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Agenda Item 6: Technical Guiding Elements on IMAP Implementation: Assessment Criteria and Scales, Thresholds, Baseline Values

Analysis of the Assessment Criteria related to Trace Elements (TEs), Organic Contaminants and Biomarkers as established by Decision IG.23/6 (COP 20, 2017), along with Analysis of Data Availability for their Upgrade

UNEP/MAP
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List of Abbreviations / Acronyms

ADR	Adriatic Sea sub-region
AEL	Aegean and Levantine Seas sub-region
AF	Assessment factor
AVS	Acid Volatile Sulphide
B	Biota
BDL	Below Detection Limit
CEN	Central Mediterranean Sea sub-region
CHASE	Chemical Status Assessment Tool
CI	Common Indicator
CORMON	Correspondence Group on Monitoring
COP	Conference of the Parties
CR	Contamination Ratio
CS	Contamination Score
BC	Background Concentration
BAC	Background Assessment Concentrations
CEN	Central Mediterranean Sea sub-region
CI	Common Indicator
CORMON	Correspondence Group on Monitoring
COP	Conference of the Parties
CRM	Certified Reference Material
DW	Dry weight
EAC	Environmental Assessment Criteria
EC	European Union Regulations
EMODnet	European Marine Observation and Data Network
EO	Ecological Objective
EqP	Equilibrium partitioning
EQS	Environmental Quality Standard
ERL	Effects Range Low
ERM	Effects Range Medium
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GES	Good Environmental Status
HCB	Hexachlorobenzene
HH	Human Health
IMAP	Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria
MAP	Mediterranean Action Plan
MED	Mediterranean
MB	*Mullus barbatus*
MED POL	Programme for the Assessment and Control of Marine Pollution in the Mediterranean Sea
MG	*Mytilus galloprovincialis*
MSFD	Marine Strategy Framework Directive
NEAT	Nested Environmental Status Assessment Tool
NOAA	National Oceanic and Atmospheric Administration
NOAC	No Observed Effect Concentration
NPA	Non Problem Area
OOAO	One Out All Out
OSPAR	Convention for the Protection of the Marine Environment for the North- East Atlantic
OWG	Online Working Group
PA	Problem Area
PAHs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl

PHS	Priority Hazardous Substances
PS	Priority Substances
QS	Quality Standard
QSR	Quality Status Report
S	Sediment
SAU	Spatial Assessment Units
Secpois	Secondary Poisoning
SoED	State of Environment and Development Report
TM	Trace metals
TOC	Total Organic Carbon
UNEP	United Nations Environmental Program
USEPA	United States Environmental Protection Agency
WFD	Water Framework Directive
WHO	World Health Organization
WMS	Western Mediterranean Sea sub-region
WW	Wet weight

1 Introduction

The criteria established by Decisions IG.22/7 (COP 19)[1] and IG. 23/6 (COP 20)[2] are reviewed in Section 2 of present document, whereas Section 3 provides an in-depth analysis of the data available for present upgrade of the assessment criteria. New upgraded regional and sub-regional Mediterranean BC and BAC values for CI17, as well as a proposal of the criteria for IMAP CI20 are presented in Section 4. This section also proposes an approach to upgrade the Mediterranean EACs.

Considering new data availability (see Section 3), present upgrade of the assessment criteria may be summarized as follows:

