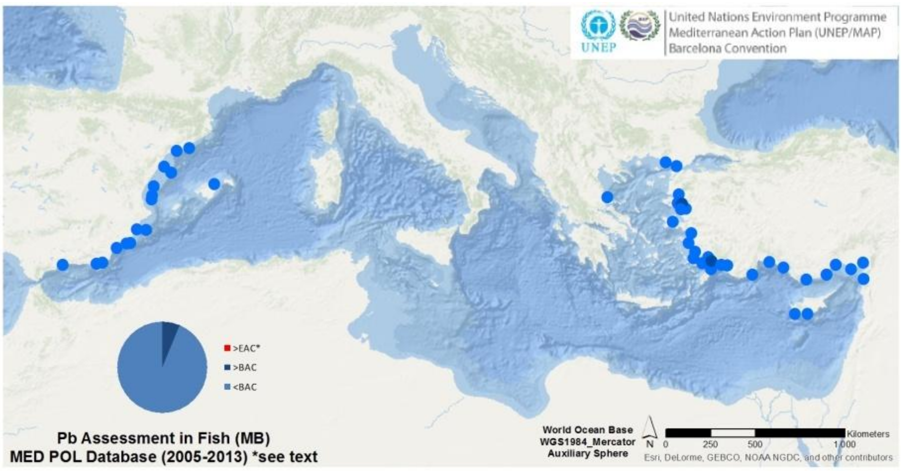

Figure 8. Regional Lead levels assessment against BAC/EAC (EC) criteria in fish sp. (*Mullus barbatus*) for the Mediterranean Sea, Mullus Pb.jpg

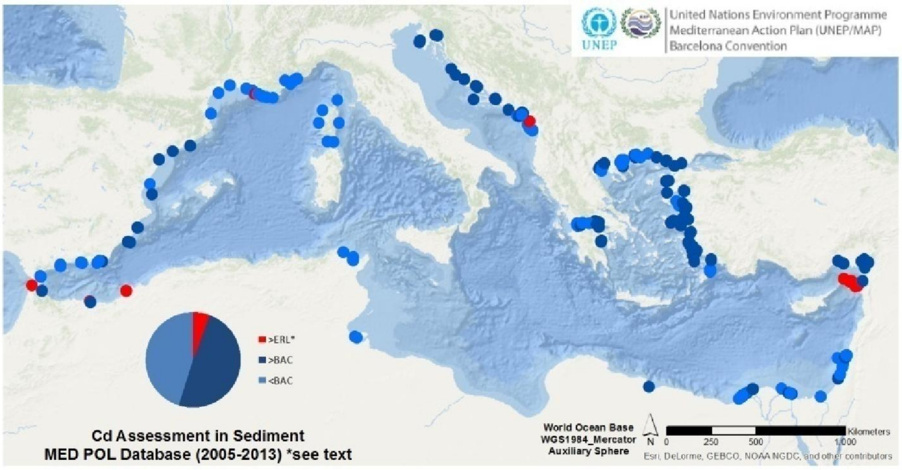

Figure 9. Regional Cadmium levels assessment against BAC/EAC (ERL) criteria in sediment for the Mediterranean Sea, Sediment Cd.jpg

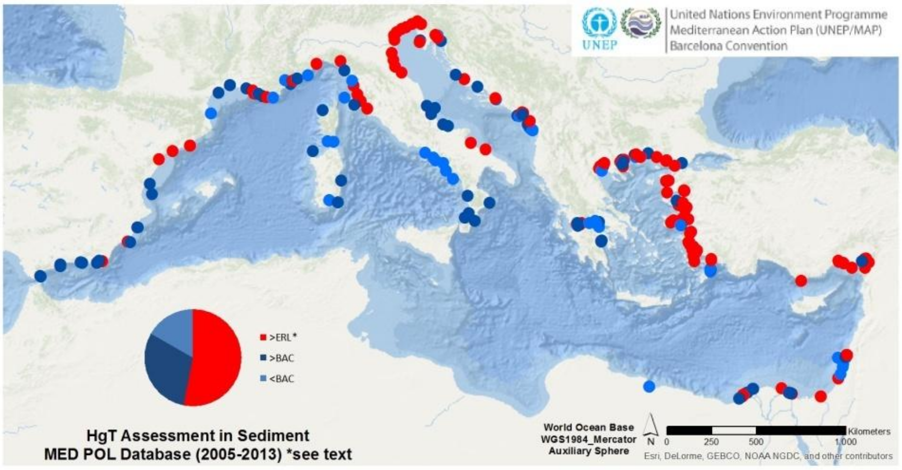

Figure 10. Regional Mercury levels assessment against BAC/EAC (ERL) criteria in sediment for the Mediterranean Sea, Sediment HgT.jpg

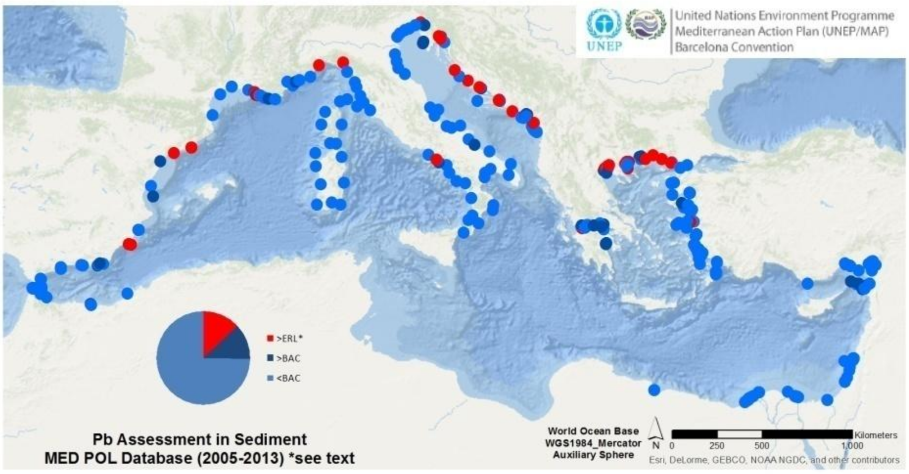

Figure 11. Regional Lead levels assessment against BAC/EAC (ERL) criteria in sediment for the Mediterranean Sea, Sediment Pb.jpg

CONCLUSIONS

Conclusions (brief)

A main conclusion of this first pollution assessment against assessment criteria performed for heavy metals in the Mediterranean Sea shows that environmental conditions differ largely between biota and coastal sediments. This current situation, in terms of environmental protection from chemical pollution and GES achievement, indicates that the LBS inputs in the coastal surface waters (and/or atmospheric inputs) from both urban or industrial activities shows little concern (ca. under control measures) with a high proportion of values in biota under the EACs (*ca*. ECs); and therefore, acceptable environmental conditions. On the contrary, the legacy of heavy metal pollution shows an accumulation in the coastal sediments close to both historical known Mediterranean hotspots and natural sources which should be locally assessed.

Conclusions (extended)

In terms of GES (Good Environmental Status) assessment, the biota (mussel and fish) show a situation where the acceptable conditions exist for coastal surface marine waters with levels below the assessment criteria (i.e. ECs), except for Pb in some mussel monitoring areas. These areas correspond to known coastal sites (hotspots) were measures and actions should be further considered to improve the marine environmental quality. The sediment evaluation in terms of GES show an impacted situation for the coastal benthic ecosystem, especially for HgT, to be further investigated and assessed. Therefore, these assessments should consider sub regional differences in the Mediterranean Sea basins, as well as the occurrence of natural and anthropogenic sources. Therefore, the development of assessment criteria for sub regional assessments should be a priority and these initial results should be taken with caution. To this regard, there is a need to consider the relationships between different policy standards and assessment metrics (i.e. WFD, MSFD, etc).

Key messages

- Levels of heavy metals in coastal water show an acceptable environmental status assessed from mussels and fish against BACs and EACs (*ca*. ECs).
- For Pb a 10% of the stations show levels above the set EC threshold for mussel samples.
- Heavy metal concerns are found in the coastal sediment compartment for Pb and HgT indicating an accumulation of these chemicals.
- For HgT, a 53% of the stations assessed are above the ERL set as regional assessment criteria for acceptable environmental conditions for the Mediterranean basin, although sub-regional differences have to be taken into account.
- Measures and actions should focus on known hotspots associated to urban and industrial areas along the coasts of the Mediterranean Sea, as well as to include sea-based sources, as these are also primary inputs.
- Background and Environmental Assessment Criteria (BACs and EACs) should be further improved to take in consideration sub-regional specificities for occurring natural compounds, such as heavy metals

Knowledge gaps

There are no new gaps identified in the Mediterranean Sea concerning the assessment of the Common Indicator 17. The improvements in the limited spatial coverage, temporal consistency and quality assurance for monitoring activities hinders to some extent the regional and sub-regional assessments, as previously observed (UNEP/MA/MED POL, 2011a and 2011b). The lack of sufficient synchronized datasets for a state assessment should be improved. To this regard, the criteria to undertake the assessment have further shown the necessity to explore the new criteria at sub regional

scale for the determination of background concentrations of those chemicals occurring also naturally, such a Pb in sediments. Two recent reports (UNEP/MAP MED POL, 2016a and 2016b) have reviewed and proposed the background and environmental assessment criteria (BACs and EACs) for the Mediterranean Sea. These reports were built in line with the 2011 reports (UNEP/MAP MED POL, 2011a and 2011b).
The current assessment period covered span for different periods including the most recent data available, despite the number of datasets did not increased significantly the potential evaluation of temporal trends. At present, the major studies are performed in the coastal population of marine bivalves (such as *Mytilus galloprovincialis*), fish (such as *Mullus barbatus*) and sediments.

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Ecological Objective 9 (EO9): Chemical pollution

EO9: Common Indicator 18: Level of pollution effects of key contaminants where a cause and effect relationship has been established

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Contracting Parties by research studies
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO9. Contaminants cause no significant impact on coastal and marine ecosystems and human health
IMAP Common Indicator	CI18. Level of pollution effects of key contaminants where a cause and effect relationship has been established
Indicator Assessment Factsheet Code	EO9CI18

RATIONALE/METHODS

Background (short)

In most Mediterranean countries, the coastal monitoring of a range of chemicals and biological effects parameters in different marine ecosystem compartments and organisms are undertaken in response to the UNEP/MAP Barcelona Convention (1975) and its Land-Based Sources (LBS)Protocol. A considerable amount of founding actions from the past decades are available through the pollution monitoring and assessment component of the UNEP/MAP MED POL Programme, including monitoring pilot programmes such as the ecotoxicological effects of contaminants (UNEP/MAP MED POL, 1997a, 1997b; UNEP/RAMOGE, 1999). When exposed to chemical substances some harmful effects can be observed at different levels in marine organism. These effects depending on the level of exposure could be classified in lethal, sublethal and chronic. These impair the normal development and life cycle of the marine organisms. The environmental assessments have been used for the identification and confirmation of significant occurrence, distributions, levels, trends of contaminants and their effects; as well as, for the continuous development of monitoring strategies. With respect to the Ecosystem Approach Process and the Integrated Monitoring and Assessment Programme (IMAP) and related Assessment Criteriatheir implementation will continue under the benefits gained from this past knowledge and the policy framework built in the Mediterranean Sea (UNEP/MAP, 2016; UNEP/MAP MED POL, 2016).

Good Environmental Status (GES) for Common Indicator 18 can be accomplish (UNEP/MAP, 2013) when contaminant effects (ca. biomarkers) are below the proposed assessment criteria (see Table 1).

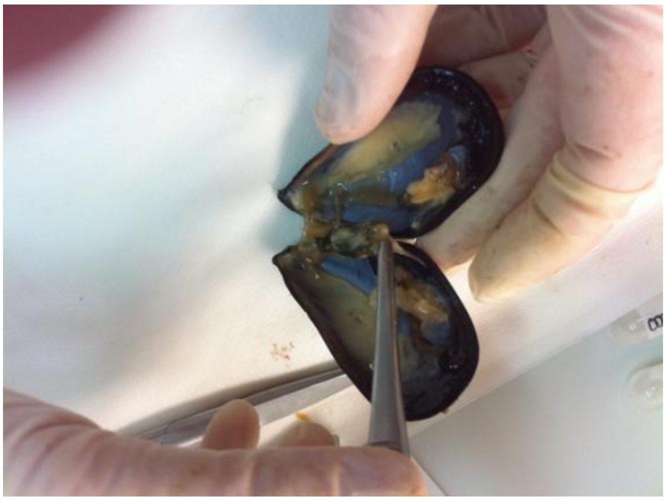


Figure 1: Preparation of a fresh mussel for both chemical and biological effects analysis by dissection of different organs, Musseldissectionforanalysis_CGuitart.jpg

Background (extended)

The marine organisms are exposed to the chemical substances released in the marine environment which cause harmful effects at subcellular and cellular organization levels of an individual, and therefore, have the potential to correlate with the disfunctioning of the populations and the ecosystem as a whole. Several pilot monitoring programmes were initiated developed by Contracting Parties (Croatia, France, Greece, Italy and Spain) with the objective to implement a biological effects monitoring onto the current national networks of sampling stations for chemical monitoring in the Mediterranean Sea under MED POL (UNEP, 1997a). The use of a number of biomarkers, bioassays and associated biological parameters in an integrated manner altogether with information on environmental chemicals should provide clearer information of the pollution effects in the marine environment; and therefore, through monitoring the biological effects, elucidate the potential of chemical pollution damages in the marine ecosystems. A number of toxicological tests have found consensus and were recommended by a number of CPs, namely, Lysosomal Membrane Stability (LMS) as a method for general physiological status screening, Acetylcholinesterase (AChE) assay as a method for assessing neurotoxic effects in aquatic organisms and Micronucleus assay (MN) as a tool for assessing cytogenetic/DNA damage in marine organisms (UNEP/RAMOGE, 1999).

Additionally, the survival on air (or Stress on Stress, SoS), was also incorporated as a general method to determine physiological condition in mussels. In the latest decade, scientific research has been intensified towards alternative biological effect-based tools for integrated pollution monitoring, thus the integrative assessment revealed a more complex panorama when real samples are exposed to lowered (environmental) concentrations (i.e. sublethal effects). A number of confounding factors (eg. nutritive status, temperature, etc.) might be hindering the cost-effectiveness and reliable use of these methods to determine the contaminant biological effects at physiological, cellular and sub-cellular levels (González-Fernández et al., 2015a and 2015b, ICES, 2012). As a consequence, most of these methods (ca. biomarkers), based on the premise of cause-effect relationship to chemical exposure, are envisaged to found applications to monitor high contaminant concentrations (hotpots stations), dredging materials assessments and local damage evaluations after acute pollution events rather than for long-term environmental monitoring (surveillance monitoring). Ongoing research (biomarkers, bioassays) and future research trends, such as ‘omics’ developments, will further shape the evaluation tools for this common indicat18 and its methodologies as recently reviewed by the European Union (EU, 2014).

Assessment methods

The present assessment has been mainly constructed based on the current status of bibliographic studies and scientific documents published in the Mediterranean Sea area, as the biological effects datasets through the MED POL Database are not yet fully available at regional scale. The full assessment of the Common Indicator 18 will be based on the integrated evaluation of the biomarkers selected for their monitoring in the Mediterranean Sea, namely, Acetylcholinesterase activity (AChE), Lysosomal membrane stability (LMS) and Micronuclei frequencies (MN) on first instance. Further, the enzyme 7-ethoxy-resorufin-O-deethylase (EROD) and Metallothionenin (MT) has been also indicated for fish and mussel samples, respectively. For the former parameters the environmental criteria has been developed in terms of Background Assessment Criteria (BACs) and Environmental Assessment Criteria (EACs) (see Table 1) and revised (UNEP/MAP/MED POL, 2016). Further, complementary biomarkers, bioassays and histology techniques and other methods are also recommended to be carried out on a country basis (such as, comet assay, hepatic pathologies assessment, etc) to contribute to the assessment of the CI18.The assessment of biomarker responses against Background Assessment Criteria (BACs) and Environmental Assessment Criteria (EACs) will allow to establish if the responses measured belong to the levels that are not causing deleterious biological effects (<BACs), levels where deleterious biological effects are possible (>BACs) or levels where deleterious biological effects are likely to occur (>EACs) in the long-term (UNEP/MAP MED POL, 2016; UNEP/MAP, 2016).

The assessment criteria (see below) was adopted by the COP19 in February 2016 for the Mediterranean Sea (UNEP/MAP, 2016) and new assessment criteria has been proposed based on Mediterranean reference stations datasets (UNEP/MAP/MED POL, 2016). Initial results with reference stations used to determine the background levels with datasets from the MED POL monitoring networks for this Common Indicator 18 are presented in the results section.

Table 1: Environmental Assessment Criteria for Biological Effects assessments under IMAP (UNEP/MAP, 2016).

Biomarkers/Bioassays	BAC levels in Mussels (*Mytilus galloprovincilais*)(mg/kg d.w.)	EAC levels in Mussels (*Mytilus galloprovincilais*) (mg/kg d.w.)
Stress on Stress (days)	10	5
Lysosomal membrane stability Neutral Red Retention Assay (minutes)	120	50
Lysosomal membrane stability Cytochemical method (minutes)	20	10
AChE activity (nmol min-1 mg-1 protein) in gills (French Mediterranean waters)	29	20
AChE activity (nmol min-1 mg-1 protein) in gills (Spanish Mediterranean waters)	15	10
Micronuclei frequency (0/00) in haemocytes)	3,9	-

RESULTS

Results and Status, including trends (brief)

In the Mediterranean Sea, the biological effects have recently been extended to studies in mussels exposed to outfall effluents and complex mixtures of pollutants using a battery of biomarkers (de los Ríos et al., 2012), pelagic fish (Fossi et al., 2002; Tomasello et al., 2012) and combining wild and caged mussels (Marigómez et al., 2013), as well as in acute pollution accidental episodes such as oil spills (Marigómez et al., 2013b, Capó et al., 2015). In the Eastern Mediterranean, the LMS (neutral red retention method, NRR) and the AChE levels have been evaluated in mussels *Mytilus galloprovincialis* collected from Thermaikos and Strymonikos Gulfs in the northern Greece (Dailanis et al., 2003) and more recently including a number of marine species from the Eastern Mediterranean and the Black Sea (Tsangaris et al., 2016). In the Adriatic Sea, the use of biomarkers has found applications in the monitoring of the anthropogenic impact due to the exploitation of gas fields (Gomiero et al. 2015) and studies of the genetic stability caused by pollution have been also investigated in Croatian laboratories (Stambuk et al. 2013). In the southern Mediterranean Sea, trials have been undertaken on the integrated use of biomarkers, and the development of biomarker indexes to study the spatial and temporal variations in locations with different levels of pollution in Algeria (Benali, et al., 2015) and in the Lagoon of Bizerte in Tunisia (Ben Ameur et al., 2015; Louiz et al., 2016). In the NW Mediterranean, investigations of benthic fish associated to the continental platform, (*Solea solea* and *Mullus barbatus)* have been investigated for hepatic and branchial biomarkers, and studies of a battery of biomarker responses for biological effects to elucidate the sentinel species in pollution monitoring (Siscar, et al., 2015, Martinez-Gómez et al., 2012). High value commercial species, such as tuna (*Thunnus thynnus*) have also been investigated in Mediterranean Sea (Maisano et al. 2016). In the coastal environment, the rivers flowing into the Mediterranean such as Llobregat River (Spain), have also been used as locations to investigate the biological effects in invertebrate communities (Prat, et al., 2013; de Castro-Català, 2015). Recently, within new methodological trends, such as metabolomic responses and differences in metabolite profiles, were observed in clams (*Ruditapes decussatus*) between control and polluted sites in the Mar Menor Lagoon in the Western Mediterranean (Campillo, et al. 2015). These biological effects based tools have been also tested for the direct effects of pharmaceuticals in laboratory experiments in the Mediterranean Sea (Mezzelani, et al., 2016).

Results and Status, including trends (extended)

The Figures 1 to 3 shows the biomarkers evaluation results for the MED POL reference stations datasets extracted from the proposed revision document (UNEP/MAP/MED POL, 2016) in the Mediterranean Sea showing differences at sub-regional levels and compared to the current IMAP assessment criteria.

In detail, it should be noticed in Figure 1, that the LMS-NRR results (median value) for the reference stations in the Mediterranean Sea are below the standard acceptable values (both <BACs and <EACs) set by OSPAR (ICES, 2012) to assess healthy biota specimens for this biomarker. Therefore, these discrepancies being datasets for reference stations might reflect the influence of confounding factors in the environment in relation to general stress biomarker responses (e.g. nutritive status, hypoxia, spawning state, temperature, etc.), and therefore, hinder the correlations with the exposure to hazardous chemical substances, as discussed recently in the literature (Minguez et al. 2012; Cuevas et al., 2015; González-Fernández et al., 2015a, 2015b). In any case, the further development of Med BCs and Med BACs in Mediterranean mussels with the number of datasets provided is not conclusive within the MEDPOL biological effects monitoring programme. In Figure 2, the Adriatic Sea sub-region show an AChE inhibition half way to unacceptable levels of biological effects (i.e. <BAC and >EAC) for reference stations, which should be further investigated, and contrasts with the median level determined in the WMS sub-region, thus being both reference areas from Croatia and Spain, respectively. Figure 3, shows that the sub-regions medians for reference stations are safely below the calculated Med BAC for metallothioneins, despite sub-regional BCs above the calculated Med BAC (Middle Adriatic Sea). Further information and details can be found in UNEP/MAP/MED POL (2016) report.

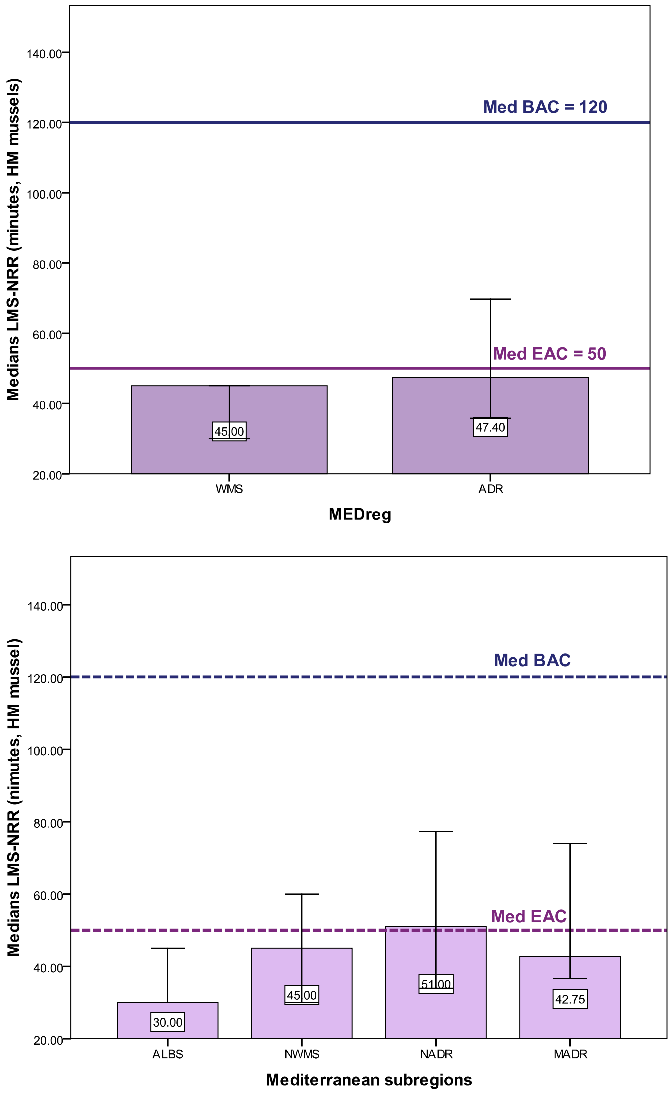
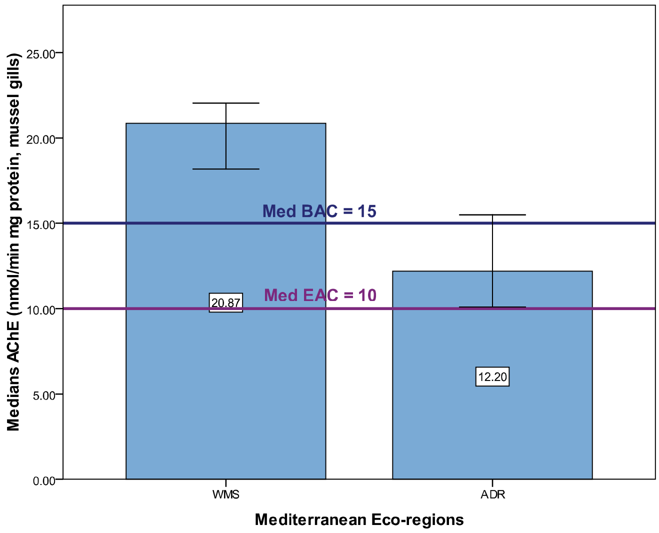


Figure 1. LMS-NRR (Neutral red retention) medians (BCs) in mussel by eco-region and sub-regions for selected reference stations in the Mediterranean Sea. The error bar is a 95% confidence interval for the mean.



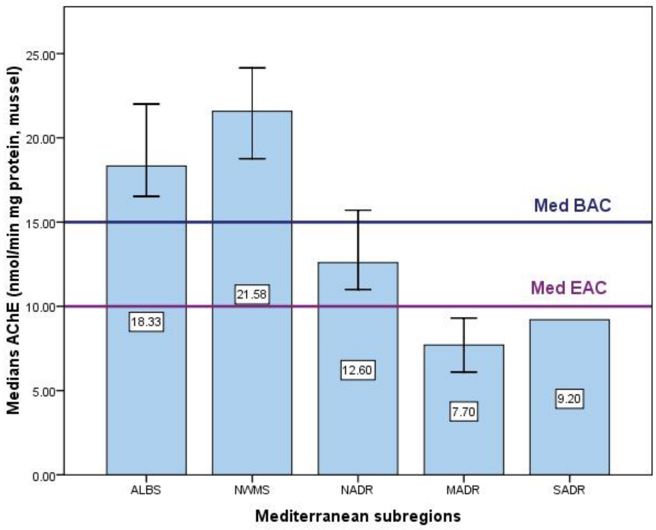


Figure 2. Metallothioneins medians (BCs) in mussel digestive gland by eco-region and sub-regions for selected reference stations in the Mediterranean Sea. The error bar is a 95% confidence interval for the mean.

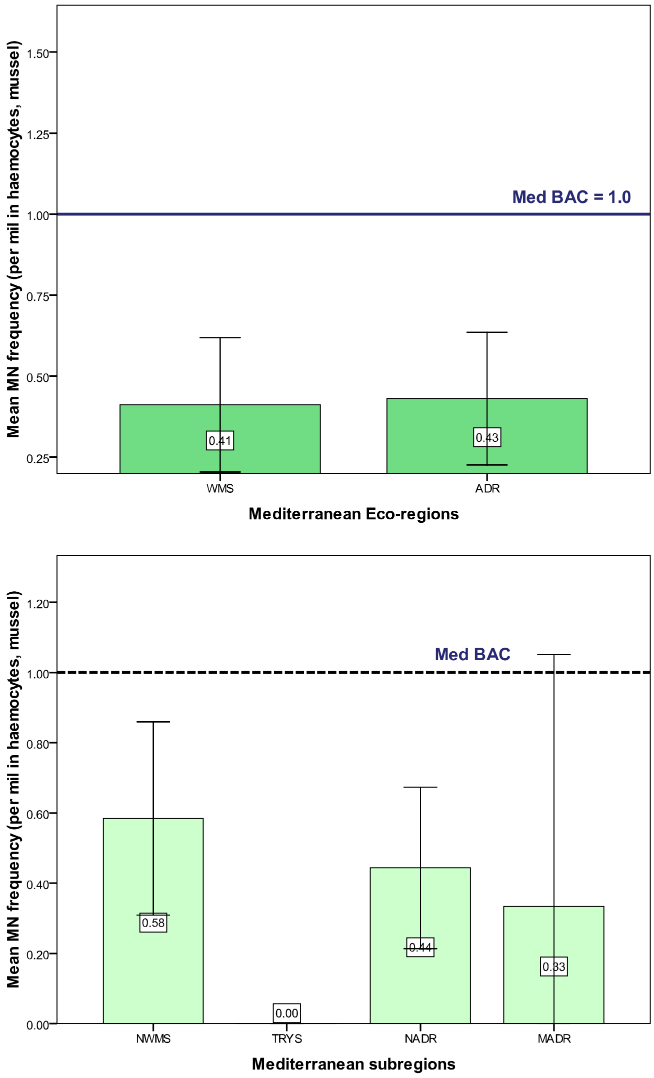


Figure 3. Micronuclei frequency medians (BCs) in mussel by eco-region and sub-regions for selected reference stations in the Mediterranean Sea. The error bar is a 95% confidence interval for the mean.

CONCLUSIONS

Conclusions (brief)

The ongoing research developments and controversy with regard biological effects and toxicological methods (*ca*. confounding factors) is one of the main reasons for the slow implementation of these techniques in marine pollution monitoring programs in the Mediterranean Sea, although as mentioned some are proposed. At present, in many Mediterranean countries, different research programmes and projects leaded by universities, research centers and government agencies are undergoing and will be the providers of the future quality assured and reliable measurements and tools to guarantee the correct implementation of a biological effects programme to assess the Common Indicator 18 in the Mediterranean Sea.

Conclusions (extended)

Assessing biological effects, in a similar manner to contaminant concentrations, ICES/OSPAR has proposed two/three categories and it has been the framework to evaluate the Mediterranean Sea MED POL datasets. Assessing biomarker responses against BAC and EAC allows establishing if the responses measured are at levels that are not causing deleterious biological effects, at levels where deleterious biological effects are possible or at levels where deleterious biological effects are likely in the long-term. In the case of biomarkers of exposure, only BAC can be estimated, whereas for biomarkers of effects both BAC and EAC can be established. However, unlike contaminant concentrations in environmental matrices, biological responses cannot be assessed against guideline values without consideration of factors such as species, gender, maturation status, season and temperature. It is expected that in the forthcoming years, the scope of experts groups would be to prepare an adapted manual establishing the BAC and when possible, the formulation of EAC for selected biomarkers in Mediterranean species.

Key messages

- Biological effects monitoring tools still in a research phase for biomarker techniques (i.e. method uncertainty assessment and confounding factors evaluation) which limits the implementation of these tools in the long-term marine monitoring networks.
- Lysosomal Membrane Stability (LMS) as a method for general status screening, Acetylcholinesterase (AChE) assay as a method for assessing neurotoxic effects and Micronucleus assay (MN) as a tool for assessing cytogenetic/DNA damage in marine organisms have been selected as primary biomarkers.

Knowledge gaps

Important development areas in the Mediterranean Sea over the next few years should include: confirmation of the added value of these batteries of biomarkers in long-term marine monitoring as ‘early warning’ systems; test of new research-proved tools such as ‘omics’, analytical quality harmonization, development of suites of assessment criteria for the integrated chemical and biological assessment methods, and review of the scope of the biological effects monitoring programmes. Through these and other actions, it will be possible to develop targeted and effective monitoring programmes tailored to meet the needs and conditions within the GES assessments.

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Ecological Objective 9 (EO9): Pollution

EO9: Common Indicator 19: Occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution

GENERAL

Reporter:	REMPEC
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Mediterranean assessment based on existing regional surveys, research and publications.
Mid-Term Strategy (MTS) Core Theme	Land and Sea Based Pollution
Ecological Objective	Ecological Objective 9 (EO9) – Pollution: Contaminants cause no significant impact on coastal and marine ecosystems and human health.
IMAP Common Indicator	Common Indicator 19: Occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution (EO9).
Indicator Assessment Factsheet Code	EO9CI19

RATIONALE/METHODS

Background (short)

Pollution from ships was one of the first issues addressed by the Mediterranean coastal States when they decided to act collaboratively to protect the Mediterranean Sea area in 1975. The 1967 Torrey Canyon oil spill accident, which resulted in massive oil pollution, raised the public awareness on pollution from shipping activities. Concern was expressed regarding possible oil and other harmful substances that may be released in the Mediterranean Sea, a semi-closed marine area. This led to the establishment of the Mediterranean Action Plan (MAP)'s first Regional Activity Centre (ROCC – Regional Oil Combating Centre, now REMPEC – Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea) and to the adoption, under the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean ("the Barcelona Convention"), of the Protocol Concerning Co-operation in Combating Pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency ("the 1976 Emergency Protocol"). This Protocol was revised in 2002 to include prevention of pollution from ships to emergency situations and is today referred to as the Protocol concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea ("the 2002 Prevention and Emergency Protocol"). The Protocol addresses pollution incidents, which includes both accidental pollution and illicit discharges. Pollution from oil and other hazardous substances were also addressed internationally in a number of conventions adopted under the aegis of the International Maritime Organization (IMO), some of which provides for stricter regime in the Mediterranean Sea. Although action at regional and international level has resulted in a significant decrease of massive oil pollutions from ships, incidents and illegal discharges are still responsible for the release of oil, oily mixtures and other Hazardous and Noxious Substances (HNS) at sea. It is on these grounds that the Contracting Parties to the Barcelona Convention included a Common Indicator (CI 19) on "*occurrence, origin* *(where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution*" under Ecological Objective 9.

Background (extended)

Increasing shipping and maritime activities are important drivers for anthropogenic pressure on the marine environment in the Mediterranean Sea. Pressure from maritime transport includes potential chemical pollution from oil and HNS, dumping of garbage at sea, release of sewage, biofouling and non-indigenous species introduction. As documented in a great number of scientific researches, chemical pollution by oil and other harmful substances has impacts on water, seabed, fauna and flora. The level of risk of an accident occurring in the Mediterranean Sea is driven by two factors: traffic density as well as routes for oil and chemical tankers. In addition, illicit discharges of oil from ships remain a concern.

- **Risk of accidents:**

The Mediterranean is a major shipping lane. It is estimated that around 80% of global trade by volume and over 70% of global trade by value are carried by sea (UNCTAD, 2015), with approximately 15% of global shipping activity by number of calls and 10% by vessel deadweight tons (dwt) (REMPEC, 2008) taking place in the Mediterranean. The area is an important transit route for shipping, with two of the narrowest and busiest straits in the world: the Strait of Gibraltar and the Bosphorus Strait. The Mediterranean is a major transit route. In 2006, around 10,000, mainly large, vessels transited the area en-route between non-Mediterranean ports. In addition to hosting an important transit lane for international shipping, the Mediterranean Sea is also a busy traffic area due to Mediterranean Sea born traffic (movement between a Mediterranean port and a port outside the Mediterranean), and short sea shipping activities. It is estimated that around 18% of the shipping traffic in the Mediterranean Sea takes place between two Mediterranean ports (REMPEC, 2008). Figure 1 is a representation of the maritime traffic in the Mediterranean Sea.

Although several factors contribute to maritime casualties, the correlation between traffic density and accidents causing a pollution is confirmed by the fact that "collisions allisions" represent the first cause of accidents (26%) resulting in an oil spill as recorded by the International Tankers Oil Pollution Federation (ITOPF) between 1970 and 2016. In the Mediterranean, the "collision/contact" category accounts for 17% of accidents reported to REMPEC, after "grounding" (21%). The contribution of other accident types are as follows: "fire/explosion": 14%, "cargo transfer failure": 11%, "sinking": 9%, and "other accidents": 28%. Several studies, based on the daily traffic crossing the Istanbul Strait and the Bosphorus, identified the east Mediterranean / Black Sea area as one of the top areas presenting the greatest probability of a shipping accident occurring.

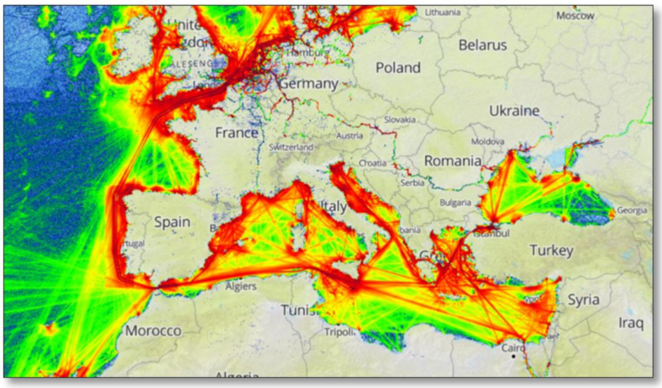

Figure 1: Density of maritime traffic in the Mediterranean Sea **(**Source: marinetraffic.com).

The Mediterranean is an important route for oil tankers' shipments. The Mediterranean Sea is also a major route for tankers. The REMPEC study mentioned above shows that the Mediterranean is both a major load and discharge centre for crude oil. Approximately 18%, or 421 million tonnes, of global seaborne crude oil shipments which in 2006 amounted to approximately 2.3 billion tonnes, take place within or through the Mediterranean. The following figures (Figure 2, Figure 3 and Figure 4) show the oil export areas and overseas destinations through the Mediterranean Sea.

Figure 2: Oil export source and destinations (North Africa) (Source: Tankers International website).

Figure 3: Oil export source and destinations (Middle East) (Source: Tankers International website).

Figure 4: Oil export source and destinations (Black Sea) (Source: Tankers International website).

Figures 3 and 4 above emphasis that the East Mediterranean area is at risk: in addition to being an area where traffic is dense, it is also a hot spot because of tanker routes from the Black Sea and the Middle East.

Deliberate discharges at sea

It was demonstrated, with the use of satellite imagery and other observation tools that deliberate oil pollution occurrences are high along busy traffic lanes. In the Mediterranean, there is evidence that the distribution of oil spills is correlated with the major shipping routes, along the major west-east axis connecting the Strait of Gibraltar through the Sicily Channel and the Ionian Sea with the different distribution branches of the Eastern Mediterranean, and along the routes towards the major discharge ports on the northern shore of the Adriatic Sea, east of Corsica, the Ligurian Sea and the Gulf of Lion (UNEP/MAP, 2012).

Assessment methods

Assessment of accidents:

In the Mediterranean region, under the 2002 Prevention and Emergency Protocol, assessment of occurrences, origins and extents of oil and HNS pollution from ships is carried out on the basis of pollution reports (POLREP) sent by the Contracting Parties to the Barcelona Convention to REMPEC and other affected States to notify a pollution or an event that could result in a pollution. These reports provide details on the incidents, including position, extent of pollution, characteristics of pollution, sources and cause of pollution, trajectory of pollution, forecast and likely impacts, as well as sea state and meteorological information.

The reports sent to REMPEC are also used to feed the database on alerts and accidents in Mediterranean Sea (the Mediterranean Alerts and Accidents Database) maintained by the Centre. Records of oil spills and accidents likely to cause spillages of oil in the Mediterranean started in 1977, while accidents involving other HNS are reported since 1988. Another main source of information used to populate the Alert and Accident Database is the Lloyd's Casualty Reporting Services (LCRS).

Accidents recorded in this database are accidents that caused or were likely to cause pollution by oil or other HNS in the Mediterranean Sea area. Accidents included are:

- Accidents happening in the Mediterranean Sea as defined in the Barcelona Convention;
- Accidents involving any type of ship, which actually resulted in an oil spill, a spill or release of a HNS, or in a loss or damage to a container containing HNS;
- Accidents on land (terminals, storage tanks, pipelines, industries, power plants, etc.) that resulted in entry into the sea of oil or HNS;
- Accidents involving one or more oil tankers or chemical tankers (either laden or not);
- Collisions, groundings or other accidents causing serious damage to the ships involved, in particular if these carried or could carry significant quantities of fuel oil as bunkers;
- Accidents involving sinking of vessels that had on board any quantity of oil as bunkers; and
- Accidents involving sinking of vessels that carried HNS as cargo (either in bulk or in packaged form).

Assessment of illicit discharges:

Monitoring of illicit discharges is conducted to detect violations of requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) and collect evidence for prosecuting ships offenders. The POLREP can also be used by a Contracting Party to the Barcelona Convention to report a deliberate discharge to REMPEC.

Methods: The following methods are used to detect a pollution and assess its origin and extent:

- Oil:
  - Expert human eye observation;

- Aerial observation (human eye observation and/or remote sensing equipment);
- Satellite imagery analysis to assess the extent and fate of an oil slick; and
- Sampling and analysis to determine the nature of the substance at sea, on shore and on board vessels. The Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances, 1983 ("the Bonn Agreement") developed an internationally recognized procedure for sampling at sea, analysis and interpretation of results.

The following can be identified:
- Volume of oil: internationally recognized guidance is used based on oil type and appearance to assess thickness (mm) and volume of oil (m^3/km^2) at sea (Bonn Agreement Oil Appearance Code – BAOAC);
- Location and coverage of slick at sea (latitude and longitude – GPS);
- Characteristics of oil (persistent vs. non persistent / viscosity); and
- Origin of slick (if visible ship name and IMO number, offshore installations identification number). Backtracking oil using trajectory modelling methods help to identify ship source.

On-shore monitoring will be used to assess the extent of impacted shorelines, type and degree of contamination as well as impact on habitats and wildlife casualties.

- HNS:

Detection of HNS pollution events and assessment of impacts are primarily achieved on site by expert human eye observation, complemented with real time monitoring, sampling and analysis, as well as the use of modelling tools. Conclusions of any risk assessment for HNS will be based on a number of information including identification of incident circumstances and location, identification of the involved chemical, its properties / toxicity, and its form (packaged / bulk) as well as identification of sensitive neighboring areas and environment conditions.

RESULTS

Results and Status, including trends (brief)

On the one hand, statistical data analyses indicate a significant downward trend in accidental pollution from ships, for both oil and HNS. This decrease can also be seen both in the number of accidents causing these pollutions and in the volumes of pollutants discharged at sea. On the other hand, the same observation cannot be made with regard to illicit discharges from ships. There is no sufficient data to identify an upward or downward trend, but based on 2016 data provided by the European Maritime Safety Agency (EMSA), it can be argued that a significant number of illegal releases are still occurring.

Results and Status, including trends (extended)

<u>Key findings for accidents:</u>

- Decrease in the number of major oil spills worldwide

Maritime casualties involving oil have decreased substantially over the years, despite a growth in the volume of oil moved by ships. Today, according to ITOPF statistics, 99.99% of crude oil transported by sea arrives safely at its destination. As shown in Figure 5 below, the average number of large oil spills from tankers, i.e. greater than 700 tonnes, has progressively diminished over the years, to an average of 1.7 spills per year between 2010 and 2016.

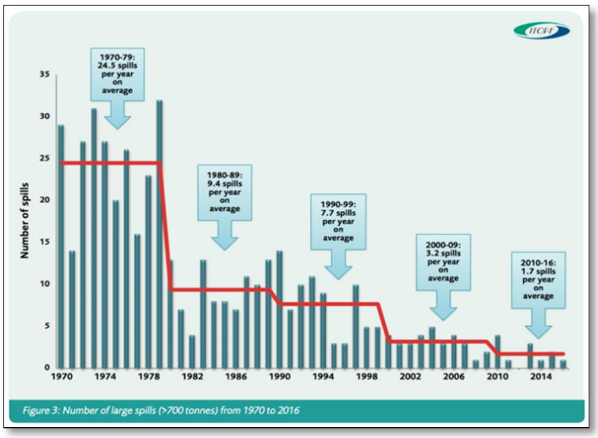

Figure 5: Number of Oil Spills Greater than 700 Tonnes Between 1970 and 2016.

- Decrease in the frequency of accidents causing a pollution in the Mediterranean

Oil:
The statistical analytical study prepared by REMPEC on the basis of its Mediterranean Alerts and Accidents Database shows that major oil spills occurred frequently between 1977 and 1981 but have become rare events since then, with the last major accident being the MT "HAVEN" accident off Genoa in April 1991, with 144,000 tonnes of crude oil spilled.

In terms of volume of oil released at sea, the 2014 REMPEC Study indicates that between 1 January 1994 and 31 December 2013, approximately 32,000 tonnes of oil entered into the Mediterranean Sea as a result of accidents.

This includes approximately 15,000 tonnes originating from the 2006 Eastern Mediterranean incident which occurred in the power plant of Jieh, Lebanon, between the 13th and 15th of July 2006. The fuel which did not burn was released in the marine environment. The exact quantity of the burnt fuel remains unknown but, according to the estimate communicated by the Lebanese authorities, between 13,000 and 15,000 tonnes were released as a consequence of the spill. The Lebanese spill is the fifth biggest spill reported since 1977 in the Mediterranean Sea, the largest spill being the spill related to the explosion of the MT HAVEN in 1991, which sunk with its cargo of 144,000 tonnes of crude oil in the Italian waters.

In terms of accidents causing pollution, the number of accidents resulting in an oil spill dropped from 56% of the total number of accidents for the period 1977 – 1993, to 40% for the period 1994 – 2013. 61% of the incidents resulted in a spillage inferior to 1 tonne.