- CI17: Updated BC values are proposed for the whole Mediterranean and sub-regions by using new data and the same methodology used in 2016. This work also follows on initial calculation of the sub-regional values undertaken in 2019 for the purpose of preparation of 2019 SoED.
- CI17: Updated BAC values are proposed for the whole Mediterranean and sub-regions further to updated BC values. Updated BC/BAC values will serve as a basis for GES assessment, that will preferably be based on combined application of CHASE+ and the NEAT methodologies (Anon 2019, Pavlidou et al. 2019)
- CI17 and CI18: EAC values cannot be updated based on existing monitoring data. This endeavor requires a very specific in-depth research of the ecotoxicological and environmental scientific literature. This research is expected to be useful for updating EACs for CI18 as well.
- CI17 and CI 18: Further work aimed at defining an optimal combination of CHASE+ and the NEAT methodologies will take place in 2021 as to deliver pilot GES assessments for the two sub-regions towards preparation of 2023 Mediterranean Quality Status Report. CHASE+ can be used to calculate contamination ratios and contamination scores, while NEAT applies such calculated ratios/scores on defined spatial assessment units (SAU) and habitats. EAC`s definition should be adjusted towards a more unified criteria for environmental status assessment (e.g. initial steps in NEAT or CHASE+).
- CI 18: Currently there are no new data to update the assessment criteria for biomarkers.
- CI20: New assessment criteria are proposed.

The data used for developing updated assessment criteria were collected in the IMAP Pilot Info System during its testing phase, and in particular after launching a formal call for reporting of monitoring data in June 2020, as well as monitoring data stored in MEDPOL database that have not been previously used for calculation of the assessment criteria applied in the 2017 and 2019 assessments. It also took into account data from EU data center (European Marine Observation and Data Network - EMODnet), as a reliable external data source, as well as data collected from the scientific literature. A detailed compilation of the available new data is given in Section 3.

2 The assessment criteria for IMAP Common Indicators 17 and 18

Deriving and setting up criteria to determine environmental status is not an easy task. It gets more complicated going from the local to sub-regional and regional assessments. While there are many methodologies to derive criteria, the first step is aimed at defining the background or reference conditions from which to measure/determine the status and trends. In the framework of UNEP/MAP (UNEP/MAP 2016, 2019), the background concentration (BC) is defined as “The concentration of a contaminant at a “pristine” or “remote” site based on contemporary or historical data”. The BC of anthropogenic (man-made) substance was defined as zero.-Similar definitions are used by OSPAR and the Marine Strategy Framework Directive (MSFD) based on the Water Framework Directive (WFD) (Tornero et al. 2019).

In line with these definitions, the BC determination is the first step of the derivation of indicators that are defined as the measure, index or model used to estimate the current state and future trends, along with thresholds for possible management action.

[1] UNEP/MAP (2015). Decision IG.22/7 on Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria (Annex II), (COP 19, 2015).
[2] UNEP/MAP (2017). Decision IG.23/6 on Mediterranean Quality Status Report (COP20, 2017).

2.1 Methodology for background concentration (BC) determination

Several methods can be used to derive BC values for natural occurring elements/substances in different environmental matrices (i.e. sediment and biota). Among the relevant methods there are the following:

- Use of global averages concentrations (Turekian and Wedepohl 1961) that is applicable only to metals in sediments.
- Use of pre-industrial age data that is applicable to metals and PAHs in sediments. The BC can be derived from historical data, usually lacking or from data from dated sediment cores[3]. BCs derived by this method should be compared to BCs derived from data from undisturbed sites and to BCs derived from data from monitoring programs.
- Use of current data from a "pristine'/undisturbed site (or a site with very minor disturbance)" with proper statistical analysis that is applicable to metals and organic contaminants in sediments and biota, biomarkers in biota. In this methodology, the data used should not exhibit a temporal trend in the concentrations.
- Use data from monitoring programs, excluding known polluted sites where BC should be determined in conjunction with rigorous statistical analysis to eliminate outliers along with xpert judgement. It is applicable to metals and organic contaminants in sediments and biota, biomarkers in biota.

2.2 The methodology for the determination of Background concentration (BC) used by UNEP/MAP

The BCs were derived using the following two methodologies: i) data from sediment cores compiled from the scientific literature (UNEP/MAP 2011)[4] and ii) data from the MEDPOL database (UNEP/MAP 2011, 2016, 2019). The specific methodologies used by UNEP/MAP for the different parameters are described in sections 2.2.1-2.2.4

2.2.1 Trace Metals (Cd, Hg and Pb) in sediments

The approved BCs for Trace Metals (TM) in sediments are summarized in Table 1. The BCs were derived using the following two methodologies: i) data from sediment cores compiled from the scientific literature (UNEP/MAP 2011)5 and ii) data from the MEDPOL database (UNEP/MAP 2011, 2016, 2019).