HNS:
In the Mediterranean, the quantities of HNS accidentally spilled considerably decreased during the period 1994 – 2013. Since 2003, the release of HNS has become insignificant compared to the period 1994 – 2002.

The last two major accidents occurred in 1996 namely:
- the sinking of Kaptan Manolis I in Tunisia, with 5,000 tonnes of phosphates on board; and
- the sinking of Kira off Greece, releasing 7,600 tonnes of phosphoric acid.

The worst HNS spill in the Mediterranean was the sinking of the Continental Lotus in 1991 in the Eastern Mediterranean, with 51,600 tonnes of iron on board.

REMPEC's statistical analysis related to geographical location of accidents indicates that the majority of accidents occur in the Eastern Mediterranean area (Cyprus, Egypt, Israel, Lebanon, Syrian Arab

Republic, Turkey) if Greece, which is treated separately in REMPEC's findings, is included, showing as Figure 6.

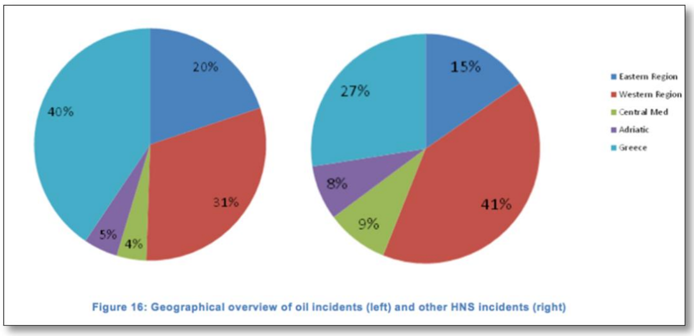

Figure 6: Geographical distribution of accidents (Source: REMPEC, 2014).

<u>Key Findings for Illicit Discharges:</u>

REMPEC's Mediterranean Alerts and Accidents Database contains a category for "Illicit Discharges". Only 5 cases were reported (1 in 2012, 1 in 2013 and 3 in 2015). By nature, as they are illegal, illicit discharges of oil are not voluntarily reported by the ship source. The use of satellite imagery can be a useful tool to provide a better picture of the number of oil spills from ships, however, unless evidence is provided that a detected illicit discharge originates from a specific ship, no definite conclusion can be made as to whether or not the spill is caused by any ship, and therefore it is difficult to precisely assess the number of illicit discharges actually happening.

<u>Trends: oil pollution occurrences still an issue in the Mediterranean.</u>

In 2016, the CleanSeaNet platform of EMSA recorded a total of 1,073 detections of probable pollution occurrences, and a total of 1,060 detections of possible pollution occurrences in the area covering the Mediterranean Sea and the Atlantic Ocean coasts of Morocco, Portugal, Spain and France (Figure 7 below). Although there is no judicial evidence that all occurrences characterised as probably or possibly oil spills are actually discharges from ships, the map provides a clear indication that oil pollution incidents from ships is still of concern.

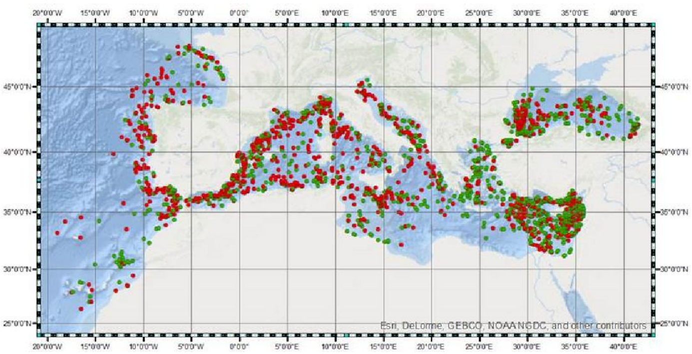

Figure 7: Number of spills detected in 2016 by satellite imagery (Source: CleanSeaNet, EMSA). Class A (red dots on the map): the detected spill is most probably oil (mineral or vegetable/fish oil) or a chemical product. Class B (green dots on the map): the detected spill is possibly oil (mineral/vegetable/fish oil) or a chemical product.

CONCLUSIONS

Conclusions (brief)

Accidents rates have gone down globally and regionally despite the increase in shipping transportation and it can be concluded that the impact of the international regulatory framework adopted through the IMO as well as technical cooperation activities undertaken at regional level is very positive, especially as far as prevention of accidental pollution is concerned. However, risks associated with the transport by ships of oil and HNS with possible harmful consequences on biota and ecosystems cannot be completely eliminated, especially in vulnerable areas such as the Mediterranean Sea. In addition, efforts have to be made to strengthen monitoring and reporting of illicit discharges from ships.

Conclusions (extended)

Decrease of pollution occurrences globally: accidents rates have gone down globally and regionally despite the increase in shipping transportation. Accidental pollution from both oil and HNS has decreased which can be related to the adoption and implementation of environmental maritime conventions addressing oil and HNS pollution prevention, preparedness and response. Indeed, statistical analysis indicates that there is a correlation between the period where the IMO regulatory framework was put in place (in the 70') and the years when this downward trend started to happen (in the 80'). It can therefore be concluded that the impact of the international regulatory framework adopted through the IMO as well as technical cooperation activities undertaken at regional level is very positive, especially as far as prevention of accidental pollution is concerned. However, the issue of illicit discharges from ships remains of concern, especially in semi-enclosed areas where the ability of the marine environment to regenerate is less likely to happen.

Oil pollution long-term effects: it is also important to keep in mind that recovery of habitats following an oil spill can take place from between a few seasonal cycles (plankton) to several years (within one to three years for sand beaches and exposed rocky shores; between 1 and 5 years for sheltered rocky shores; between 3 and 5 years for saltmarshes; and up to 10 years or greater for mangrove).

According to ITOPF, while considerable debate exists over the definition of recovery and the point at which an ecosystem can be said to have recovered, there is broad acceptance that natural variability in ecosystems makes a return to the exact pre-spill conditions unlikely. Most definitions of recovery instead focus on the re-establishment of a community of fora and fauna that is characteristic of the habitat and functions normally in terms of biodiversity and productivity.

Therefore, despite the progress achieved in mitigating oil spill incidents from ships, it is clear that continuous monitoring of illicit discharges occurrences as well as cumulative effects and impacts, and continuous monitoring of accidental post-spill consequences on biota and ecosystems are needed.

Key messages

Chronic sources (illicit discharges) of pollution into the marine environment from ships are the principal target for pollution reduction, as the trends for acute pollution (accidents) are controlled and decreasing.

Knowledge gaps

- The information collected via pollution reports is related to specific pollution events and not always useful or compatible with the information needed to assess the status of the marine environment.
- Maintaining the Mediterranean Alerts and Accidents Database is a prerequisite and the condition for being able to measure Common Indicator CI19.

- There is no obligation for countries to carry out environmental surveys of sea and shorelines affected by a spill. Systematic environmental shorelines assessment post spill is today recognised as a “must do” practice and can provide information on biota on a case by case basis.
- Very little data is available regarding illegal discharges from ships.

Environmental monitoring and reporting: the focus of IMO conventions and guidelines relating to prevention of marine pollution is on ships’ compliance monitoring rather than on monitoring or measuring the state of the marine and coastal environment. The same can be noted with respect to reporting obligations. Reporting is required in the case of an accident causing pollution or in case of an illegal pollution is discovered (operational discharges). This perspective is reflected in the 2002 Prevention and Emergency Protocol. Therefore, the information collected is related to specific pollution events and not always useful or compatible with the information needed to assess the status of the marine environment.

Accidents monitoring and reporting: there is an increase in the number of accidents reported to REMPEC, which is most likely due to a better compliance by the Contracting Parties to the Barcelona Convention to report casualties, as required by Article 9 of the 2002 Prevention and Emergency Protocol. It is of utmost importance that the Contracting Parties to the Barcelona Convention continue to report on accidents as accurately as possible, as it is paramount that REMPEC continues to maintain the Mediterranean Alerts and Accidents Database to keep track of pollution events. This is a prerequisite and the condition for being able to measure Common Indicator CI19.

Impact on biota affected by pollution: for the reason explained above, there is little information on the impact of pollution events caused by shipping on biota. Ship generated pollution impact is usually considered from a response perspective (protection of sensitive areas and facilities). There is no obligation for countries to carry out environmental surveys of sea and shorelines affected by a spill. However, systematic environmental shorelines assessment post spill is today recognized as a “must do” practice in terms of assessing the level of cleanliness of the affected area, as well as from a remediation perspective.

Illicit discharges from ships: very little data is available regarding discharges from ships. As these are illegal operations by nature (when not within the limits set by MARPOL), it is extremely difficult to get information on occurrences and extent of spills. Marine surveillance requires aerial means and equipment (planes, airborne radars and sampling sets) or special technology such as the use of satellite images. There is no regionally centralized system for surveying the Mediterranean waters as defined in the Barcelona Convention. The CleanSeaNet platform, the European satellite-based oil spill monitoring and vessel detection service, is a good resource, but only available in principle to countries that are Members States of the European Union.

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Ecological Objective 9 (EO9): Chemical pollution

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

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Contracting Parties by research studies
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO9. Contaminants cause no significant impact on coastal and marine ecosystems and human health
IMAP Common Indicator	CI20. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood
Indicator Assessment Factsheet Code	EO9CI20

RATIONALE/METHODS

Background (short)

The human exposure to chemical contaminants through commercial fish and shellfish species (ca. fisheries and aquaculture, respectively) is one the main concerns with regard the occurrence of pollutants in the marine environment. Wild and farmed marine species are exposed to environmental chemical contaminants through different mechanisms and pathways according their thropic level, which include from filter feeding to predatory species (bivalves, crustaceans, fish, etc.). The understanding of the health risks to humans (maximum levels, intake, toxic equivalent factors, etc.), through the consumption of potentially contaminated seafood is a challenge and a priority policy issue for governments, as well as a major societal concern. GES for Common Indicator 20 can be achieved when the concentrations of contaminants in seafood are within regulatory limits set by legislation for human consumption.

Figure1: Major seafood species commercialized in the Mediterranean Sea in a fish market in Athens, Greece, CommonseafoodMediterranean_CGuitart.jpg

Background (extended)

There exist both bioaccumulation and biomagnification processes of the harmful chemicals released in the marine environment. Common examples are the well-known bioaccumulation processes of heavy metals and organic compounds in commercial bivalve species (such as *Mytillus galloprovincialis* in the Mediterranean Sea) or alkyl mercury compounds in fish (e.g. methylmercury in tuna fish), however, many of the current emerging chemicals have also been detected in commercial fisheries. There are different initiatives and regulations at national and international level, which have established public health recommendations and maximum regulatory levels for some contaminants (mainly, for legacy pollutants) in numerous marine commercial target species. The methylmercury potential poisoning continues as a global priority policy issue. In 2013 the Global Legally Binding Treaty (the Minamata Convention on Mercury) was relaunched by UNEP (UNEP, 2002). Further, the USFDA (US Food and Drugs Administration), the EFSA (European Food Safety Authority) and FAO/WHO (Food and Agriculture Organization and World Health Organisation) (FAO/WHO, 2011), are also leading national and international authorities with regard seafood safety and regulatory levels to assess this Common Indicator 20. In relation to this, as mentioned, the European Council (EC) has introduced maximum levels for chemical contaminants, and subsequent amendments, including recently PCDDs, PCDFs and dioxin-like-PCBs in fishery products (Official Journal of the European Union, 2006 and 2011) which could serve as a preliminary target levels in the Mediterranean Sea.

Assessment methods

The present assessment has been undertaken based on bibliographic studies and scientific documents in the Mediterranean Sea thus there are not yet representative MED POL datasets available for this Common Indicator 20. More, the assessment of the CI 20 will be based, tentatively, on the statistics about the number of detected contaminants and their deviations from legal permissions in commercial fish species set by national, European and international regulations within national jurisdictional areas. These areas will need to be further defined from a spatial scale perspective (i.e. limited by national jurisdiction boundaries, GFCM-FAO subdivisions, etc.) within IMAP. The levels set by the European Regulations (Official Journal of the European Union, 2006 and 2011, see Table 1) and other international standards (such as WHO) can be of initial application to harmonize and compare future available datasets in the Mediterranean Sea. However, at present, the majority of the available datasets are hold in databases from surveys by national food laboratories, as well as regulatory and inspection bodies. Therefore, the frequencies in the number and excess of the occurrence on a temporal basis would define the GES achievement with regard to this common indicator (UNEP/MAP, 2013).

Table 1. Summary of current regulatory levels set by the European Union (extracted from Maggi et al., 2014).

Table 1. Regulatory levels, reference legislation, code and foodstuff categories.

Category code	Legislation	Foodstuff	Regulatory levels
Cd 3.2.5	Reg.1881/2006/CE	Muscle meat of fish (footnote 24)	0,05 mg/kg w.w.
Cd 3.2.6	Reg.1881/2006/CE	Muscle meat of listened fish	0,10 mg/kg w.w.
Cd 3.2.8	Reg.1881/2006/CE	Crustaceans	0,50 mg/kg w.w.
Cd 3.2.9	Reg.1881/2006/CE	Bivalve molluscs	1,0 mg/kg w.w.
Cd 3.2.10	Reg.1881/2006/CE	Cephalopods	1,0 mg/kg w.w.
Hg 3.3.1	Reg.1881/2006/CE	Fishery products and muscle meat of fish (footnotes 24, 25, 26)	0,50 mg/kg w.w.
Hg 3.3.2	Reg.1881/2006/CE	Muscle meat of listened fish	1,0 mg/kg w.w.
Pb 3.1.5	Reg.1881/2006/CE	Muscle meat of fish (footnote 24)	0,3 mg/kg w.w.
Pb 3.1.6	Reg.1881/2006/CE	Crustaceans	0,50 mg/kg w.w.
Pb 3.1.7	Reg.1881/2006/CE	Bivalve molluscs	1,5 mg/kg w.w.
Pb 3.1.8	Reg.1881/2006/CE	Cephalopods	1,0 mg/kg w.w.
Dioxins 5.3	Reg.1259/2011/CE	Muscle meat of fish and Bivalve molluscs	3,5 pg/g w.w.
Sum dioxins and dioxin like PCBs 5.3	Reg.1259/2011/CE	Muscle meat fish and Bivalve molluscs	6,5 pg/g w.w.
Benzo(a)pyrene 6.1.4	Reg.1881/2006/CE	Muscle meat of fish (footnote 24)	2,0 µg/kg w.w.
Benzo(a)pyrene 6.1.5	Reg.1881/2006/CE	Crustaceans and Cephalopods	5,0 µg/kg w.w.
Benzo(a)pyrene 6.1.6	Reg.835/2011/CE	Bivalve molluscs	5 µg/kg w.w.
Sum PAH 6.1.6	Reg.835/2011/CE	Bivalve molluscs	30 µg/kg w.w.

doi:10.1371/journal.pone.0108463.t001

RESULTS

Results and Status, including trends (brief)

With regard the content of chemical contaminants fish and shellfish, different research studies have been recently conducted in the Mediterranean Sea taking into account a number of legacy and emerging chemicals. At present, scattered datasets all along the Mediterranean sub-basins mostly from research studies are available with few assessments recently undertaken under European marine policy (e.g. the Descriptor 9 under EU Marine Strategy Framework Directive) by European Contracting Parties of the Barcelona Convention. Future harmonization and data sharing will improve the assessment in the Mediterranean Sea at a regional scale for this CI 20.

Results and Status, including trends (extended)

In the Eastern Mediterranean, selected heavy and essential metals (Cd, Pb, Cu and Zn) have been determined in some different brands and types of fishery products in Turkey (Çelik and Oehlen, 2007; Mol, S., 2011). Dioxins, dioxin-like and non dioxin-like PCBs have been also determined in Greek farmed fish (Costopoulou et al., 2016) and the levels found were well below the limits set by EU Legislation. In the Ionian Sea, the levels of a large set of toxic metals (As, Cd, Cr, Pb, Mn, Ni, V and Zn) were assessed in fish and shellfish from the Gulf of Catania (Copat et al., 2013, 2014), and did not exceed the limits set by the EU legislation. However, a more recent study in the same area found levels exceeding the legal limits for some species, such as gastropods and fish (Giandomenico et al., 2016). The concentrations and congener specific profiles of legacy and emerging compounds, such as PCBs, PCDDs and PCDFs have been determined in various edible fish from the Adriatic Sea. The results obtained shown that levels were under the recommendations of the EU legislation (Storelli et al., 2011). Similarly, PCBs and PCDD/F concentrations and congener specific profiles were also determined in seafood (e.g. fish and cephalopods) in supermarkets in Southern Italy (Barone et al., 2014). Further, in terms of shellfish contamination levels transferred to seafood consumers, cultured and harvested bivalves have been recently evaluated in the Adriatic Sea (Croatia), and shown no risk (Milun, V., 2016). With regard an assessment performed under the context of the EU Marine Strategy Framework Directive (MSFD), Italy developed a full methodology and assessed the Descriptor 9 for heavy metals and PAH , which is equivalent to the EO9 Common Indicator 20 (Figure 1and 2). The conclusion, based on a statistical ranges of acceptance and defined criteria in Mediterranean sub-regions under Italian jurisdiction, was a good GES status. Nevertheless, the datasets for synthetic compounds and their spatial coverage were somehow limited (Maggi, et al., 2014). Fish, molluscs, and crustaceans of commercial size of 69 different species were sampled and analyzed for total mercury (HgT), and were evaluated for their compliance with the EU Maximum Residue Limits (MRLs, Table 1) (Bambrilla, et al., 2013).

In the NW Mediterranean, mercury contamination was studied in deep-sea organisms to understand the transfer, fate and human implications of contaminated commercial species (Koenig et al., 2013). France, as a part of a specific monitoring programme, determined, toxic metals in gastropods, echinoderms and tunicates, which are also consumed locally in the Mediterranean Sea (Noël, L. et al., 2011). In the southern Mediterranean countries, Morocco has investigated the exposure of the coastal population to mercury via seafood consumption (Elhsmri, H., 2007). From a human health perspective, beyond environmental levels and compliance regulatory limits, some studies have been investigated both for legacy and emerging chemical of concern to assess the intake of seafood products to end-consumers. To this regard, it is worth to mention the study of the intake of arsenic (As), cadmium (Cd), mercury (Hg), lead (Pb), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), polychlorinated naphthalenes (PCNs), polybrominated diphenylethers (PBDEs), polychlorinated diphenylethers (PCDEs), hexachlorobenzene and polycyclic aromatic hydrocarbons (PAHs) through fish and seafood consumption by children of Spain (Martí-Cid et al., 2007). Similarly, the estimated dietary intake of dioxins and dioxin-like PCBs in food marketed were also studied for seafood consumers in Spain (Marin, et al., 2011).

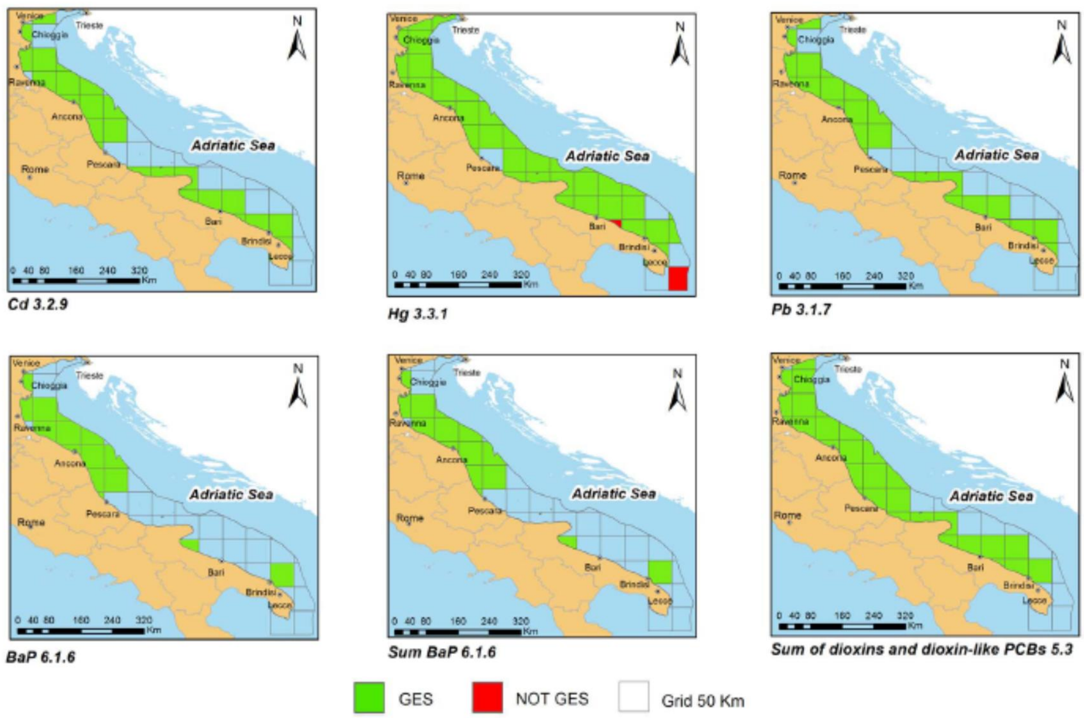

Figure 2: Results on Metals, PAH and Dioxins/Dioxin-like PCBs in Adriatic Sea Subregion (AS), (source: Maggi, C., Lomiri, S., et al., 2014)

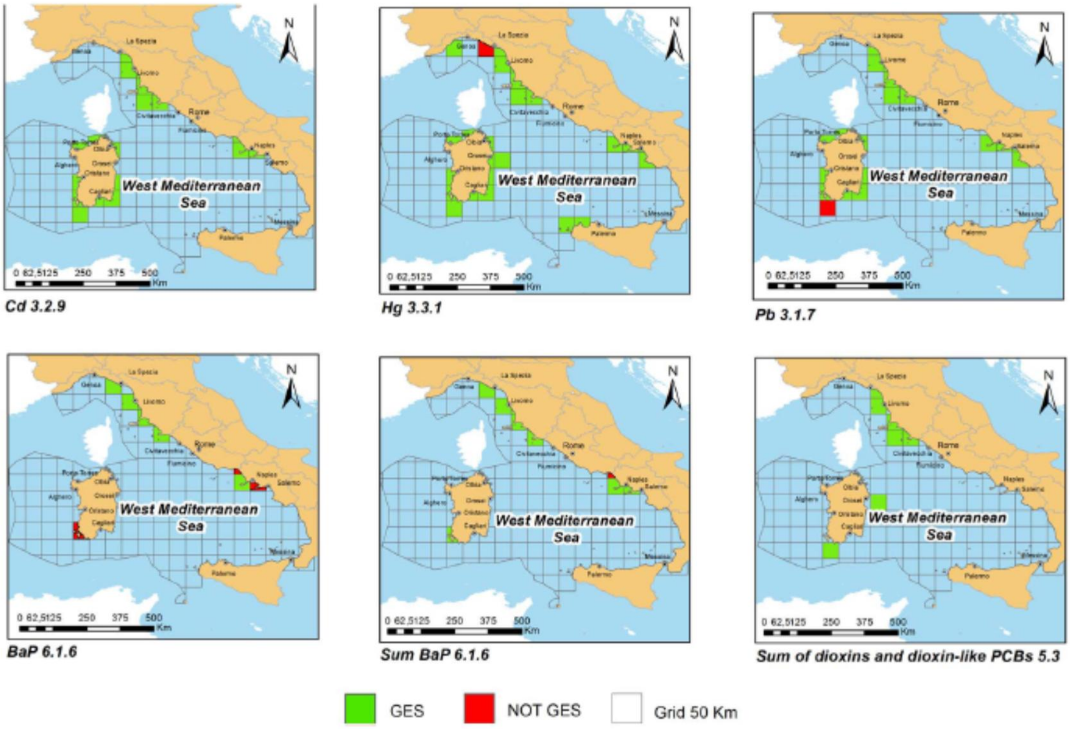

Figure 3: Results on Metals, PAH and Dioxins/Dioxin-like PCBs in Western Mediterranean (WMS), (source: Maggi, C., Lomiri, S., et al., 2014)

CONCLUSIONS

Conclusions (brief)

At present, few research studies and EU policy driven reports (ca. MSFD) in some Mediterranean countries have investigated the occurrence of contaminants in seafood, from an environmental perspective, which are exceeding the maximum regulatory levels established within regulatory standards. Overall, from available studies, no major significant concerns or extreme high levels were on served within these recent research studies by different authors and no confirmation based on temporal trends have been performed yet.