Data from sediment cores: Published data for concentrations found in sediment cores collected in the Mediterranean Sea were compiled and organized by geographical area. The median for each area was computed, and the median of the geographical medians taken as the BC. Although data from 32 sediment cores were compiled, most of them did not include all three TM (Cd, Hg and Pb) and the BCs were computed based on fewer data points (Table 4 in the report UNEP/MAP 2011).

Data from MEDPOL data base: The concentrations measured from surficial sediments were used to determine BC in two similar ways. In 2011 known polluted sites were excluded and the data aggregated based on geographical area. The median was calculated for each area based on the lowest 5^{th} percentile of the data and the median of the area medians taken as the BC (UNEP/MAP 2011). In 2016, the first step was to examine the database in order to choose the stations to be considered as reference at a country level. The complete detailed methodology is provided in the report UNEP/MAP (2016). Briefly, the first step was to choose the stations to be considered as reference at a country level. For each country, each parameter was grouped by year and the years without temporal trend chosen. Next, the parameters were grouped by stations and the overall median value computed. Stations where the 75^{th} percentile of the data were below the overall median were chosen as reference stations. Data of the reference stations were aggregated for the whole Mediterranean Sea and the MedBC computed as the median value of all reference stations. In 2019, BC values were computed in

[3] Caution is recommended while setting BC for PAHs from sediment cores data due to selective degradation of the different compounds.
[4] UNEP/MAP (2011). UNEP(DEPI)/MED WG365/Inf.8. Development of assessment criteria for hazardous substances in the Mediterranean.
[5] UNEP/MAP (2011). UNEP(DEPI)/MED WG365/Inf.8. Development of assessment criteria for hazardous substances in the Mediterranean.

a similar way for 3 out of the 4 Mediterranean sub-regions[6]: Western Mediterranean (WMS), Adriatic Sea (ADR) and Aegean-Levantine Seas (AEL)[7]. No data were available to calculate BC for the Central Mediterranean (CEN). It was recommended to normalize the concentrations to Al (5%) concentrations[8] (See Section 2.2.5).

Table 1. Background concentrations (BC) and Background assessment concentrations (BAC) calculated for trace metals (TM) in sediments for the Mediterranean Sea and sub-regions in 2011 and 2019[9]. The table also presents the MedBAC and MedEAC values agreed upon in Decisions IG.22/7 and IG.23/6. Concentrations are given in µg/kg dry wt, as requested by IMAP[10].

	Decisions IG.22/7 and IG.23/6 (COP 19 and COP 20)			UNEP/MAP (2011)		UNEP/MAP (2019)			
	MedBAC	MedBAC	MedEAC*	Med BC	Med BC	Med BC	BC	BC	BC
TM	IG.22/7	IG.23/6	IG.23/6	Sed cores	Surf Sed	Ref Stn	WMS	ADR	AEL
Cd	150	127.5	1200	100	20	85	91.2	92.3	56
Hg	45	79.5	150	30	10	53	60	106.8	31.2
Pb	30000	25425	46700	20000	2310	16950	20465	13932	4920

* ERL (Effects Range Low, Long et al. 1995, idem OSPAR values). Sediment (Sed); Surficial (Surf); Reference stations (Ref Stn); Western Mediterranean (WMS); Adriatic (ADR) Aegean; Levantine Sea (AEL). No data were available to set up BCs for the Central Mediterranean (CEN).

For comparison, BACs for trace elements in sediments used by OSPAR[11] are 310, 70 and 38000 µg/kg for Cd, Hg and Pb, respectively

Further to this work, present document (Section 4) provides updated BC and BAC values for TM in sediments. They were calculated by using the new data and the same methodologies as applied in 2016 and 2019

2.2.2 Naturally occurring organic compounds (PAHs) in sediment

MedBC values for PAHs in sediments are summarized in Table 2. The BCs were computed based on data derived from sediment cores compiled from the scientific literature, as well as data available in MEDPOL database (UNEP/MAP 2011). Normalization of organic compounds concentrations to total organic carbon (TOC) (2.5%) was recommended (See Section 2.2.5).