Conclusions (extended)

For future assessments within this CI 20, the GFCM-FAO defined areas in the Mediterranean Sea (Area 37 and their subdivisions), could be selected and assessed under different national strategies, although harmonized at a regional scale, to evaluate contaminants in commercial species to assess CI20 under IMAP. For example, Naccari et al (2015), reported the residual levels of Pb, Cd and Hg in different species, caught from FAO zones around Italy; particularly, small pelagic, benthic and demersal fishes. Whilst in all samples was observed the absence of Pb, small concentrations of Cd and higher Hg levels were found, as well as differences between the two subdivisions. Only Cd concentrations exceeded the EU regulatory limits in different fish species, despite a large number of uncontaminated samples, 67%, 84% and 62% for Cd in mackerel, mullet and seabream, respectively. A recent study with tuna (*Thunnus thynnus*) in Mediterranean FAO areas, shown that residues of PCBs and PBDEs are present. The study concludes that the Mediterranean area show the highest levels for these chemical compounds (Figure 4) compared to other evaluations in FAO areas worldwide (Chiesa et al., 2016).

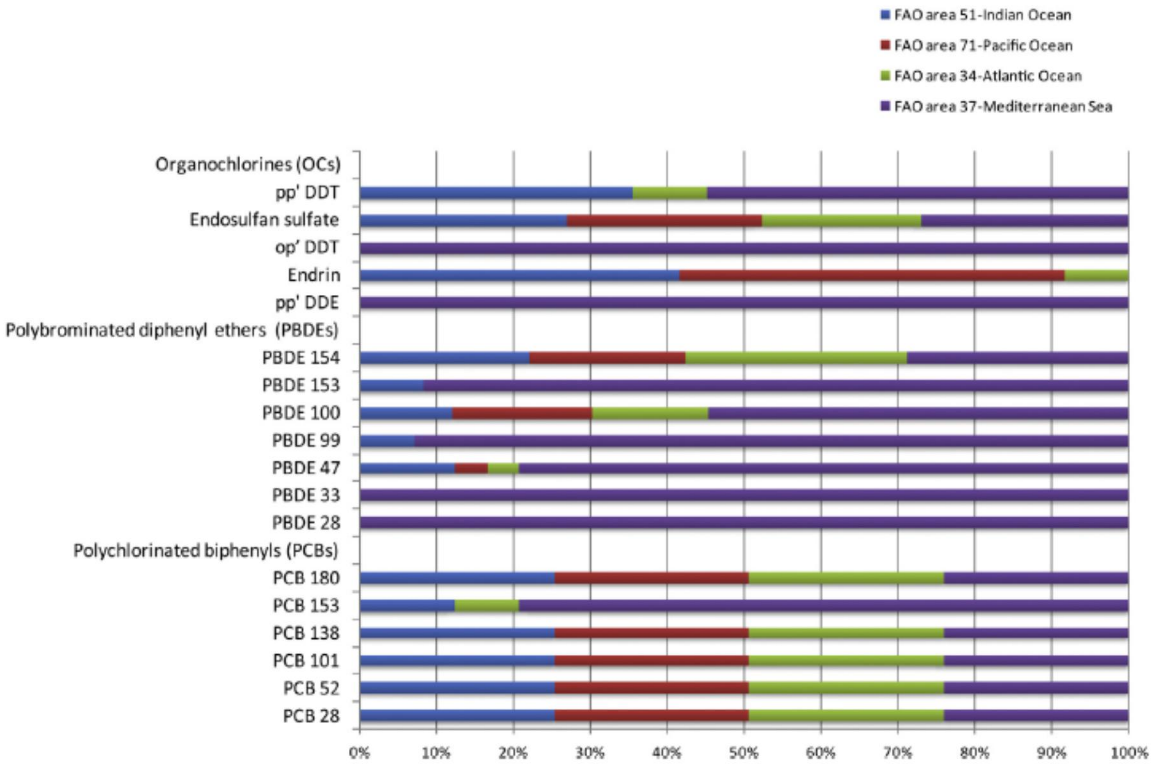

Figure 4: Comparison of POPs levels in different FAO areas worldwide (source: Chiesa et al., 2016)

Key messages

- Regular datasets are unavailable to perform an assessment of the Common Indicator 20.
- Chemical contaminants occurrence in fish and shellfish and the possible intake scenarios for population have been studied in different Mediterranean locations.
- Some of the FAO delimited zones in the Mediterranean Sea have been investigated for a number of legacy and emerging contaminants within research studies.
- Pelagic, demersal and benthic species have been targeted and investigated to assess GES in terms of potential seafood contamination and to reflect the health condition of the marine ecosystem

Knowledge gaps

The regular information required to assess this indicator is clearly lacking on a regional scale (ca. comparable and quality assured data), and at sub regional scale to some extent to be able to perform a complete assessment. Monitoring protocols, risk-based approaches, analytical testing and assessment methodologies would need to be further developed focusing on the harmonization between Contracting Parties. The liason with national food safety authorities, research organisations and/or environmental agencies will be required.

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Ecological Objective 9 (EO9): Chemical pollution

EO9: Common Indicator 21: Percentage of intestinal enterococci concentration measurements within established standards

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Contracting Parties by research studies
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	EO9. Contaminants cause no significant impact on coastal and marine ecosystems and human health
IMAP Common Indicator	CI21. Percentage of intestinal enterococci concentration measurements within established standards
Indicator Assessment Factsheet Code	EO9CI21

RATIONALE/METHODS

Background (short)

The Mediterranean Sea continues to attract every year an ever increasing number of international and local tourists that among their activities use the sea for recreational purposes. Back in 2005, the number of sewage treatment plants were doubled with respect the precedent decade and the water quality with regard to fecal pollution clearly improved (UNEP/MAP MED POL, 2010). The establishment of sewage treatment plants and the construction of submarine outfall structures have decreased the potential for episodes of microbiological pollution; despite few major coastal hotpots still exist. A revision of the Mediterranean guidelines for bathing water quality was formulated in 2007 based on the WHO Guidelines for Safe Recreational Water Environments (WHO, 2003) and on the EC Directive for Bathing Waters (Directive 2006/7/ EU). Later on, a revised UNEP/MAPt proposal was made in an effort to provide updated criteria and standards that could be used in the Mediterranean countries, as well as to harmonize their legislation in order to provide homogenous information and data (UNEP/MAP, 2012a). High levels of enterococci bacteria in recreational marine waters (coasts, beaches, tourism spots, etc) are known to be indicative of human pathogens due to non-treated discharges into the marine environment and cause human infections (Kay et al., 2004; Mansilha et al, 2009). Therefore, these new standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol should be further used to define GES in bathing and recreational waters. GES for Common Indicator 21 will be accomplished when concentrations of intestinal enterococci would be within the established standards (UNEP/MAP, 2013).

Figure 1: A high bathing water quality in Mediterranean beaches is a key element within safe recreational activities in the coastal environment, Bathingwaterquality_CGuitart.jpg

Background (extended)

Enterococci concentrations are frequently used as a faecal indicator bacteria, or general indicators of faecal contamination. Particularly, *E. faecalis* and *E.faecium* species are related to urinary tract infections, endocarditis, bacteriema, neonatal infections, central nervous system, abdominal and pelvic infections.. It has been suggested and latterly demonstrated that enterococci sp. might be more appropriate than traditional Escherichia coli (E.coli) in marine waters as an index of faecal pollution. Currently, is the only faecal indicator bacteria recommended by the US Environmental Protection Agency (EPA) for brackish and marine waters, since they correlate better than faecal coliforms or *E.coli*. The abundance in human and animal feces and the simplicity of the analytical methods for their measurements has favoured the use of enterococci species as a surrogate of polluted recreational waters, and therefore, as a Common Indicator 21 for GES under EO9. The World Health Organization has been concerned with health aspects of the management of water resources for many years and published various documents concerning the safety of environmental waters and its importance for health, including marine waters. A revision of the Mediterranean guidelines (UNEP/MAP, 2012) for bathing water quality were formulated in 2007 based on the WHO Guidelines for Safe Recreational Water Environments (WHO, 2003) and on the EC Directive for Bathing Waters (Directive 2006/7/EU). Therefore, these standards for bathing waters quality in the framework of the implementation of Article 7 of the LBS Protocol should be further used to define GES in bathing and recreational waters.

Assessment methods

The present assessment has been undertaken based on reference documents, as no sufficient updated datasets at regional scale are available. The future assessments of Common Indicator 21will be based on the statistics from datasets submitted by local national authorities or/and the corresponding agencies. Standards of application within IMAP Common Indicator 21 compliance by Mediterranean countries will be the proposed criteria adopted by decision IG.20/9, which includes the intestinal enterococci sample criteria (see table below):

Table 1: Microbiological Water Quality Criteria for intestinal enterococci sp., Source: Decision IG. 20/9, UNEP/MAP, 2012.

Microbial Water Quality Assessment Category
(based on Intestinal enterococci (cfu/100 mL)

Category	A	B	C	D
Limit values	<100*	101-200*	185**	>185**(1)
Water quality	Excellent quality	Good quality	Sufficient	Poor quality/ Immediate Action

RESULTS

Results and Status, including trends (brief)

As mentioned, the datasets for the most Eastern and Southern Mediterranean countries are not updated recently, and therefore, the full assessment at regional scale for Common Indicator 21 is not possible. An assessment report from the European Environment Agency (EEA) in 2015 merged with MED POL data for Tunisia (from 2014) shows about a 90% or higher of the sites monitored during the bathing season for some Contracting Parties of the Barcelona Convention classified as good or excellent. Exceptions are Albania and Tunisia were around a 40% and 10%, respectively, show a poor sanitary condition of the bathing and recreational waters. The temporal trends were calculated by the EEA (EEA, 2015) and exhibit an steady-state and conservative trend for almost all the countries with respect the number of acceptable sites were bathing water quality is controlled.

Results and Status, including trends (extended)

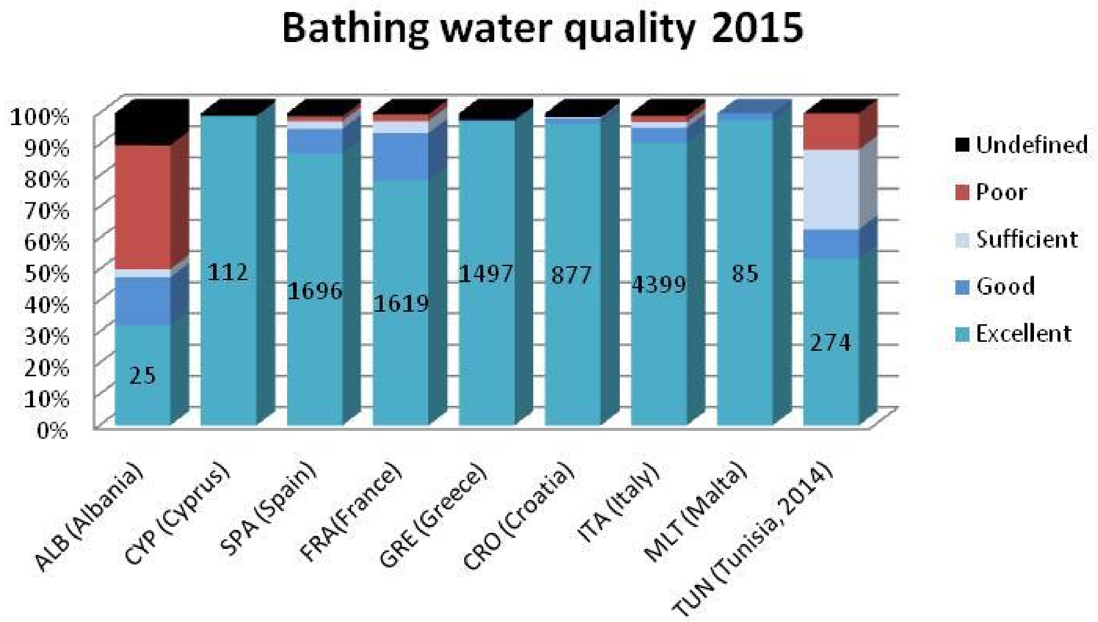

Figure 2: Percentages of the bathing water quality assessment with respect Common Indicator 21 in 2015 for some Contracting Parties of the Barcelona Convention. Please, note France and Spain data includes also the Atlantic coastal sites, in any case, with almost a 100% of sites with good and excellent quality. (Source: EEA, 2015 and MED POL Database for Tunisia).

CONCLUSIONS

Conclusions (brief)

The implementation of measures (e.g. sewage treatment plants) to reduce, among others, the fecal pollution in coastal waters, has been a story-of-success in the Mediterranean Sea through the UN Mediterranean Action Plan. The generalization of the domestic waters depuration in a number of countries the latest decade has demonstrated the benefits of implementing the LBS protocol and environmental measures to reduce pollution, despite some few improvements still need to be taken.

Conclusions (extended)

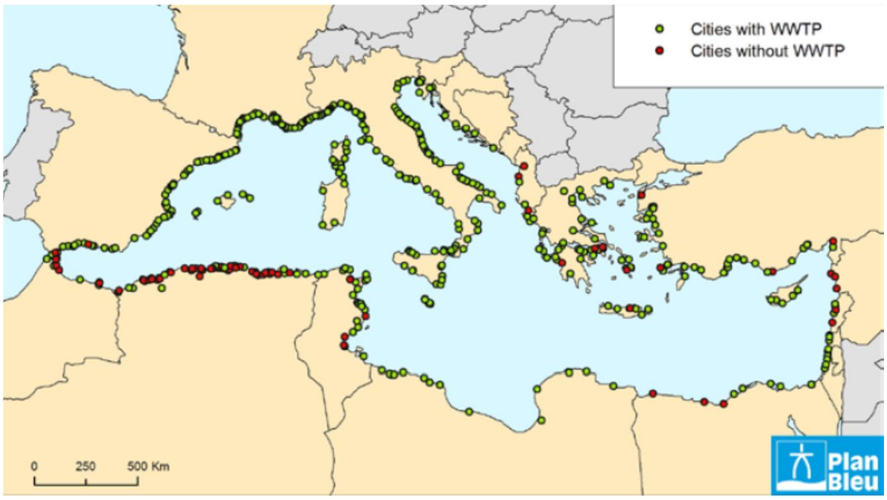

Figure 3: Waste water treatment in the Mediterranean coasts back in 2010 to prevent microbiological pollution of bathing waters (Source: EEA, 2014, based on MAP Technical Report Series No 157, 2004; UNEP/MAP, 2011 and UNEP(DEPI)/MED WG.357/Inf.7).

Key messages

- Initial target of GES under Common Indicator 21 would be an increasing trend in measurements to be able to test that levels of intestinal enterococci comply with established regulation standards

Knowledge gaps

The lack of recent datasets on microbiological pollution in [th]e Mediterranean Sea submitted to the MAP Secretariat is the main current gap and concern, and therefore, to be able to monitor the future progresses under the Common Indicator 21.

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Ecological Objective 10 (EO10): Marine Litter

EO10: Common Indicator 22: Trends in the amount of litter washed ashore and/or deposited on coastlines (including analysis of its composition, spatial distribution and, where possible, source)

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Regional, Mediterranean Sea
Contributing countries:	Mediterranean assessment based on existing regional and national surveys, research and publications and as appropriate data from national monitoring programmes of the Contracting Parties.
Mid-Term Strategy (MTS) Core Theme	1-Land and Sea Based Pollution
Ecological Objective	Ecological Objective 10 (EO10): Marine and coastal litter do not adversely affect the coastal and marine environment.
IMAP Common Indicator	Common Indicator 22 (CI22): Trends in the amount of litter washed ashore and/or deposited on coastlines (including analysis of its composition, spatial distribution and, where possible, source).
Indicator Assessment Factsheet Code	EO10CI22

RATIONALE/METHODS

Background (short)

Much of what we know on the presence of marine litter (abundance, distribution, origin) in the marine and coastal environment comes from information collected on marine litter stranded on beaches (Ryan et al., 2009). Beach marine litter has drawn a lot of attention and numerous surveys and corresponding campaigns have been organized. However, a comparison among all these different studies is made difficult as the majority of these studies use different sampling protocols, techniques and methods. As in all marine compartments, plastics are predominant among the collected marine litter items found stranded on beaches. Several NGOs have been very active in tackling the problem, increasing the environmental awareness of the citizens, along with engaging them in marine litter related surveys, events and actions. Most of the available information on beach marine litter for the Mediterranean Sea comes from standing-stock surveys.

Monitoring of marine litter found stranded along the coastline of the Mediterranean still remains a priority. Special attention should be drawn upon the quantification and characterization of litter pollution found on beaches along with providing comparable datasets to support national and regional assessment of beach marine litter (JRC, 2013). This is also the key to introduce and implement effective policy and management measures. An in depth and comprehensive understanding of the level of threat posed by marine litter to biota and ecosystems at regional should be based upon reliable, quality assured, homogenized and comparable datasets and all efforts should target towards that direction.

Background (extended)

Even the most remote parts of the Mediterranean are affected by marine litter. The findings of the "Assessment of the status of marine litter in the Mediterranean" (2009) undertaken by UNEP/MAP MED POL in collaboration with the Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE), the Hellenic Marine Environment Protection Association (HELMEPA), and Clean up Greece Environmental Organization, illustrate that although useful data on types and quantity of marine litter exists in the region, it is inconsistent and geographically restricted mainly to parts of the North Mediterranean.

The economic values from coastal recreation are considerable (Ghermandi and Nunes, 2013). Clean seas and beaches are key to attract local and international tourism and are an integral part of the UN Environment / Mediterranean Action Plan Integrated Monitoring Assessment Programme and related Assessment Criteria (IMAP) and the European Marine Strategy Framework Directive (MSFD), in which marine litter is one of the key indicators to assess Good Environmental Status (GES) and the effectiveness of policy measures (Brouwer et al., 2017; Galgani et al., 2013). Beach marine litter have been argued to pose a significant cost on society, in particular in the way they affect coastal tourism and recreation (UNEP, 2009).

The issue of marine litter and related information on the amounts and types in the Mediterranean is rather complicated; most Contracting Parties have not yet put in place their official monitoring programmes and thus do not submit related data on marine litter. In these cases, the situation can only be addressed principally by scientific institutions and sub-regional and local authorities in most countries on the one hand, and by competent NGOs on the other hand. Collection of information is a task that requires considerable human resources directly and indirectly related to the subject along with the sophisticated central coordination mechanism. A relatively systematic and reliable source for amounts and types of litter is usually the existing NGO initiatives in the region. NGO efforts are the most significant in terms of surveying and cleaning beaches and the sea and providing information on the volume and types of litter existing in the Mediterranean. However, the role of the Contracting Parties is very important and all national monitoring programmes, when in place, should take into consideration a harmonized approach/methodology applied at regional level.

Furthermore initiatives of varying importance are taken up by NGOs, local authorities and other partners at national and local level in almost all Mediterranean countries. Thousands of volunteers have been gathered in the Mediterranean countries with the purpose not only to clean the coasts, rivers and lakes in their local communities but also to raise awareness amongst students, citizens, and various stakeholders about the serious implications of marine litter and to inspire people to make a difference and improve their daily environmental conduct.

Strandline surveys, cleaning, and regular surveys at sea are gradually being organized in many Mediterranean countries for the aim of providing information on temporal and spatial distribution. Various strategies based on the measurement of quantities or fluxes have been adopted for data collection purposes. However, most surveys are conducted by NGOs with a focus on cleaning. Moreover, small fragments measuring less than 2.5 cm, also referred to as meso-litter(versus macro-litter), are often buried and may not be targeted by clean-up campaigns or monitoring surveys. Stranding fluxes are therefore difficult to assess, and a decrease in litter amounts at sea will only serve to slow stranding rates. They can comprise a large proportion of the debris found on beaches and very high densities have been found in some areas.

Standing stock evaluations of beach litter reflect the long-term balance between inputs, land-based sources or stranding, and outputs from export, burial, degradation and clean-ups. Recording the rate at which litter accumulates on beaches through regular surveys is currently the most commonly-used approach for assessing long-term accumulation patterns and cycles.

One of the major problems that still occur for beach marine litter is due to the fact that each initiative is conducted with different data cards, standards, and measures (litter types are classified differently, if at all; in some cases litter is measured in items while in others by weight, etc.), while certain crucial information is completely lacking (length of coast cleaned, type of coast, proximity of coast to sources of litter, etc.) (UNEP/MAP, 2015).

Assessment methods

The current assessment has been based on recent key assessments, reports and publications by UNEP/MAP, and other projects and initiatives. The UNEP/MAP (2015) Marine Litter Assessment in the Mediterranean report has been used as the main source for this indicator assessment factsheet.

Strandline surveys, cleaning, and regular surveys at sea are gradually being organized in many Mediterranean countries for the aim of providing information on temporal and spatial distribution. Various strategies based on the measurement of quantities or fluxes have been adopted for data collection purposes. However, most surveys are conducted by NGOs with a focus on cleaning. Moreover, small fragments measuring less than 2.5 cm, also referred to as meso-litter (versus macro-litter), are often buried and may not be targeted by clean-up campaigns or monitoring surveys. Stranding fluxes are therefore difficult to assess, and a decrease in litter amounts at sea will only serve to slow stranding rates. They can comprise a large proportion of marine litter found on beaches and very high densities have been found in some areas.

Moreover, more sophisticated strategies for monitoring beach marine litter can be also applied including the following aspects: selection of survey sites (100m stretch) and number of sites, frequency and timing of surveys, documentation and characterization of sites, selection of sampling unit and unit for quantifying litter, collection and identification of litter items (survey forms, master list of items), size limit and classes of items, and removal and disposal of litter.

The recruitment and training of the corresponding staff and groups of volunteers are a requirement for any long-term marine litter assessment (UNEP, 2009). Staff and volunteers should have a very good level of understanding on the context and purpose of the marine litter assessment programme. Quality assurance and quality control of the collected data should be also ensured, mainly addressed through a consistent way of collecting and characterizing data at regional level.

RESULTS

Results and Status, including trends (brief)

It is currently difficult to assess the impact of marine litter on beaches due to the spatial availability of data and information in the Mediterranean (with most data found on northern shores), and also a lack of comparability between data dues to differing methodologies used. Mediterranean NGOs have significantly contributed in providing data and information on the temporal and spatial distribution of marine litter found stranded on beaches through beach clean-up campaigns and dedicated monitoring surveys but still many of these are not comparable to give a complete picture at regional level. Also, little is known on the accumulation and loading rates and correspondingly stranding fluxes and rates are difficult to assess.

Figure 1: Marine litter stranded along the coastline

Information is available on the main types of beach marine litter comprise of plastic, glass, paper, metal, polystyrene, cloth, rubber, fishing-related items, munitions, wood, smoking-related items, sanitary waste , and other un-identified items (Table 1). According to 2016 International Coastal Cleanup report, the top items for the Mediterranean Sea are: cigarette butts, plastic beverage bottles, food wrappers, plastic bottle caps, straws/stirrers, other plastic bags, glass beverage bottles, plastic grocery bags, metal bottle caps, and plastic lids. Plastics are the predominant type of litter found on beaches accounting for over 80% of the recorded marine litter (UNEP/MAP, 2015). Within these marine litter types, specific items are found more frequently i.e. cigarette butts, food wrappers, plastic bottles, caps, straws and stirrers, grocery plastic bags, glass bottles, other plastic bags and cans. Most of the recorded marine litter items are derived from land-based sources (including poor waste management practices, recreational and tourism activities).

Table 1: Composition/ sources of marine litter in the Mediterranean

Source (Literature)	Items/Consistency (beaches; top five)	Type of material	Sources
IPA Adriatic DeFishGear (2016)	Items (top 5): -Plastic pieces 2.5 cm > < 50 cm : 19.89% -Polystyrene pieces 2.5 cm > < 50 cm: 11.93% -Cotton bud sticks: 9.17% -Plastic caps/lids from drinks: 6.67% -Cigarette butts and filters: 6.60%	Plastics: 91%	Recreational & tourism:40% Households(combined):40 % Coastal tourism: 32,3% Toilet/sanitary: 26,2% Household: 11,2% Waste collection: 6% Recreational: 5,6%

Marine Litter Watch (MLW) / European Environment Agency (EEA)	- Other types: 32% - Cigarette butts: 18% - Plastic pieces 2.5><50 cm: 11% - Shopping bags (incl. pieces): 7% - Cotton butt sticks: 6% - Plastic caps/lids drinks: 6% - Polystyrene pieces 2.5><50 cm: 6% - Glass/ceramic fragments <2.5 cm: 4% - String and cord (less than 1cm): 4% - Crisps packet/sweets wrappers: 3% Drink bottles <=0.5lt: 3%	Plastics: 64% Glass: 4%	
Öko-Institut (2012; figures mainly from UNEP, 2009)	-Cigarette butts: 29,1% - Caps/lids: 6,7% - Beverage cans: 6,3% - Beverage bottles (glass): 5,5% - Cigarette lighters: 5,2%	Beaches: 37-80% plastics Floating: 60-83% plastics Sea-floor: 36-90% plastics	Recreational/shoreline activities: >50%, Increase in tourism season
Ocean Conservancy/ ICC 2002-2006			Beach litter: recreational activities: 52% Smoking-related activities: 40% waterways activities: 5%
JRC IES (2011)		Beach:83% plastics/polystyrene	

Shoreline activities (including poor waste management practices, tourism and recreation), along with sea/waterway activities, smoking-related activities, dumping and improper disposal of medical/personal hygiene items are among the main beach marine litter sources (Table 1). Tourism has a significant share in the generation of beach marine litter. During the summer period population is almost doubled in the coastal areas of the Mediterranean Sea being directly linked with the increased waste generation reaching up to 75% of the annual waste production for some areas. In the same extent marine litter concentration has been found to double during summer.
Public and awareness, citizen engagement and participation are effectively contributing in tackling the problem of marine litter along the shorelines of the Mediterranean Sea.

Results and Status, including trends (extended)

Strandline surveys, cleaning, and regular surveys at sea are gradually being organized in many Mediterranean countries for the aim of providing information on temporal and spatial distribution. Various strategies based on the measurement of quantities or fluxes have been adopted for data collection purposes. However, most surveys are conducted by NGOs with a focus on cleaning. Moreover, small fragments measuring less than 2.5 cm, also referred to as mesolitter (versus macro litter), are often buried and may not be targeted by clean-up campaigns or monitoring surveys. Stranding fluxes are therefore difficult to assess, and a decrease in litter amounts at sea will only serve to slow stranding rates. They can comprise a large proportion of the litter found on beaches and very high densities have been found in some areas.

Based on data provided by the Ocean Conservancy and processed and analyzed by HELMEPA from beach clean-ups in Mediterranean countries within the framework of the International Coastal Cleanup (ICC) campaign, the main types of litter found on Mediterranean beaches, are listed in Table 2, 3 and 4 hereunder.

Table 2: Main types of beach marine litter in the Mediterranean (ICC after UNEP, 2011)

Plastics: bags, balloons, beverage bottles, caps/lids, food wrappers/ containers, six-pack holders, straws/stirrers, sheeting/tarps, tobacco packaging and lighters
Glass: beverage bottles, light bulbs
Paper and cardboard of all types
Metals: aluminium beverage cans, pull tabs, oil drums, aerosol containers, tin cans, scrap, household appliances, car parts
Polystyrene: cups/plates/cutlery, packaging, buoys
Cloth: clothing, furniture, shoes
Rubber: gloves, boots/soles, tires
Fishing related waste: abandoned/lost fishing nets/line and other gear
Munitions: shotgun shells/wadding
Wood: construction timber, crates and pallets, furniture, fragments of all the previous
Cigarette filters and cigar tips
Sanitary or sewage related litter: condoms, diapers, syringes, tampons
Other: rope, toys, strapping bands

Table 3: Top ten items in the Mediterranean Sea (International Coastal Clean-up, ICC, 2016). Total number is the number of items collected on 94.4 km of beaches from 11 different countries (Albania, Algeria, Bosnia/Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Morocco, Slovenia, Spain, and Turkey)

	cigarette butts	**plastic beverage bottles**	**food wrappers**	**plastic bottle caps**	**straws/ stirrers**	**other plastic bags**	**glass beverage bottles**	**plastic grocery**	**metal bottle caps**	**plastic lids**
Total collected number	68561	17652	8429	16809	16061	4026	2914	3908	2918	6833
number /100m	73	19	9	18	17	4	3	4	3	7

Table 4: Top fifteen beach litter items for the Mediterranean Sea and their share and average frequency per 100m coast line, based OSPAR screening (after JRC 2016)

Description	**Average # / 100m**	**Share**
Cutlery/trays/straws (total)	131	17%
Cigarette butts	112	14%
Caps/lids (total)	110	14%
Drink bottles (total)	91	12%
Bags (e.g. shopping)	43	5%
Cotton bud sticks	37	5%
Bags	35	4%
Plastic/polystyrene pieces 2.5 cm > < 50 cm (total)	30	4%
Bottles	28	4%
Crisp/sweet packets and lolly sticks (total)	26	3%
Food incl. fast food containers	15	2%
Cigarette packets	12	2%
Cigarette lighters	11	1%
Drink cans	11	1%
Other sanitary items	9	1%

TOTAL	**701**	**89%**

By far the most predominant type of marine litter in the Mediterranean is cigarette filters (closely followed by cigar tips), which constitute a concern to the region and can be found even in the most remote coastal areas. Thus, 4822 volunteers collected 68,561 cigarette filters in 2015, which corresponds to almost 14.2 cigarette filters per volunteer, while the corresponding average in 2013 was 19.6 and the global average in 2006 was only 3.66 cigarette filters per volunteer. The degradation time for each type of litter is an important factor, as some may degrade fast, in the range of months or years, indicating more concern. It is also important to note that in the ICC Campaign, the small fragments do not appear in the corresponding list of recorded beach marine litter items.

Table 5: Composition/ sources of marine litter in the Mediterranean

Source (Literature)	Items/Consistency (beaches; top five)	Type of material	Sources
IPA Adriatic DeFishGear (2016)	Items (top 5): -Plastic pieces 2.5 cm > < 50 cm : 19.89% -Polystyrene pieces 2.5 cm > < 50 cm: 11.93% -Cotton bud sticks: 9.17% -Plastic caps/lids from drinks: 6.67% -Cigarette butts and filters: 6.60%	Plastics: 91%	Recreational & tourism:40% Households(combined):40% Coastal tourism: 32,3% Toilet/sanitary: 26,2% Household: 11,2% Waste collection: 6% Recreational: 5,6%
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Marine litter items cannot always be linked to a specific source as several marine litter items can be attributed to more than one sources, means of release, geographic origin, pathways and transport mechanism (Veiga et al., 2016). We often categorize the origin of marine litter into land-based and sea-based sources. Similarly, riverine litter is sometimes considered to be land-based, even though some of the littering can occur by boats and ships navigating rivers. Possible riverine sources include the following: public littering on riverbanks or directly in the river, and waste from cities and harbours; poor waste management practices, fly tipping; improper disposal or loss of products from industrial and agricultural activities; debris from the discharge of untreated sewage, either through lack of waste - treatment facilities or from sewer overflows; and storm water discharges (González et al., 2016).

Marine litter from smoking related activities accounts for 40% of total marine litter in the same period and 53.5% of the top ten items counted in 2013. Although the number of litter items from smokers dropped significantly between 2004 and 2005, since 2005 it has been on the rise again. The figure in the Mediterranean is considerably higher than the global average, and constitutes a serious problem that has to be given priority in a Regional Strategy to address the issue.

Many studies dedicated to the local beaches surveys and litter collection provide information on litter and tourism. During summer season, the populations of seaside towns are sometimes double what they are in wintertime. In some tourist areas, more than 75% of the annual waste production is generated in summer season. According to statistics from holiday destinations in the Mediterranean (Bibione-Italy and Kos-Greece), tourists generate an average of 10% to 15% more waste than inhabitants. In the example of Kos Island, the tourism period is from April to October, with 70% of the total annual waste produced during this period (UNEP 2011).

Malta, where over 20% of the Global Net Production is generated from tourism, realized an increase of packaging (37% of municipal solid waste) in 2004 and introduced “bring-in sites” with 400 stations installed by 2006 (State of the Environment Report Malta, 2005, in UNEP 2011). Unfortunately, no new data regarding the results of the introduction is yet available, and the latest report from 2005 still shows an increasing waste production per capita and tourism.

Research funded by the Balearic Government in 2005 (Martinez-Ribes *et al.*, 2007) focused on the origin and abundance of beach litter in the Balearic Islands, including Mallorca, Menorca, and Ibiza, which are all main tourist destinations. This fundamental study shows similarities to other tourism areas and is therefore very helpful regarding the sources of littering, which are highly connected to tourism. Litter found in summertime is twice as much as in winter (Figure 1).

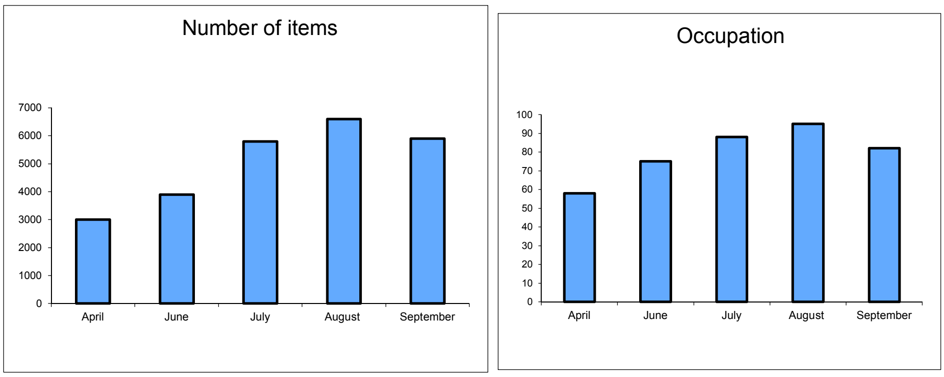

Figure 2: Monthly variation of litter items (A) and percentage of hotel occupation for the corresponding date (B) in the Balearic Islands (Source Martinez-Ribes et al., 2007)

In another example, Israel achieved good results with their pollution abatement Clean Coast Index, involving Municipalities and NGOs in beach clean-ups (Ministry of Environmental Protection, 2008). Although there is no data about the types and quantities of litter pollution in the coastal areas, the published index shows a 30% reduction of littered beaches. Raising public awareness with leaflets and competitions in tourism and public areas supported the strategy, and the ongoing efforts will be continued on a yearly basis to continue to tackle the litter problem on the shorelines of Israel. Moreover, data from a monitoring experiment on a sample of 52 beaches in France (Mer-terre.org) confirmed the existence of tourism and fishing related activities as main sources of litter.

The IPA-Adriatic DeFishGear provides valuable data on beach litter from its one-year long surveys carried on beaches in the seven countries of the Adriatic-Ionian macroregion, namely Albania, Bosnia and Herzegovina, Croatia, Italy, Greece, Montenegro and Slovenia. More specifically 180 beach transects were surveyed in 31 locations, covering 32,200 m2 and extending over 18 km of coastline. The majority of litter items were artificial polymer materials accounting for 91.1% of all beach litter. Shoreline sources -including poor waste management practices, tourism and recreational activities- accounted for 33.4% of total litter items collected on beaches. When looking at the sea-based sources of litter (fisheries and aquaculture, shipping) these ranged from 1.54% to 14.84% between countries, with an average of 6.30% at regional level for beach litter.

Standing stock evaluations of beach litter reflect the long-term balance between inputs, land-based sources or stranding, and outputs from export, burial, degradation and clean-ups. Recording the rate at which litter accumulates on beaches through regular surveys is currently the most commonly-used approach for assessing long-term accumulation patterns and cycles. The majority of studies performed to date have demonstrated densities in the 1 item/m^2 range but show a high variability in the density of litter depending the use or characteristics of each beach (UNEP/MAP, 2015). Plastic accounts for a large proportion of the litter found on beaches in many areas, although other specific types of plastic are widely-found in certain areas, according to type (Styrofoam, etc.) or use (fishing gear). For ICC (Table 6), cigarette butts, plastic bags, fishing equipment, and food and beverage packaging are the most commonly-found items, accounting for over 80% of litter stranded on beaches.

Table 6: Top ten items by country (International Coastal Clean-up, ICC 2016) expressed as number of items/100m of beach

	Number of items per 100 m									
COUNTRY	cigarette butts	Plastic beverage bottles	Food wrappers	Plastic bottle caps	Straws, stirrers	Other plastic bags	Glass beverage bottles	Plastic grocery bags	Metal bottle caps	Plastic lids
Albania	535	39	55	26	35	27	5	25	8	1
Cyprus	30	7	8	3	4	1	1	3	2	2
Egypt	1	1	1	4		1	1	1		
France	34	3	3	2	1	3	1	4	1	1
Greece	71	16	5	15	14	2	2	4	3	10
Italy[1]							5			
Malta		2					1			
Morocco	7	13	1	23	5	7	10	5	13	3
Slovenia	63	2	5	6	2	6	0	1	1	
Spain	83	21	20	36	39	9	5	6	5	7
Turkey	613	811	14				137	12		

Data from *Clean up Greece* between 2004 and 2008 indicated however the importance plastic and paper abandoned and wind born on island beaches. On isolated beaches, other visible and larger sized litter items (metal, rubber, glass, and textile) have increased due to illegal dumping. The abundance, nature, and possible sources of litter on 32 beaches on the Balearic Islands (Mediterranean Sea) were investigated in 2005 (Figure 2). Mean summer abundance in the Balearics reached approximately 36 items per linear meter, with a corresponding weight of 32±25 g per m^{-1}, which is comparable to the results of other studies in the Mediterranean. Strong similarities between islands and a statistically significant seasonal evolution of litter composition and abundance were demonstrated. In summer (the high tourist season), litter contamination was double that in the low season and showed a heterogeneous nature associated with beach use. Again, cigarette butts were the most abundant item, accounting for up to 46% of the objects observed in the high tourist season. In contrast, plastics related to personal hygiene/medical items were predominant in wintertime (67%)In both seasons, litter characteristics suggested a strong relationship with local land-based origins. While beach users were

[1] The participation of Italy to ICC was limited to only 16 volunteers in a very small portion of coastline, so data reported in table 6 are not representative of the Italian situation.

the main source of summer litter, low tourist season litter was primarily attributed to drainage and outfall systems.

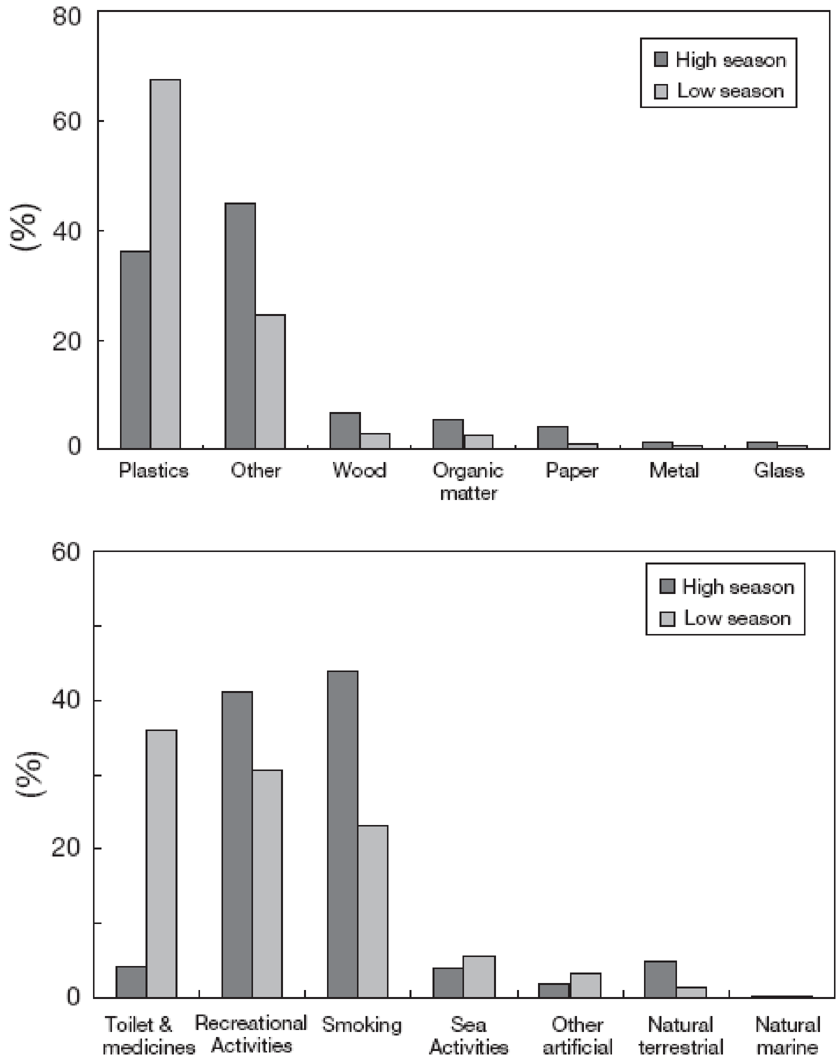

Figure 3: Litter composition (A) and estimated origin (B) of the litter collected in low and high tourist season in Balearic Islands (source Martinez-ribes et al., 2007)

CONCLUSIONS

Conclusions (brief)

Knowing the amounts of marine litter found stranded on beaches can help us assess the potential harm to the environment and would also increase our knowledge on sources (JRC, 2013), as currently there is limited data and great spatial variability on the amounts and composition of marine litter reflecting the different characteristics of the shorelines along the Mediterranean.

Existing studies however indicate the main types of beach litter are of land-based origin, coming from poor waste management practices, recreational and tourism activities, household items and smoking related waste (Table 4). Moreover, it is difficult to draw conclusions regarding the overall increase or decrease of marine litter in the Mediterranean (UNEP/MAP, 2015). Assessments of the composition of beach litter in different regions of the Mediterranean Sea show that synthetic polymer materials (bottles, bags, caps/lids, fishing nets, and small pieces of unidentifiable plastic and polystyrene) make up the largest proportion of overall litter pollution.

Conclusions (extended)

The amount of litter originating from recreational/tourism activities greatly increases during and after the tourism season. Smoking related wastes in general also seems to be a significant problem in the Mediterranean, as several surveys suggest (UNEP 2009). According to the analysis of data collected, shoreline and recreational activities were the main source every year of the last decade, until it was surpassed by smoking-related waste (UNEP, 2011). Moreover, the fishing industry is of significance (UNEP, 2013), as well as the shipping industry, especially off the African coast.

National Case Studies may provide more detailed information on local constraints and effective factors on the distribution of litter. Moreover national data coming from national monitoring programmes on marine litter will improve a lot the picture for beach marine litter. It is important to note, however, that volunteer groups should be informed about the necessity to submit standardized research data for statistical purposes. Clean up actions by NGOs are usually organized to raise awareness and not so much for data collection, and cleanup programmes should increase public knowledge of the scientific relevance of information and information sharing.