Table 2. Background concentrations (BC) calculated for PAHs in sediments for the Mediterranean Sea in 2011. The table also presents the MedEAC values agreed upon in Decisions IG.22/7 and IG.23/6. Concentrations are given in µg/kg dry wt, as requested by IMAP.

	Decisions (COP 19 and COP 20)	UNEP/MAP (2011)	
PAH compounds	EAC* IG.22/7 and IG.23/6	BC Sed cores	BC Sur sed
Naphthalene (N)		4	
Acenaphthylene (ACY)		0.5	1.05
Acenaphtene (ACE)		0.38	0.45
Fluorene (F)		0.75	0.33
Phenanthrene (P)	240	4.55	3.95
Anthracene (A)	85	0.8	1.56
Fluoranthene (FL)	600	5.6	6.7
Pyrene (PY)	665	10.28	2.1

[6]Although sub-regional values for the BCs in sediment were proposed, an updated 2019 assessment used the ones calculated in 2016, awaiting further confirmation of sub-regional values when new reference datasets will be available, whilst for mussels the proposed sub-regional values of BCs were exercised.
[7] The Mediterranean sub-regions and subareas are initially proposed according to availability of database sources for calculation of the assessment criteria (UNEP(DEPI)/MED WG.427/Inf.3; UNEP/MED WG.463/8; UNEP/MED WG.467/7).

[9] ~~For comparison, BACs used by OSPAR are 310, 70 and 38000 mg/kg for Cd, Hg and Pb, respectively.~~
[10]UNEP/MED WG.467/5. IMAP Guidance Factsheets: Update for Common Indicators 13, 14, 17, 18, 20 and 21: New proposal for candidate indicators 26 and 27; UNEP/MED WG.467/8. Data Standards and Data Dictionaries for Common Indicators related to Pollution and Marine Litter.
[11] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/

PAH compounds	Decisions (COP 19 and COP 20) EAC* IG.22/7 and IG.23/6	UNEP/MAP (2011) BC Sed cores	BC Sur sed
Benzo[a]anthracene (BaA)	261	3.45	1.28
Chrysene (C)	384	1.3	6.64
Benzo(b)fluoranthene (BbF)		1.1	8.32
Benzo(k)fluoranthene (BkF)		0.53	6.03
Benzo[a]pyrene (BaP)	430	2.55	3.71
Benzo[g.h,i]perylene (GHI)		1.25	3.25
Dibenzo[a,h]anthracene (DA)	63.4	0.18	1.37
Indeno[1,2,3,c,d]pyrene (ID)		1.7	4.49

* ERL. ERL for Naphthalene (160 µg/kg dw) and Total PAHs (4022 µg/kg dw) were derived by Long et al., 1995, but they do not appear in the COPs decisions

For comparison, BAC for PAHs in sediments used by OSPAR[12], in units of µg/kg dw are: 8 (naphthalene), 7.3 (phenanthrene), 1.8 (anthracene), 14.4 (fluoranthene), 11.3 (pyrene), 7.1 (benzo[a]anthracene), 8 (chrysene), 8.2 (benzo[a]pyrene), 6.9 (benzo[g.h,i]perylene) and 8.3 (indeno[1,2,3,c,d]pyrene).

Further to this work, present document (Section 4) provides updated BC and BAC values for PAHs in sediment. They were calculated by using the new data and the same methodologies as applied in 2016 and 2019 for trace metals.

2.2.3 Naturally occurring trace metals (Cd, Hg and Pb) and organic compounds (PAHs) in biota[13]

Unlike the sediments, there are no values of the pristine, pre-industrial concentrations of naturally occurring compounds in biota. In 2011, the BC concentrations were computed based on the whole MEDPOL database (excluding known polluted stations), as the median of the lower 5% of the data. In 2016 and 2019, the BC concentrations were computed as for trace metals in sediments, based on the data sets from the selected reference stations. The calculated BC values for TM are presented in Table 3 for mussel and fish. The calculated BCs for PAHs in mussel are presented in Table 4. It should be emphasized that BC concentrations are species specific as well as tissue specific (i.e. natural concentrations in muscle are different from the natural concentrations in liver). In addition, BC concentration may depend on age of the specimens, with length and weight usually used as a proxy to age (See section 2.2.5).

Table 3. Background concentrations (BC) calculated for trace metals in mussel and fish for the Mediterranean Sea and sub-regions in 2016 and 2019. The table also present the MedBAC and MedEAC values agreed upon in Decisions IG.22/7 and IG.23/6. Concentrations are given in the units requested by IMAP.

TM	Decisions (COP 19 and COP 20)			UNEP/MAP (2019)			
	MedBAC IG.22/7	MedBAC IG.23/6	#MedEAC IG.23/6	BC Med	BC WMS	BC ADR	BC AEL
Mussel soft tissue (*Mytilus galloprovincialis*), µg/kg dry wt							
Cd	1088	1095	5000	730	660.5	782	942
Hg	188	173.2	2500	115.5	109.4	126	110
Pb	3800	2313	7500	1542	1585	1381	2300
Fish muscle (*Mullus barbatus*) µg/kg wet wt							
Cd	16**	*3.7	50	*3.7			
Hg	600**	101.2	1000	50.6	68	150.5	44.6
Pb	359**	*31	300	*31	38		20

* Most values below detection limit, ** Concentrations in µg/kg dry wt as given in Decision IG. 22/7. # EACs are the ECs, the maximum levels for certain contaminants in foodstuffs based on European policy (EC/EU 1881/2006, 1259/2011 Directives and amendments 488/2014 and 1005/2015). Western Mediterranean (WMS); Adriatic (ADR) Aegean; Levantine Sea (AEL). No data were available to set up BCs for the Central Mediterranean (CEN)

12 https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/

13 The mussel *Mytilus galloprovinciallis* (MG) and the fish *Mullus barbatus* (MB), the agreed mandatory species for monitoring

Table 4. Background concentrations (BC) calculated for PAHs in mussel (*Mytilus galloprovincialis*) soft tissue for the Mediterranean Sea and sub-regions in 2016 and 2019. The table also present the MedBAC and EAC values agreed upon in Decisions IG.22/7 and IG.23/6. Concentrations are given in µg/kg dry wt, as requested by IMAP. In red, sub-regional BCs higher than regional MedBC.

PAH compounds	Decisions (COP 19 and COP 20)		UNEP/MAP (2019)			
	MedBAC	EAC*	BC	BC	BC	BC
	IG.23/6	IG.22/7 and IG.23/6	Med	WMS	ADR	AEL
Naphthalene			(2.4) #	2.24		2.80
Acenaphthylene			(0.6) #			
Acenaphtene			(0.6) #			
Fluorene	2.5		1.0	0.96	1.07	0.60
Phenanthrene	17.8	1700	7.1	4.93	9.04	7.55
Anthracene	1.2	290	0.5	0.52	0.38	0.30
Fluoranthene	7.4	110	3.0	3.38	2.03	6.60
Pyrene	5.0	100	2.0	3.02	0.85	5.90
Benzo[a]anthracene	1.9	80	0.8	1.20	0.53	1.60
Chrysene	2.4		1.0	1.24	0.27	5.20
Benzo(k)fluoranthene	1.4	260	0.6	1.27	0.29	1.50
Benzo[a]pyrene	1.2	600	0.5	0.60	0.32	0.70
Benzo[g.h,i]perylene	2.3	110	0.9	0.90		1.20
Dibenzo[a,h]anthracene	1.3		0.5	0.53		
Indeno[1,2,3,c,d]pyrene	2.9		1.2	1.23		0.90