There are certain limitations to the results on beach marine litter in the Mediterranean. As it has been already stated for the moment the Contracting Parties are not submitting official marine litter data to the Secretariat as a result of the national monitoring programmes. Moreover, the smaller sized items are not included in most of the case among the cleanup campaigns items list and thus these results are not at all representative for the presence of smaller fragments i.e. micro-litter along the beaches in the Mediterranean.

However, interesting observations have been made on the proliferation of lighter marine litter items in the Mediterranean (plastics, aluminum and smoking-related litter), as opposed to heavier items from basic use (bottles, cans, see Figure 3) or litter from dumping activities (household appliances, construction materials, tires, etc.) This could be related to the efficiency of preventive action (easier collection, recycling, adoption and/or implementation of stricter legislation with regards to dumping activities, etc.) for larger items and the difficulty to manage inputs from sources such as the general public.

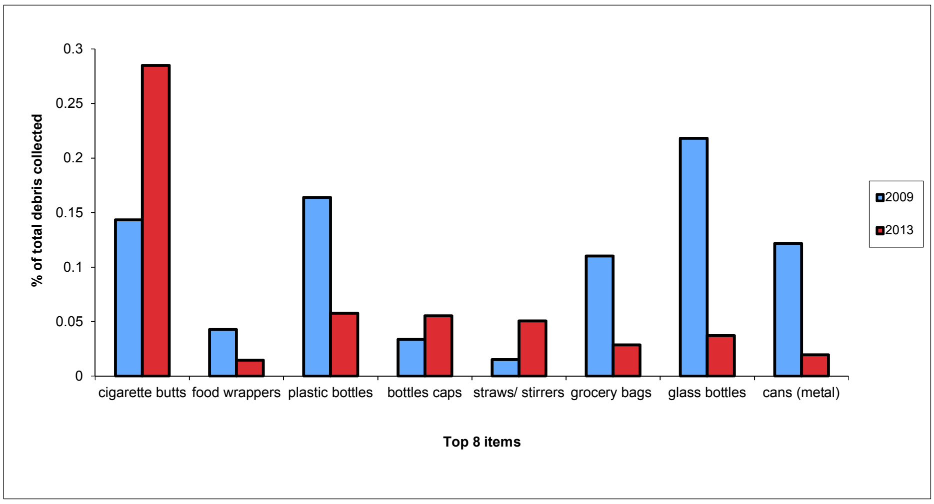

Figure 4: Changes in percentages of the top 8 items in the Mediterranean Sea between 2009 and 2013. Data from Ocean Coastal Cleanup on types of litter of 303522 items and 110698 items collected in 2009 and 2013 respectively on beaches from Greece, Turkey, Egypt and Spain (data from http://www.oceanconservancy.org/)

Environmental awareness is also observed when this general public, conscious of the impact of their actions, do not use beaches as disposal sites for heavy garbage items as lightheartedly as they did in the past. The removal of these heavier items, combined with the persistent nature of plastics and other lighter marine litter items that can still be found in considerable numbers in the Mediterranean, has led to the changing nature of marine litter in the region.

Key messages

Information on beach marine litter exist but the picture is still fragmented and is geographically restricted to the northern part of the Mediterranean. Plastics are the major components with cigarette butts, food wrappers and plastic being the top marine litter items. Land-based sources are predominant but they have to be further specified. Tourism is directly affecting marine litter generation on beaches. There is an urgent need to develop and implement the Integrated Monitoring and Assessment Programme (IMAP) protocol for Common Indicator 22, and submit corresponding data to the Secretariat at national level.

Knowledge gaps

Information on the distribution, quantities and identification of litter sources for beach marine litter needs to be further advanced. For the moment information and data are inconsistent for the Mediterranean. In that aspect, monitoring strategies should be encouraged at regional level based on harmonized and standardized monitoring and assessment methods. Mapping of the shorelines and coasts at basin scale where marine litter accumulates needs to be implemented. Accumulation and stranding fluxes needs to be evaluated along with information on corresponding loads and linkage with specific sources. Efforts should be enhanced towards engaging citizens, informing them about certain aspects and effects of marine litter found stranded on beaches, along with make responsible citizens (responsible consumption and littering behavior).. Harmonized beach clean-up campaign organized at basin scale should be organized based on a science-based protocol which will enable the collection of relevant scientific information.

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Ecological Objective 10 (EO10): Marine Litter

EO10: Common Indicator 23: Trends in the amount of litter in the water column including microplastics and on the seafloor

GENERAL

Reporter:	UNEP/MAP/MED POL
Geographical scale of the assessment:	Mediterranean Sea
Contributing countries:	Mediterranean assessment based on existing regional and national surveys, research and publications and as appropriate data from national monitoring programmes of the Contracting Parties.
Mid-Term Strategty (MTS) Core Theme:	1-Land and Sea Based Pollution
Ecological Objective	Ecological Objective 10 (EO10): Marine and coastal litter do not adversely affect the coastal and marine environment
IMAP Common Indicator	Common Indicator 23 (CI23): Trends in the amount of litter in the water column including microplastics and on the seafloor
Indicator Assessment Factsheet Code	EO10CI23

RATIONALE/METHODS

Background (short)

The marine environment is directly linked to human life. Nowadays, marine litter is found widespread in the environment, from shallow water till the deep abyssal plains, posing one of the major threats for the marine environment.

The Mediterranean Sea has been described as one of the areas most affected by marine litter in the world. Human activities generate considerable amounts of waste, and quantities are increasing, although they vary between countries. In addition, some of the largest amounts of Municipal Solid Waste (MSW), generated annually per person occur in the Mediterranean Sea (208 – 760 kg/year, http://atlas.d-waste.com/). Plastic, which is the main marine litter component, has now become ubiquitous and may comprise up to 90% for seafloor litter.

Surveys conducted to date in the Mediterranean Sea, show considerable spatial variability. Accumulation rates vary widely and are influenced by many factors, such as the presence of large cities, shore use, hydrodynamics, and maritime activities. Marine litter is even more abundant in enclosed areas, which has some of the highest densities of marine litter stranded on the sea floor, sometimes reaching over 100,000 items/km2 (Galgani et al., 2000). Moreover, the estimated plastic densities found floating in the Mediterranean Sea seems to be of the same range as in the five sub-tropical gyres. To date, the fate of this litter is still questionable and the identification of areas where litter permanently accumulate is a major challenge.

Plastic densities on the deep sea floor did not change over the years (1994 – 2009) in the Gulf of Lion, but conversely the abundance of marine litter in deep waters was found to increase over the years in the Central Mediterranean (Koutsodendris et al., 2008; Ioakeimidis et al., 2014).

Background extended

The global amount of litter entering into the oceans has been calculated at between 4.8 and 12.7 million tons, only for plastics (Jambeck et al., 2015). Moreover, the deep-sea floor is probably the final global sink for marine litter mostly comprising of plastic.

The Mediterranean Sea has been described as one of the areas most affected by marine litter in the world geographical distribution of marine litter and plastic in particular, is highly impacted by hydrodynamics, geomorphology, and human factors. The Mediterranean geomorphology is very peculiar with not extensive shelves and deep-sea environments that can be influenced by the presence of coastal canyons. Continental shelves are proven accumulation zones, but they often gather smaller concentrations of marine litter than canyons; as litter is washed offshore by currents associated with offshore winds and river plumes.

Most litter is comprised of high-density materials and hence sinks. Even low-density synthetic polymers such as polyethylene and polypropylene, may sink under the weight of fouling or additives. The fouling of litter by a wide variety of bacteria, algae, animals and fine-grained accumulated sediments, increases their weight and litter can sink to the seafloor. In the Mediterranean, plastic which is the main marine litter component, is ubiquitous in the marine environment and may comprise up to 90% of the recorded seafloor marine litter. Human activities generate considerable amounts of waste, and quantities are increasing, although they vary between countries. Some of the largest amounts of Municipal Solid Waste (MSW), generated annually per person occur in the Mediterranean Sea (208 – 760 kg/year, http://atlas.d-waste.com/)

Important policy achievements have been expanded at regional level in the Mediterranean. United Nations Environment / Mediterranean Action Plan has adopted the Strategic Framework for Marine Litter Management in 2012 (Decision IG.20/10 - 17th Meeting of the Contracting Parties of the Barcelona Convention). Following, the Regional Plan on Marine Litter Management in the Mediterranean in the Framework of Article 15 of the Land Based Sources Protocol was adopted in 2013 (Decision IG.21/7 – 18th Meeting of the Contracting Parties of the Barcelona Convention), together with a decision (IG.22/10) in 2016 to support the implementation of the Marine Litter Regional Plan including Fishing-for-Litter Guidelines, an Assessment Report, Baselines Values, and Reduction Targets (19th Meeting of the Contracting Parties of the Barcelona Convention). In addition the Integrated Monitoring and Assessment Programme of the Mediterranean Sea Coast and Related Assessment Criteria adopted in 2016 (Decision IG.22/7 – 19th Meeting of the Contracting Parties of the Barcelona Convention) two common and one candidate indicators on marine litter along with an Integrated Monitoring and Assessment Guidance document (UNEP(DEPI)/MED IG.22/Inf7 - 19th Meeting of the Contracting Parties of the Barcelona Convention).

Floating litter comprises the mobile fraction of litter in the marine environment, as it is less dense than seawater. However, the buoyancy and density of plastics may change during their stay in the sea due to weathering and biofouling (Barnes et al., 2009). Polymers comprise the majority of floating marine litter, with figures reaching up to 100%. Although synthetic polymers are resistant to biological or chemical degradation processes, they can be physically degraded into smaller fragments and hence turn into micro litter, measuring less than 5 mm.

The Mediterranean Sea is often referred to as one of the places with the highest concentrations of litter in the world. For floating litter, very high levels of plastic pollution are found, but densities are generally comparable to those being reported from many coastal areas worldwide (UNEP/MAP, 2015). A 30-year circulation model using various input scenarios showed the accumulation of floating litter in ocean gyres and closed seas, such as the Mediterranean Sea, made up 7-8% of the total litter expected to accumulate (Lebreton et al., 2012).

There are several studies investigating the abundance of marine litter in the Mediterranean Sea. The abundance of floating microplastic fragments was investigated in the Mediterranean Sea by Kornilios et al., 1998; Collignon et al., 2012; Fossi et al., 2012; Collignon et al., 2014; de Lucia et al., 2014; Pedrotti et al., 2014; Cozar et al., 2015; Panti et al., 2015; Fossi et al., 2016 ; Ruiz-Orejón 2016 and Suaria et al., 2016. Few studies have been also published on the abundance of floating macro and mega litter in Mediterranean waters (Aliani et al., 2003; UNEP, 2009; Topcu et al., 2010, Gerigny et al., 2011, Suaria and Aliani, 2015). Information also exist on the abundance of seafloor marine litter for the Mediterranean Sea (Galil et al., 1995; Galgani et al., 1996, 2000; Ioakeimidis et al., 2014; Pham et al., 2014; Ramirez-Llodra et al., 2013).

Floating litter can be transported by currents until they sink to the sea floor, are deposited on the shore, or are degraded over time. Litter that reaches the seafloor may have already been transported considerable distance, only sinking when weighted down by entanglement and fouling. The consequence is an accumulation of litter on specific seafloor locations in response to local sources and oceanographic conditions (Galgani et al., 2000; Keller et al., 2010; Watters et al., 2010; Ramirez-L lodra et al., 2013; Pham et al., 2013). Moreover, seafloor litter tends to become trapped in areas of low circulation. Once litter reaches the seafloor, it lies on the seafloor and it may even partly buried in areas of very high sedimentation rate (Ye and Andrady, 1991).

In terms of data availability on marine litter lying on the seafloor of the Mediterranean, there are several studies investigating the abundance of marine litter (Galil et al., 1995; Galgani et al., 1996, 2000; Ioakeimidis et al., 2014; Pham et al., 2014; Ramirez-Llodra et al., 2013, Vlachogianni et al., 2017) but the information is still fragmented and geographically restricted to the northern Mediterranean. Litter that reaches the seafloor may have already been transported considerable distance, only sinking when weighted down by entanglement and fouling. The consequence is an accumulation of litter on specific seafloor locations in response to local sources and oceanographic conditions (Galgani et al., 2000; Keller et al., 2010; Watters et al., 2010; Ramirez-Llodra et al., 2013; Pham et al., 2013). Moreover, seafloor litter tends to become trapped in areas of low circulation like the enclosed and semi-enclosed gulfs. Once litter reaches the seafloor, it lies on the seafloor and it may even partly buried in areas of very high sedimentation rate (Ye and Andrady, 1991).

Marine litter and plastics in particular it was believed to last in the marine environment for decades or even hundreds of years when in surface (Gregory and Andrady, 2003), likely far longer when in deep sea (Barnes et al., 2009). However, recent studies (Ioakeimidis et al., 2016) have found that the degradation of plastics in the marine environment may occur much faster than it was expected. Surveys conducted to date show considerable spatial variability on marine litter abundance. Accumulation rates vary widely and are influenced by many factors, such as the presence of large cities, shore use, hydrodynamics, and maritime activities. They are higher in enclosed seas such as the Mediterranean basin, which has some of the highest densities of marine litter stranded on the sea floor, sometimes reaching over 100,000 items / km² (Galgani et al., 2000). Plastic densities on the deep sea floor did not change between 1994 and 2009 in the Gulf of Lion (Galgani et al., 2011). Conversely, the abundance of litter in deep waters, such as the central Mediterranean, was found to increase over the years (Koutsodendris et al., 2008; Ioakeimidis et al., 2014).

In the Mediterranean, reports from Greece (Koutsodendris et al., 2008; Ioakeimidis et al., 2014) classify land-based sources (up to 69% of litter) and vessel-based sources (up to 26%) as the two predominant litter sources. In addition, litter items have variable floatability and hence variable dispersal potential.

Assessment methods

The current assessment has been based on recent key assessments, reports and publications by UNEP/MAP, and other projects and initiatives. The UNEP/MAP (2015) Marine Litter Assessment in the Mediterranean report has been used as the main source for this indicator assessment factsheet.

For the moment there is no reporting on UN Environment / Mediterranean Action Plan on floating and seafloor marine litter and the assessment is based on the available data and information from reports and scientific publications.

Several approaches, protocols and units (items/km, items/km^2, kg/km^2, kg/h) have been used. However the expression of the abundance of marine litter found float at sea or lying on the seafloor in items per surface are (m2, km^2, ha2) coupled with information on weight seems to be the most appropriate. Nowadays the harmonization of all the sampling methodologies is among the top-priorities of the marine litter agenda.

A. Floating Marine Litter

Visual assessment of floating macro-litter particles include the use of research vessels, marine mammal surveys, commercial shipping carriers, and dedicated litter observations (UNEP/MAP, 2015). Aerial surveys have also being employed for larger items. For floating micro-litter particles the manta-trawl net system is used for sampling the surface layers of the seas. The net it pulls is made of thin mesh (normally with mesh size of 333μm) and the whole trawl is towed behind a vessel. Then laboratory work is required in order to analyze the collected samples.

B. Seafloor Marine Litter

Most of the data and information on seafloor marine litter are coming from general strategies for the investigation of seabed marine litter which are often similar to those used to assess the abundance and type of benthic species. Several approaches are applied in order to assess seafloor litter abundance and distribution: i) visual surveys with SCUBA in shallow waters; ii) opportunistic sampling using otter-trawls; and iii) observation tools (Remote Operated Vehicles - ROV etc.).

The most common approaches to evaluate sea-floor litter distributions is the opportunistic sampling. This type of sampling is usually coupled with regular fisheries surveys and programmes on biodiversity, since methods for determining seafloor litter distributions (e.g. trawling, diving, video) are similar to those used for benthic and biodiversity assessments.

Monitoring programmes for demersal fish stocks, undertaken as part of the Mediterranean International Bottom Trawl Surveys (MEDITS), operate at large regional scale and provide data using a harmonized protocol, which may provide a consistent support for monitoring litter at Regional scale on a regular basis and within the Ecosytem Approach (EcAp) requirements.

The use of observation tools i.e. Remote Operated Vehicles (ROVs) and Submersible Vehicles is a possible approach for deep-sea environments (Galgani et al. 1996; Pham et al., 2014). These methods unfortunately require considerable means but are of great use for areas that cannot be accessed with other ways. The use of observation tools helped scientists assess marine litter far beyond the commonly used fishing grounds (sandy bottoms) and the continental shelf, and extend the assessment of marine litter in bathyal and abyssal environments, reaching in depths up to 4km.

RESULTS

Results and Status, including trends (brief)

A. Floating Marine Litter

The abundance of floating macro and mega litter in Mediterranean waters has been reported at quantities measuring over 2 cm range from 0 to over 600 items per square kilometer (Aliani et al., 2003; UNEP, 2009; Topcu et al., 2010, Gerigny et al., 2011, Suaria and Aliani, 2015) (Figures 1, 2). Plastics are predominant among floating marine macro- and micro-litter items.

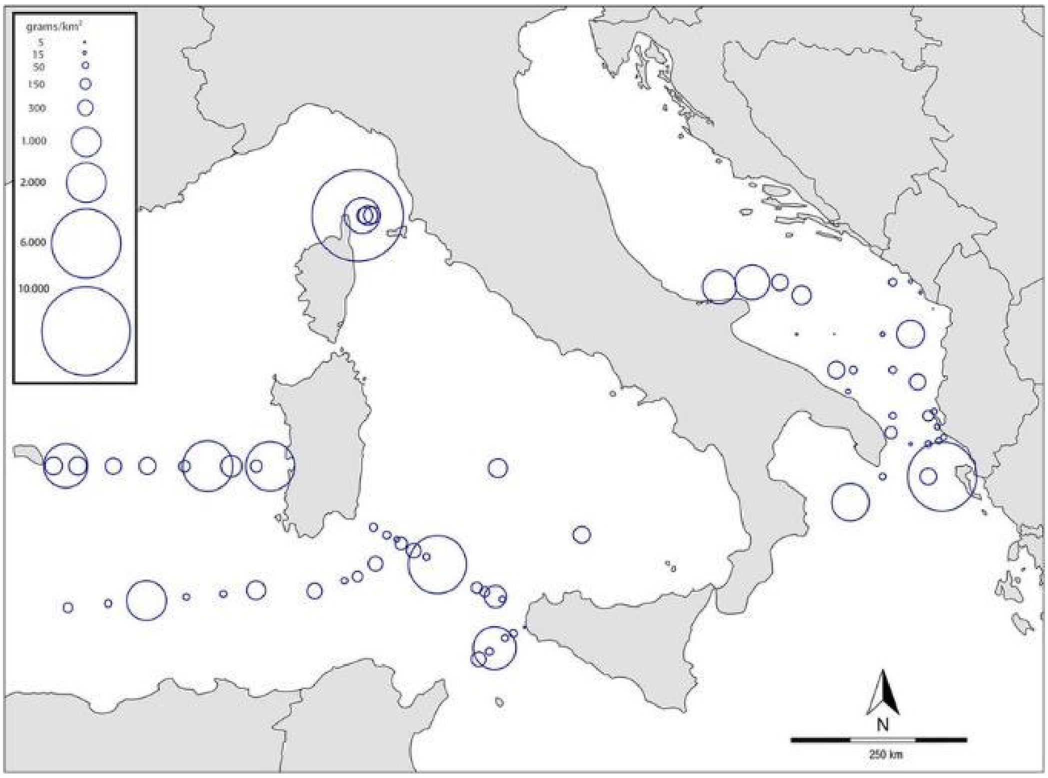

Figure 1: Map of the central-western Mediterranean Sea showing the distribution of plastic densities expressed as grams of plastic per km^2 (after Suaria et al., 2016)

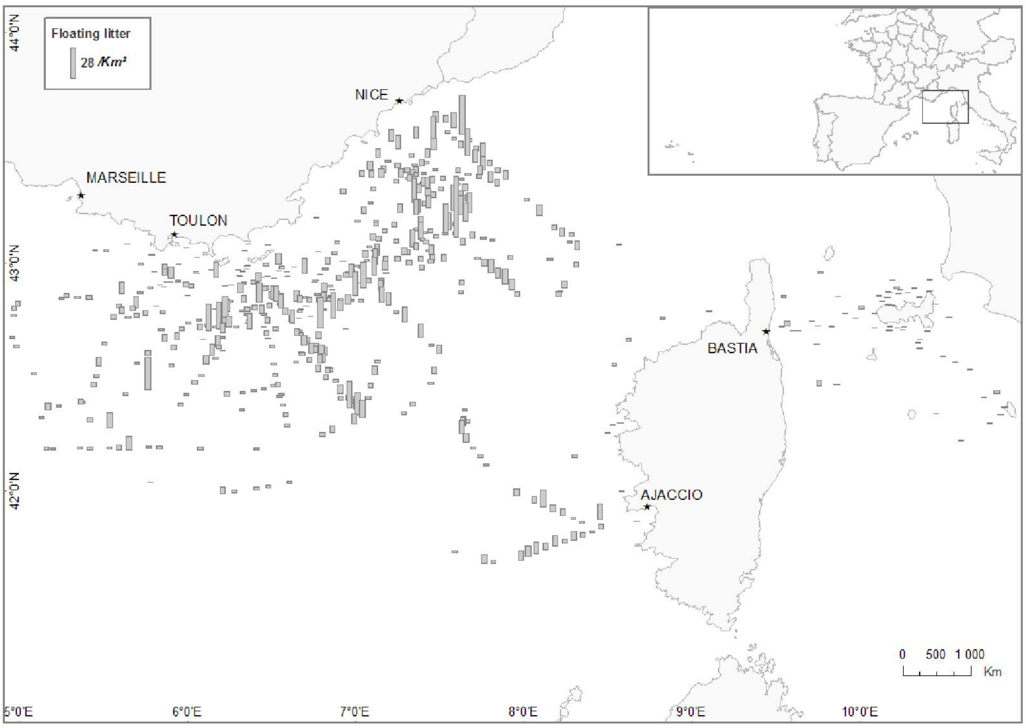

Figure 2: Distribution of floating litter in the northwestern Mediterranean Sea (2006-2008) (visual observations). IFREMER/SHOM map using data from the Ecocean/ParticipeFutur project for initial MSFD assessment (Gerigny et al., 2011)

B. Seafloor Marine Litter

The 2015 UN Environment / Mediterranean Action Plan Marine Litter Assessment report states that approximately 0.5 billion litter items are currently lying on the Mediterranean Seafloor. Moreover, there is great variability in the abundance of seafloor marine litter items ranging from 0 to over 7,700 items per km² depending on the study area. Plastic is the major marine litter component, found widespread in the continental shelf of the Mediterranean, ranging up to 80% and 90% of the recorded marine litter items.