* EC, maximum levels for certain contaminants in foodstuffs based on European policy (EC/EU 1881/2006, 1259/2011 Directives and amendments 488/2014 and 1005/2015). # most data below detection limit. In red, sub-regional BC values higher than MedBAC (MedBAC= 1.5 MedBC, see Section 2.3.1)

For comparison, BACs for trace elements used by OSPAR[14] are: in mussel - 960, 90 and 1300 µg/kg dw for Cd, Hg and Pb, respectively; in oyster 3000, 180 and 1300 µg/kg dw for Cd, Hg and Pb, respectively; Hg in fish muscle 35 µg/kg ww; and 26 µg/kg ww for both Cd and Pb in fish liver. OSPAR BACs for PAHs in mussel and oyster are as follows in units of µg/kg dw: 11.0 (phenanthrene), 12.2 (fluoranthene), 9.0 (pyrene), 2.5 (benzo[a]anthracene), 8.1 (chrysene), 1.4 (benzo[a]pyrene), 2.5 (benzo[g.h,i]perylene) and 2.4 (indeno[1,2,3,c,d]pyrene).

Further to this work, present document (Section 4) provides updated BC and BAC values for TM in biota and PAHs in mussel. They were calculated using the new data and the same methodologies as applied in 2016 and 2019.

2.2.4 Synthetic substances (non-naturally occurring) in sediments and biota

The BC of any anthropogenic (man-made) substance is defined as zero. However, analytically, it is impossible to measure a concentration that equals zero. Therefore, the BC determination is based on the detection limits of the methods used and its uncertainty (precision and accuracy), as determined from CRMs (Certified reference materials) and proficiency testing. IMAP addresses organochlorinated compounds (PCBs and pesticides) as detailed in Table 5. This table summarizes the EAC values for the Mediterranean, agreed upon in Decisions IG.22/7 (COP19) and IG.23/6 (COP20). No BC nor LC (Low concentrations) were calculated for the Mediterranean in 2016 nor in 2019 (UNEP/MAP, 2016, 2019).

Table 5. EAC values for organochlorinated contaminants in sediments, in mussel (*Mytilus galloprovincialis*) soft tissue and muscle tissue in fish (*Mullus barbatus*) to be used in the Mediterranean Sea. The values were agreed

[14] https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/

upon in Decisions IG.22/7 and IG.23/6 and follow OSPAR's recommendations. Concentrations are given in the units requested by IMAP.

	Sediments		Mussel	Fish
	EAC* IG.22/7(µg/kg dw)	MedEAC* IG.23/6(µg/kg dw)	EAC IG.22/7 and IG.23/6 (µg/kg dw)	EAC IG.22/7 and IG.23/6 (µg/kg lipid)
PCBs				
CB28		1.7	3.2	64
CB52		2.7	5.4	108
CB101		3	6	120
CB118		0.6	1.2	24
CB138		7.9	15.8	316
CB153		40	80	1600
CB156				
CB180		12	24	480
Sum 7 PCBs	11.5			
Pesticides				
γ-HCH (Lindane)	3		1.45	11 µg/kg ww
DDE(p,p')	2.2		5-50	
Hexachlorobenzene	20			
Dieldrin	2		5-50	

* ERL (Effects Range Low, Long et al. 1995, idem OSPAR values).

Further to this work, present document (Section 4) shows that the data were not sufficient to provide BC and BAC values for organochlorinated contaminants in sediment and biota.

2.2.5 Normalization

Normalization is a procedure used to transform data to compensate for existing natural variability and help differentiate between natural variability and contamination. The natural variability may arise from different sediment compositions (grain-size, minerology), or from different biotic taxa analyzed, among others. For example, the natural Pb concentration in sediment depends in its composition (grain-size and minerology): the natural concentrations in sand are lower than the natural concentration in silt; the natural concentrations of Hg in the mussel *M. galloprovincialis* is different from the natural concentration in the fish *M. barbatus* that in turn is lower than the natural concentration measured in tuna fish.