We yet don't have a clear picture on the abundance (number and mass) of marine litter lying on the Mediterranean seafloor, from the shallow water till the deep abyssal plain (Figure 3). The information is only limited and fragmented as only few studies exist investigating marine litter on the Mediterranean seafloor. In addition, the geographical distribution of marine litter items is highly impacted by hydrodynamics, geomorphology, and human factors. Moreover, most of them are geographically restricted to the Northern part of the Mediterranean Sea.

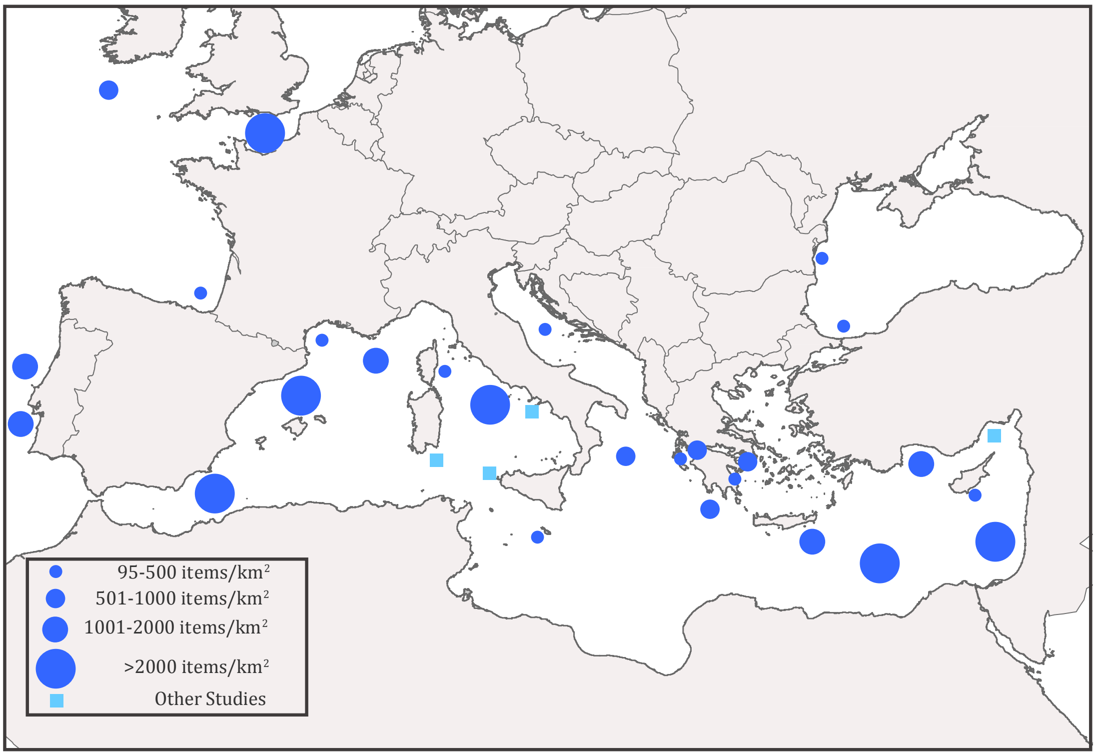

Figure 3: Seafloor marine litter distribution in the Mediterranean and other European Seas (Ioakeimdis, 2015)

Most of the studies have been using traditional fish stock assessment methods i.e. otter trawlers, but recently new, costly and more sophisticated techniques have been also used. In addition to that, little is known on the existence and importance of the corresponding accumulation areas in the Mediterranean.

Results and Status, including trends (extended)

A. Floating Marine Litter

The abundance of floating macro and mega litter in Mediterranean waters has been reported at quantities measuring over 2 cm range from 0 to over 600 items per square kilometer (Aliani et al., 2003; UNEP, 2009; Topcu et al., 2010, Gerigny et al., 2011, Suaria and Aliani, 2015).

In the Ligurian Sea, data was collected through ship-based visual observations in 1997 and 2000; 15-25 items/km² were found in 1997, which decreased to 1.5-3 items in 2000 (Aliani et al., 2003). In the regional assessment conducted by the IPA-Adriatic DeFishGear project (Vlachogianni et al., 2017), the average density of floating macro-litter in coastal Adriatic waters was found 332 ± 749 items/km^2 and in the Adriatic-Ionian waters 4 ± 3 items/km^2. In the Adriatic waters, the highest average abundances were recorded in the coastal waters of Hvar Aquatorium (Croatian coast) (576 ± 650 items/km^2; median 393 items/km^2), followed by the Gulf of Venice (475 ± 1203 items/km^2; median 154 items/km^2) and Cesenatico related area (324 ± 492 items/km^2; median 210 items/km^2). Moreover, during the surveys carried out by observers on ferries on the same areas floating macro-litter abundances were found about two times higher in the Adriatic (5.03 ± 3.86 items/km2) when compared to the Ionian Sea (2.94 ± 2.54 items/km2). Plastic items were dominant (Coastal: 91.4%; Adriatic-Ionian: 91.6%) of total items), followed by paper (Coastal 7.5%; Adriatic-Ionian: 5.1%) and wood items (Coastal: 2.1%; Adriatic-Ionian: 1.4%). The most abundant categories were bags (Coastal: 26.5%; Adriatic-Ionian: 20.4%), plastic pieces (Coastal: 20.3%; Adriatic-Ionian: 21.5%), sheets (Coastal: 13.3%; Adriatic-Ionian: 12.5%), fish polystyrene boxes (Coastal: 11.4%; Adriatic-Ionian: 12.5%), cover/packaging (Coastal: 8.1%), other plastic items (Coastal: 6.0%; Adriatic-Ionian: 2.9%), polystyrene pieces (Coastal: 3.9%; Adriatic-Ionian: 3.6%), and bottles (Coastal: 1.3%; Adriatic-Ionian: 7.7%).

Floating litter was also quantified during marine mammal observation cruises in the northern western basin Mediterranean Sea in a 100 x 200 km offshore area between Marseille and Nice and in the Corsican channel. A maximum density of 55 items/km² was found, with a clearly discernible spatial variability relating to residual circulation and a Liguro-Provencal current vein routing litter to the West (Gerigny et al., 2012 and Figure 4).

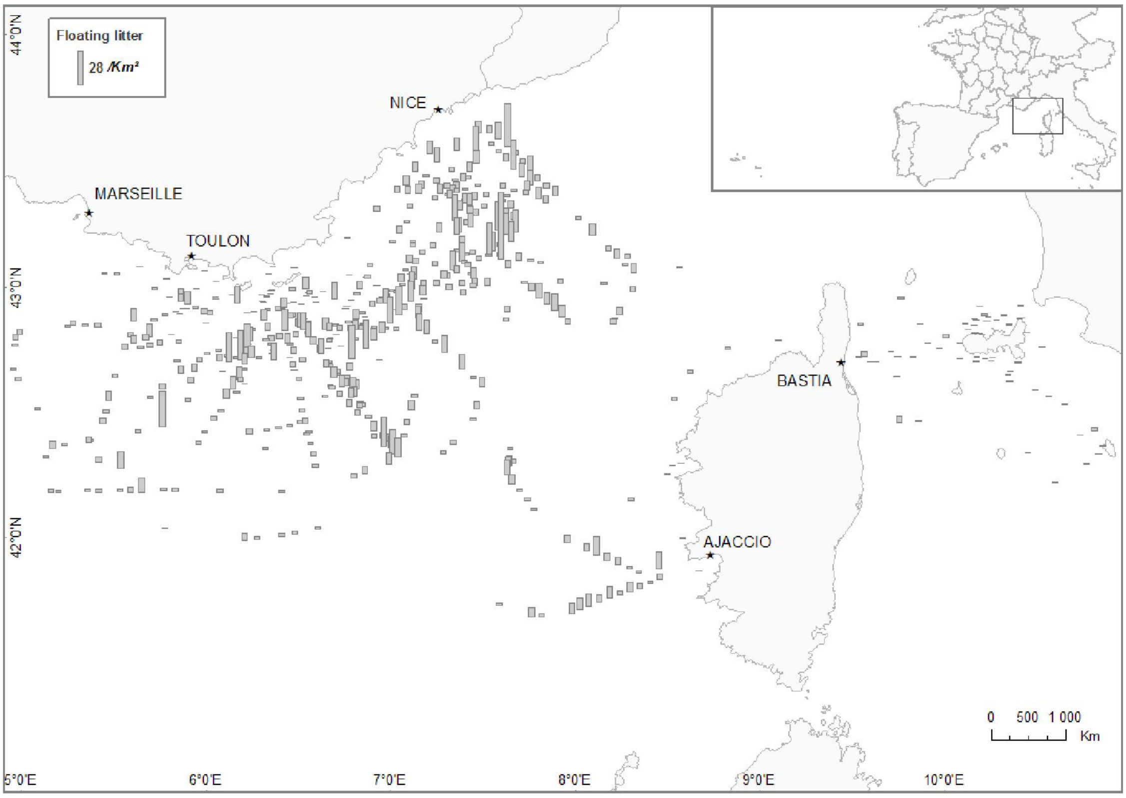

Figure 4: Distribution of floating litter in the northwestern Mediterranean Sea (2006-2008) (visual observations). IFREMER/SHOM map using data from the Ecocean/ParticipeFutur project for initial MSFD assessment (Gerigny et al., 2011)

A subsequent survey made in the Eastern Mediterranean (Topcu et al., 2010) reported densities of less than 2.5 items/ km^2. More recently, results from Suaria and Aliani (2014), dedicated to the first large-scale survey of anthropogenic litter (>2 cm) in the central and western part of the Mediterranean Sea (Figure 5). Throughout the entire study area, densities ranged from 0 to 194.6 items/km^2, with a mean abundance of 24.9 items/km^2. The highest litter densities (>52 items/km^2) were found in the Adriatic Sea and in the Algerian basin, while the lowest densities (<6.3 items/km^2) were observed in the Central Tyrrhenian and in the Sicilian Sea. All of the other areas had mean densities ranging from 10.9 to 30.7 items/km^2.

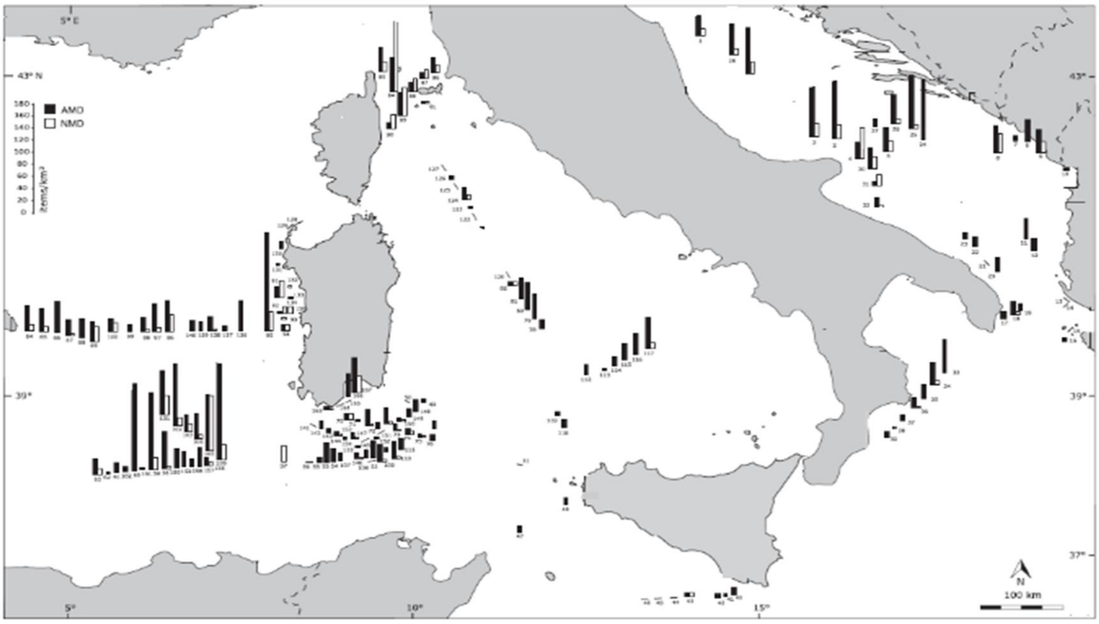

Figure 5: Anthropogenic (black bars) and Natural (white bars) Marine Litter densities (items/km2) in the Western, Adriatic and Northern Ionian basins of the Mediterranean Sea (From Suaria and Aliani, 2014)

Suaria et al. (2016) along with presenting their results (Figure 6) on the distribution of plastic densities in the central Mediterranean Sea, are also providing a detailed comparison table (Table 1) on floating microplastic concentrations based on the available studies performed in the Mediterranean Sea.

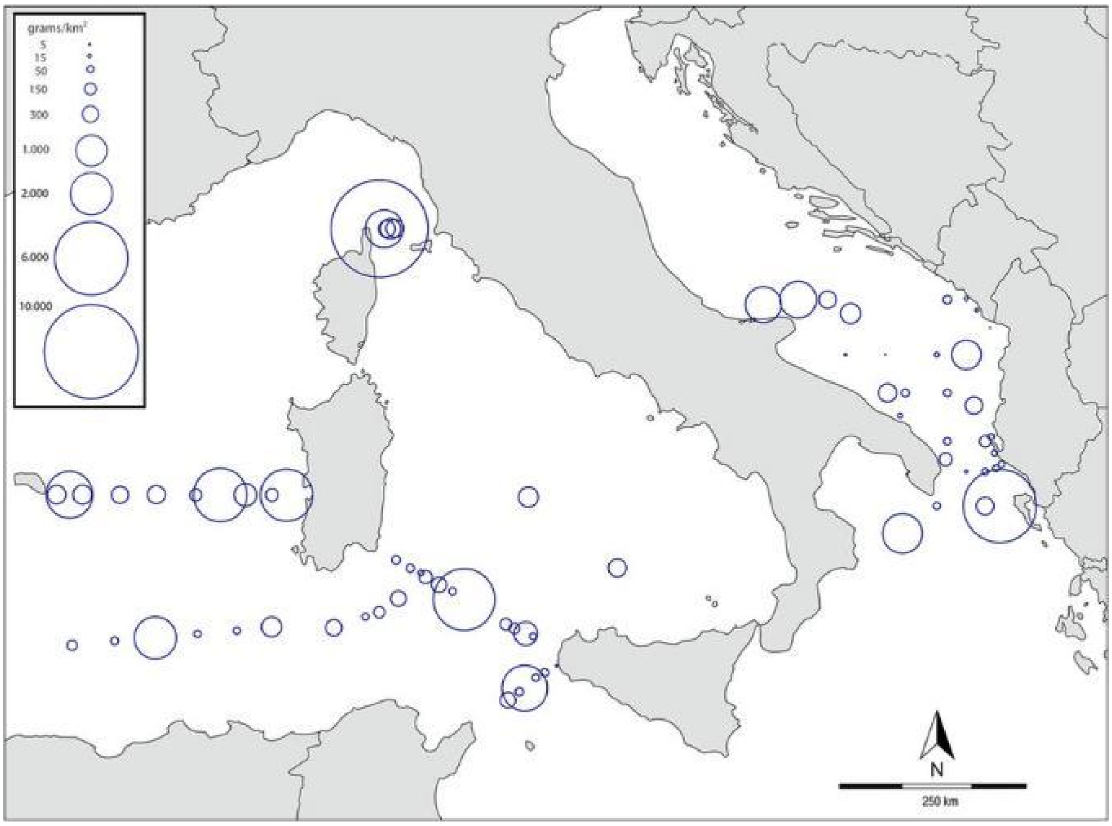

Figure 6: Map of the central-western Mediterranean Sea showing the distribution of plastic densities expressed as grams of plastic per km^2 (after Suaria et al., 2016)

Table 1: Floating microplastic concentrations in the Mediterranean Sea

Study Area	Year	Net mesh	Samples	Mean Abundance	Reference
Cretan Sea	1997	500 µm	25	119 ± 250 g/km^2	Kornilios et al., 1998
NW Med.	2010	333 µm	40	0.116 items/m^2 2020 g/km^2	Collignon et al., 2012
Ligurian/ Sardinian Sea	2011	200 µm	23	0.31 ± 1.0 items/m^2	Fossi et al., 2012
Bay of Calvi (Corsica)	2011-2012	200 µm	38	0.062 items/m^2	Collignon et al., 2014
W. Med.	2011-2012	333 µm	41	0.135 items/m^2 187 g/km^2	Faure et al., 2015
W. Sardinia	2012-2013	500 µm	30	0.15 items/m^3	de Lucia et al., 2014
Ligurian Sea	2013	333 µm	35	0.103 items/m^2	Pedrotti et al., 2014
NW Sardinia	2012-2013	200 µm	27	0.17 ± 0.32 items/m^3	Panti et al, 2015
Ligurian Sea	2011-2013	200 µm	70	0.31 ± 1.17 items/m^3	Fossi et al., 2016
Med.	2013	200 µm	39	0.243 items/m^2 423 g/km^2	Cózar et al., 2015
Central W Med.	2011-2013	333 µm	71	0.147 items/m^2 579.3 g/km^2	Ruiz-Orejón et al., 2016
W Med/ Adriatic	2013	200 µm	74	0.40 ± 0.74 items/m^2 1.00 ± 1.84 items/m^3 671.91 ± 1544.16 g/km^2	Suaria et al., 2016

Data may also be obtained from NGOs. HELMEPA, a Greek organization of maritime stakeholders, invited its member managing companies with ships traveling in or transiting the Mediterranean to implement a programme for the monitoring and recording of litter floating on the sea surface. During the period February – April 2008, 14 reports were received by HELMEPA member-vessels containing information on litter observations from various sea areas in the Mediterranean. In total, observations of 1,051.8 nautical miles (n.m.) of Mediterranean Sea resulted in the recording of 500.8 Kg of marine litter.

The total length of observation for floating marine litter carried out by HELMEPA member vessels was 1,051.8 nautical miles (1,947 kilometers), corresponding to an observation area of around 172.8 km2. The width of observation depended on the weather conditions, the sea state, the position of the Observer, the use of binoculars, the freeboard and volume of marine litter, etc., and generally fluctuated between 22 and 150 meters. Observations were carried out mainly in the eastern Mediterranean (Aegean Sea, Libyan Sea and Eastern Mediterranean Levantine Sea), in the Alboran Sea between Spain and Morocco, and in the Adriatic Sea. The total of marine litter recorded was 366 items, corresponding to a concentration of one item per 3 n.m., or 2.1 items per km2. The concentration of marine litter ranged from 0.08 to 71 items/n.m. relatively higher concentrations of marine litter were observed along routes close to coastal areas, while there were cases in which lengthy observations (more than 120 n.m.) revealed no existence of marine litter. Plastics accounted for about 83.0% of marine litter items, while all other major categories accounted for about 17%, as the following graph shows. Based on weight extrapolations, the average quantity of marine litter was estimated to be 230.8 kg/km2 ranging from 0.002 to 2,627.0 kg/km2. Relatively heavy items such as steel drums, wooden pallets, and crates observed on the sea surface were responsible for the majority of marine litter in certain routes. In terms of the length of observation, the average weight was 0.47 kg/n.m.

B. Seafloor Marine Litter

In the Mediterranean Sea, no more than 15 studies exist (Fig. 7), dedicated on the assessment and accumulation of marine litter on the seafloor by using otter-trawl, with the corresponding cod-end mess size ranging from 10 mm to 15,000 mm. So far, in the Western Mediterranean Sea, the Gulf o

Lions (1993-94: 633-1935 items/km2; 1996: 3900 items/km2; 1996-97: 143 items/km2), the Catalan Coast (2009: 7003±6010 items/km2; 2007-2010: 0.02-3264.6 kg/km2) and the Murcian Coast (4424±3743 items/km2) have been studied (Galgani et al., 1995; Galgani et al., 1996; Galgani et al., 2000; Sanchez et al., 2013; Ramirez-Llodra et al., 2013). In the Central Mediterranean Sea, data on seafloor marine litter exist for the areas of the E. Ionian Sea (2300 items/km2), the Corsica (1993-94: 633-1935 items/km2; 1998: 229 items/km2), the Adriatic Sea (1998: 378 items/km2; 2011-2012: 47.9±23.4-170.6±35.8 kg/km2) Tyrrhenian Sea (2009: 5950 items/km2) (Galgani et al., 1995; Galgani et al., 2000; Sanchez et al., 2013; Misfud et al., 2013; Strafella et al., 2015). The Eastern Mediterranean is the less studied among the three compartments (western, central, eastern Med.). Galil et al. (1995) assessed 200-8,500 items/km2 in several areas in the E. Mediterranean Sea. while more targeted studies have been conducted in the Saronikos Gulf (2013-2014: 1211±594 items/km2) Gulf of Patras (1997-98: 240 items/km2; 2000-2003: 313 items/km2; 2013-2014: 641±579 items/km2), the Gulf of Echinades (1997-98: 89-240 items/km2; 2000-2003: 313 items/km2; 2013-2014: 416±379 items/km2), the Gulfs of Corinth and the Lakonikos Gulf (165 items/km2), the Antalya (115-2,762 items/km2) and the Mersin (0.01-5.85 kg/h) bays (Galil et al., 1995; Stefatos et al., 1999; Koutsodendris et al., 2008; Guven et al., 2013; Eryasar et al., 2014).

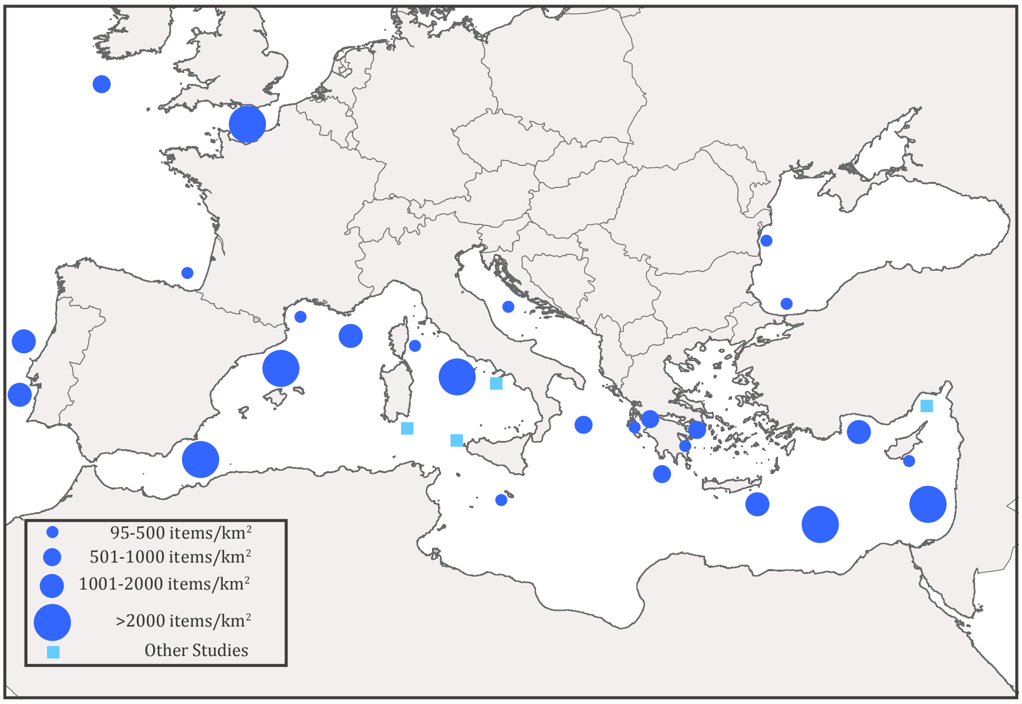

Figure 7: Seafloor marine litter distribution in the Mediterranean and other European Seas (Ioakeimdis, 2015)

Counts from 7 surveys and 295 samples in the Mediterranean Sea and Black Sea (2,500,000 km², worldatlas.com) indicate an average density of 179 plastic items/ km^2 for all compartments, including shelves, slopes, canyons, and deep sea plains, in line with trawl data on 3 sites described by Pham et al., 2014. On the basis of this data, we can assume that approximately 0.5 billion litter items are currently lying on the Mediterranean Sea floor (UNEP/MAP, 2015). \

In the Adriatic and Ionian Seas. within 121 transects (hauls) conducted in the framework of the IPA-Adriatic DeFishGear project, 510 ± 517 items/km^2 were recorded on an aggregated basis at regional level, with the a mean weight per haul found at 65 ± 322 kg/km^2. From the 11 locations the highest density of litter items was found in the North Corfu area (Greece) with the average density being at 1,099 ± 589 items/km^2, followed by the South area of the Western Gulf of Venice with 1,023 ± 616 items/km^2. In terms of weight, the highest quantity of litter was found in the South area of the Gulf of Venice (average density 339 ± 910 kg/km2) (Vlachogianni et al., 2017).

Plastics have been found widespread in the continental shelf of the Mediterranean, exceeding in some areas the 80% of the recorded marine (Table 2).

Table 2: Plastic abundance (%) lying on the seafloor of the Mediterranean Sea

Stydy Area	Plastic (%)	Reference
Gulf of Lions (France)	64-77%	Galgani et al., 1995b; Galgani et al., 2000
Catalanian Provence (Spain)	60%	Sanchez et al.
Murcian Provence (Spain)	84%	Sanchez et al.
Central Med	87%	Sanchez et al., 2013
Corsica (France)	77%	Galgani et al., 1995
Maltese islands	47%	Misfud et al., 2013;
North-Central Adriatic Sea	24-62%	Strafella et al., 2015
Eastern Mediterranean Sea (Italy, Greece, Egypt, Cyprus, Israel).	36%	Galil et al. 1995
Gulf of Patras (Greece)	81%	Stefatos et al. 1999
Echinades Gulf (Greece)	56%,	Koutsodendris et al. 2008
Gulf of Patras (Greece)	60%	Ioakeimidis et al. 2014
Echinades Gulf (Greece)	67%	Ioakeimidis et al. 2014
Antalya (Turhey)	81%	Guven et al., 2013
Mersin (Turkey)	73%	Eryasar et al., 2014
Limassol Gulf (Cyprus)	59%	Ioakeimidis et al. 2014
Saronikos Gulf (Greece)	95%	Ioakeimidis et al. 2014
Argolikos Gulf (Greece)	75%	Ioakeimidis et al., 2015

In a study on 67 sites conducted in the Adriatic Sea using commercial trawl analysis of Marine litter sorted and classified in major categories confirmed that plastic is dominant in terms of concentration by weight, followed by metal (UNEP/MAP, 2015). The highest concentration of litter was found close to the coast, likely as a consequence of high coastal urbanization, river inflow, and extensive navigation. Metals and Glass/Ceramics reached maximum values of 21.9% and of 22.4%, respectively in a study conducted in 4 study areas in the Eastern Mediterranean (Saronikos; Patras and Echinades Gulfs; Limassol Gulf) (Ioakeimidis et al., 2014).

Very limited studies in the Mediterranean have been investigating the presence of seafloor litter in shallow waters. Only one study records marine litter in selected study areas in Greece (Saronikos Gulf, W. Crete, S. Peloponesse, Santorini isl., W. Greece), in depths ranging from the shoreline (0m) till the 25m (Katsanevakis & Katsarou, 2004). In the Saronikos Gulf were recorded 31,660 items/km2 (Plastics: 47%, Metals: 31%), W. Crete 18,944 items/km2 (Plastics: 45%, Metals: 28%), S. Peloponesse 14,025 items/km2 (Plastics: 47%, Metals: 33%), Santorini isl. 9,133 items/km^2 (Plastics: 52%, Metals: 31%).

The first assessment of marine litter in the deep-sea environment of the Mediterranean Sea was conducted back in 1995 by Galgani et al. (1996) in the marine Canyon of Marseille-Nice (1623 items/km2). Nowadays, in the Mediterranean Sea such data exist only for the Western (NW Mediterranean: 1935 items/km^2; French Mediterranean: 3 items/km^2) and the Central Mediterranean Sea (Tyrrhenian Sea: 30,000-120,000 items/km2), while no relevant data exist for the Eastern Mediterranean Sea (Galgani et al., 1996; Galgani et al., 2000; Bo et al., 2014; Fabri et al., 2014; Angiolillo et al., 2015).

The distribution and abundance of large marine litter were investigated on the continental slope and bathyal plain of the northwestern Mediterranean Sea during annual cruises undertaken between 1994 and 2009 (Galgani et al., 2011). Different types of litter were enumerated, particularly pieces of plastic, plastic and glass bottles, metallic objects, glass, and diverse materials including fishing gear.

The results showed considerable geographical variation, with concentrations ranging from 0 to 176 pieces of litter/ha. In most stations sampled, plastic bags accounted for a very high percentage (more than 70%) of total litter. In the Gulf of Lions, only small amounts of litter were collected on the continental shelf. Most of the litter was found in canyons descending from the continental slope and in the bathyal plain, with high amounts occurring to a depth of more than 500 m.

Information regarding the abundance of small plastic particles accumulating in the deep-sea sediments is still very limited. However, plastic particles sized in the micrometer range have been found in deep-sea sediments ranging from 1000 to 5000m depth (Van Cauwenberghe et al., 2013; Woodall et al., 2014).

CONCLUSIONS

Conclusions (brief)

Plastic is the main component of floating marine litter and also for those lying on the Mediterranean seafloor, from shallow water, the continental shelf, till the deep abyssal plains. Regarding marine litter (floating and on seafloor) that are accumulating in the Mediterranean basin, no safe conclusion can be drawn for the moment. Probably hydrodynamics and geomorphology favor the constant circulation. More consistent, interconnected and interlinked studies need to be promoted in order to have a better picture at basin scale. The comparability of the existing and future studies seems to be a key point towards an integrated assessment at basin scale. The Mediterranean Sea is heavily impacted by floating marine litter items, giving concentrations comparable to those found in the 5 sub-tropical gyres. Moreover, the seafloor seems to be the final global sink for most marine litter items with densities ranging from 0 to over 7,700 items per km². The deep-sea canyons are of particular concern as they may act as a conduit for the transport of marine litter into the deep sea. As in any other marine litter cases, the human activities (fishing, urban development, and tourism) are primarily responsible for the increased abundance of marine litter items in the Mediterranean Sea.

Conclusions (extended)

Marine litter and mainly plastics are present in the Mediterranean basin from the shallow water, the continental shelf, till the abyssal plains, in all different sea compartments and basins and thus, posing an important problem for the marine environment. Unfortunately so far, we do not have a clear picture regarding the areas in the Mediterranean where the accumulation of marine litter and plastics is significant although several ongoing studies try to give a clearer picture. The Eastern Mediterranean is certainly the least studied of the three compartments (western, central, eastern).

The Mediterranean Sea is very peculiar as there are no areas where marine litter permanently accumulate. Instead, the constant circulation is favored. The picture is fragmented as only through nonrecurring studies information becomes available and this is not enough to drawn safe results or even to partially assess the situation. In addition information on floating and seafloor marine litter is only available for the northern part of the Mediterranean Sea. The combination of the last two points makes the assessment of floating and seafloor marine litter in regional scale almost impossible.

A. Floating Marine Litter

Once floating litter has entered into the marine environment, the hydrographic characteristics of the basin may play an important role in its transport, accumulation, and distribution. Atlantic surface waters enter the Mediterranean Sea through the strait of Gibraltar and circulate anticlockwise in the whole Algero-Provencal Basin, forming the so-called Algerian Current, which flows until the Channel of Sardinia and most often leads to the generation of a series of anticyclonic eddies 50–100 km in diameter wandering in the middle basin (UNEP/MAP, 2015). Despite not being permanent, these mesoscale features could act as retention zones for floating litter and would help explain the high litter densities found in the central Algerian basin at around 80 nautical miles from the nearest shore. For the southern Adriatic Sea, it should be noticed that about one-third of the total mean annual river discharge into the whole Mediterranean basin flows into this basin, particularly from the Po River in the northern basin and the Albanian rivers (UNEP, 2012).

The highest densities found in the Adriatic Sea and along the North-western African coast are related to some of the heaviest densities in coastal population of the entire Mediterranean basin (UNEP/MAP 2015). The Adriatic Sea has more than 3.5 million people along its shores, which along with fisheries and tourism seems to be the most significant sources for floating marine litter in the region. In addition the significant cyclonic gyres which are found in the central and southern Adriatic Sea (Suaria and Aliani, 2014), are favoring the retention of floating marine litter in the middle of the basin. This is also the Case in the Northeastern part of the Aegean Sea, where densities of floating litter are higher due to circulating waters and Black sea/Mediterranean sea water exchanges.

Coastal population is an important aspect also for the North African countries in particular also have the highest rates of growth in coastal population densities, including touristic densities. Algeria, for instance, has a coastal population that has increased by 112% in the last 30 years, and it currently represents one of the most densely populated coastlines in the whole basin (UNEP, 2009). In addition, it should be noted that in some countries appropriate recycling facilities have not been fully implemented yet, and the cost of proper solid waste disposal is still often beyond their financial capacity (UNEP, 2009). Suaria and Aliani (2014), demonstrated that 78% of all sighted objects were of anthropogenic origin, 95.6% of which were petrochemical derivatives (i.e. plastic and Styrofoam). The authors then evaluated the number of macro-litter items currently floating on the surface of the whole Mediterranean basin to be more than 62 million.

As for anthropogenic litter accumulating in oceans gyres and convergence zones, the existence of Floating Marine Litter accumulation zones is a stimulating hypothesis, as their presence was supported recently (Mansui et al., 2015). The existence of one or more ‘‘Mediterranean Garbage Patches’’ should be investigated in more detail, as there are no permanent hydrodynamic structures in the Mediterranean Sea where local drivers may have a greater effect on litter distribution (CIESM, 2014).

B. Seafloor Marine Litter

The deep-sea floor is probably the final global sink for most marine litter and there are several areas in the Mediterranean for which marine litter have been recorded in densities exceeding 1000 items/km^2 (i.e. Gulf of Lions, Catalan Coast, Murcian Coast, Corsica, Saronikos Gulf, Antalya Coast). However, long-term data is scarce for the Mediterranean Sea. Density of litter collected on the sea floor between 1994 and 2014 in the Gulf of Lion (France), does not clearly show any significant trends with regards to variations in marine litter quantities (Galgani, 2015). In another example in Greece (Gulf of Patras, Echinades Gulf) albeit the increase of marine litter abundance plastic percentage seems to remain stable over the years. In much deeper marine environments, Galgani et al. (2000) observed decreasing trends in deep sea pollution over time off the European coast, with extremely variable distribution and litter aggregation in submarine canyons.

The abundance of plastic litter is very location-dependent, with mean values ranging from 0 to over 7,700 items per km^2. Mediterranean sites tend to show the highest densities, due to the combination of a populated coastline, coastal shipping, limited tidal flows, and a closed basin with exchanges limited to Gibraltar. In general, bottom litter tends to become trapped in areas with low circulation, where sediments accumulate.

Only a few studies have focused on litter located at depths of over 500 m in the Mediterranean (Galil, 1995; Galgani et al., 1996, 2000, 2004; Pham et al., 2014; Ramirez-Llodra et al., 2013). Submarine canyons may act as a conduit for the transport of marine litter into the deep sea. Higher bottom densities are also found in particular areas, such as around rocks and wrecks, and in depressions and channels. In some areas, local water movements carry litter away from the coast to accumulate in high sedimentation zones. The distal deltas of rivers may also fan out into deeper waters, creating high accumulation areas.

A wide variety of human activities, such as fishing, urban development, and tourism, contribute to these patterns of seabed litter distribution. Fishing litter, including ghost nets, prevails in commercial fishing zones and can constitute a considerable share of total litter. It has been estimated that 640,000 tons of ghost nets are scattered overall in the world oceans, representing 10% of all marine litter (UNEP, 2009). More generally, accumulation trends in the deep sea are of particular concern, as plastic longevity increases in deep waters and most polymers degrade slowly in areas devoid of light and with lower oxygen content.

Key messages

The abundance of floating litter in Mediterranean waters has been reported at quantities measuring over 2 cm range from 0 to over 600 items per square kilometer (Aliani et al., 2003; UNEP, 2009; Topcu et al., 2010, Gerigny et al., 2011, Suaria and Aliani, 2015). The 2015 UN Environment / Mediterranean Action Plan Marine Litter Assessment report states that approximately 0.5 billion litter items are currently lying on the Mediterranean Seafloor. Moreover, there is great variability in the abundance of seafloor marine litter items ranging from from 0 to over 7,700 items per km² depending on the study area.
However, the information on floating and seafloor marine litter in the Mediterranean is fragmented and is spatially restricted mainly to its northern part. To this extent, no basin-scale conclusions can be exerted and information is only available at local level. However there are many areas with significant marine litter densities, ranging from 0 to over 7,700 items per km² depending on the study area. Plastic is the major marine litter component, found widespread in the continental shelf of the Mediterranean, ranging up to 80% and 90% of the recorded marine litter items.

Knowledge gaps (brief)

Research and monitoring have become critical for the Mediterranean Sea, where information is inconsistent. UNEP/MAP-MED POL (2013), MSFD (Galgani et al., 2011), the European project STAGES (http://www.stagesproject.eu), and CIESM (2014) recently reviewed the gaps and research needs of knowledge, monitoring, and management of marine litter. This requires scientific cooperation among the parties involved prior to reduction measures due to complexity of issues.

Accumulation rates vary widely in the Mediterranean Sea and are subject to factors such as adjacent urban activities, shore and coastal uses, winds, currents, and accumulation areas. Additional basic information is still required before an accurate global litter assessment can be provided. Moreover the available data are geographically restricted in the northern part of the Mediterranean Sea.

For this, more valuable and comparable data could be obtained by standardizing our approaches. In terms of distribution and quantities, identification (size, type, possible impact), evaluation of accumulation areas (closed bays, gyres, canyons, and specific deep sea zones), and detection of litter sources (rivers, diffuse inputs), are the necessary steps that would enable the development of GIS and mapping systems to locate hotspots.

An important aspect of litter research to be established is the evaluation of links between hydrodynamic factors. This will give a better understanding of transport dynamics and accumulation zones. Further development and improvement of modelling tools must be considered for the evaluation and identification of both the sources and fate of litter in the marine environment. Comprehensive models should define source regions of interest and accumulation zones, and backtrack simulations should be initiated at those locations where monitoring data are collected.

For monitoring, there is often a lack of information needed to determine the optimum sampling strategy and required number of replicates in time and space. Moreover, the comparability of available data remains highly restricted, especially with respect to different size class categories, sampling procedures, and reference values.

Data on floating and seafloor marine litter are inconsistent and geographically restricted in only few areas of the Mediterranean Sea. In addition to that, the lack on long-term assessment data makes the assessment of trends of the years extremely difficult. Sources needs also to be further specified and linked to macro- and micro-litter contribution. Moreover, monitoring and assessment of marine litter should be done in a consistent way, based on common protocols and standardized methods, leading to comparable results at basin scale. Effective management practices are also missing, requiring strong policy will and societal engagement. Further work should also be promoted towards identifying marine litter sources more precisely. Cooperation and collaboration between the major marine litter partners in the region with common priority actions is also considered important.

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Annex I
List of Case Studies for the Ecological Objectives 9 (Contaminants), 5 (Eutrophication) and 10 (Marine Litter)

The Annex I provides the list of Case Studies that have been submitted by Contracting Parties and Partners for the Ecological Objectives 9 (Contaminants), 5 (Eutrophication) and 10 (Marine Litter). **The Case Studies are in the process of editing.**

EO5	**Title**	**Contracting Parties, Partners**	**Authors and Affiliation**
1	Long-term variability along a trophic gradient in the North Adriatic Sea	Croatia Italy	M. Chaves Montero, M. Lipizer, A. Giorgetti, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS (Italy) Robert Precali, Tamara Djakovac, Cener for Marine Research, Rudjer Boskovic Institut (Croatia)
2	Overview of the assessment of pollution related indicators - EO9 Common Indicators with link to the EO5, based on results of CAMP Montenegro assessments and EcAp/MSP Boka Kotorska Bay pilot project	Montenegro	Jelena Knežević, MAP FP, Ministry of Sustainable Development and Tourism, Ivana Stojanović, assistant to MAP FP, Ministry of Sustainable Development and Tourism, Ivana Bulatović, MEDPOL FP, Environmental Protection Agency
3	Eutrophication Status of the Turkish Mediterranean Coastal Waters and Trend Analysis of the Eutrophication-Related Parameters in the Mersin Bay	Turkey	Süleyman Tuğrul, Koray Özhan, İsmail Akçay, Middle East Technical University-Institute of Marine Sciences, Çolpan Polat Beken, TUBITAK Marmara Research Center, Hacer SELAMOĞLU ÇAĞLAYAN, Ministry of Environment and Urbanization of Turkey
EO9	**Title**	**Contracting Parties, Partners**	**Authors and Affiliation**
1	Surveillance de la qualité des eaux de baignade des plages du Marco	Morocco	Laboratoire National des Etudes et de Surveillance de la Pollution relevant du Secrétariat d’Etat chargé du Développement Durable en collaboration avec la Direction des Ports et du Domaine Publics Maritime relevant du Ministère de l’Equipement, du Transport, de la Logistique et de l’Eau ; avec l’appui de la Fondation Mohammed VI pour la Protection de l’Environnement
2	Case Study title: Overview of the assessment of pollution related indicators - EO9 Common Indicators with link to the EO5, based on results of CAMP Montenegro assessments and EcAp/MSP Boka Kotorska Bay pilot project	Montenegro	Jelena Knežević, MAP FP, Ministry of Sustainable Development and Tourism; Ivana Stojanović, assistant to MAP FP, Ministry of Sustainable Development and Tourism; Ivana Bulatović, MEDPOL FP, Environmental Protection Agency
3	Levels and trends of Cd and Zn bioaccumulation in Israeli Mediterranean coastal marine mollusks (Patella sp.)	Israel	Prof. Barak Herut, PhD, Israel Oceanographic and Limnological Research Institute (IOLR) Jack Silverman, PhD, Israel Oceanographic and Limnological Research Institute (IOLR) Shefer Edna, PhD, Israel Oceanographic and Limnological Research Institute (IOLR)

			Dror Zurel, PhD, Marine Monitoring and research Coordinator, Israel Ministry of Environmental Protection, Marine Environment Protection Division
4	Levels and trends of TriButyltin (TBT) in Israeli ports and marinas	Israel	Prof. Barak Herut, PhD, Israel Oceanographic and Limnological Research Institute (IOLR) Dror Zurel, PhD, Marine Monitoring and research Coordinator, Israel Ministry of Environmental Protection, Marine Environment Protection Division.
EO 10	**Title**	**Contracting Parties, Partners**	**Authors and Affiliation**
1	Coordinated and harmonized pilot surveys to assess marine litter along the Adriatic and Ionian coasts	Albania Bosnia and Herzegovina Croatia Greece Italy Montenegro Slovenia MIO-ECSDE	MIO-ECSDE, Agricultural University of Tirana (Albania), Hydro-Engineering Institute of the Faculty of Civil Engineering (Bosnia and Herzegovina), Institute of Oceanography and Fisheries Croatia), Hellenic Centre for Marine Research (Greece), Regional Agency for Environmental Protection in the Emilia-Romagna region (Italy), Italian National Institute for Environmental Protection and Research (Italy), Institute of Marine Biology (Montenegro), Institute for Water of the Republic of Slovenia (Slovenia)
2	Déchets marins benthiques en Mer Méditerranée : quantités à l'échelle régionale et variation temporelle des tendances dans le bassin nord occidental	France Italy	O. Gerigny, Institut Français de Recherche pour l'Exploitation de la Mer, France, M.Spedicato, COISPA Tecnologia & Ricerca, Bari, Italy, MEDITS coordinator, A.Jadaud, Institut Français de Recherche pour l'Exploitation de la Mer, France, C.Ioakeimidis, UN Environment/Mediterranean Action Plan MED POL, Athens, Francois Galgani, Institut Français de Recherche pour l'Exploitation de la Mer, France
3	Marine Litter Fluctuations at the Metu Beach, Mersin Bay (Turkey), the Northeastern Mediterranean during 2013-2017	Turkey	Olgaç Güven, Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey, Ahmet Erkan Kideys, Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey, Kerem Gökdağ, Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey
4	Microplastic Pollution on the Sea Surface, Water Column and Sediment of Mersin Bay (Turkey), in the Northeastern Mediterranean	Turkey	Ahmet Erkan Kideys, Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey, Olgaç Güven, Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey, Kerem Gökdağ, Institute of Marine Sciences, Middle East Technical University, Erdemli, Mersin, Turkey, Çolpan Polat Beken, TUBITAK Marmara Research Center,

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