To compensate for natural variability of trace metals in sediments, it is possible to compare concentrations measured in the same grain-size range, assuming similar minerology. In this case normalization is not needed. A second approach is to use geochemical normalization, in which a mathematical relationship between metal concentrations and the concentrations of an abundant conservative element (normalizer) in the same sample is established. The assessment is then performed using the ratios of the measured concentration of the metal divided by the concentration of the normalizer in the sample. It is recommended to use Al (5%) as normalizer for TM and total organic carbon (TOC) (2.5%) for organic contaminants in sediments.

In biota, natural concentrations are taxa and species specific. Moreover, in the same species, the concentrations depend on the tissue analyzed. Therefore, contamination assessment must be done on a species and tissue level. In addition, contaminants may accumulate with age. Weight and length of the specimen are usually used as a proxy to age. To avoid the need for normalization, concentrations of contaminants may be measured in specimens from the same species and age. An additional methodology is check for age dependence and if present, normalize to age (weight or length) similar to the normalization in sediments. Organic contaminants, that accumulate through hydrophobic partitioning into the lipids of organisms, may be normalised to lipid content (5% for fish and 1% for bivalves).

Normalization should be used with care, and only if field data support that normalization is valid for the area. A detailed explanation on normalization (theory and practice) is provided in the Monitoring Guidelines/Protocols for Sample Preparation and Analysis of Sediment and Biota for IMAP Common Indicator 17 ((UNEP/MAP WG.482/12; and UNEP/MAP WG.482/14).

2.3 The methodologies for thresholds` determination used by UNEP/MAP

UNEP/MAP has adopted the threshold assessment methodology, based on the "traffic light" approach, by defining 2 values to classify 3 environmental categories: 1) good (acceptable, not different from BC); 2) above background but with low risk for environment and biota population, or below dietary limits for fish and sea food concerning human health; and 3) unacceptable. The two values defined were i) the Background Assessment Concentration (BAC) (or T_0) and ii) the Environmental Assessment Criteria (EAC) for TM and organic contaminants in sediments and biota, or EC for TM and organic contaminants in biota, (or T_1). The above Tables 1-5 tabulate the values of BAC and EAC adopted or proposed to be used for the assessment of the quality status of the Mediterranean Sea (IMAP Decisions 22/7 (COP 19) and 23/6 (COP 20)).

2.3.1 Background Assessment Concentration (BAC) determination

BAC are the concentrations below which no deterioration of the environment can be expected. Observed concentrations are said to be near BC if the mean concentration is statistically significantly below BAC. For calculation of BAC values from BC concentrations UNEP/MAP adopted the methodology that corresponds to the OSPAR methodology. The BAC values were computed as the BC concentration multiplied by a factor that was determined based on the uncertainty (precision and accuracy) of the determinations. The multiplication factors were as follows: MedBAC=1.5 x MedBC (for mussel and sediment matrices); MedBAC=2.0 x MedBC (fish).

The MedBAC values endorsed in Decisions IG.22/7 and IG.23/6 are as follows: MedBAC for TM in sediments, mussel and fish (Tables 1,3) and PAHs in mussel (Table 4). In 2019, the same methodology was used to propose derivation of specific sub-regional MedBAC values.

Further to work undertaken in 2019, this document proposes updated regional and sub-regional BAC values for the Mediterranean, using the same methodology as in 2019. The proposed values are presented in Section 4.

2.3.2 Environmental Assessment Criteria (EAC) determination

EAC values are the concentrations above which significant adverse effect to the environment or to human health are most likely to occur. Conversely, EAC values are defined as the concentrations below which it is unlikely that unexpected or unacceptable biological effects will occur in exposed marine species. Due to that fact that it was not possible to develop EAC for MED at that time, it was agreed to use the criteria developed by OSPAR and NOAA/USEPA (ERL values) (Long et al. 1995), as the EAC values for the Mediterranean. The EAC values agreed in Decisions IG.22/7 and IG.23/6 are as follows: EAC values for TM, PAHs and organochlorinated contaminants (PCBs and pesticides) are provided for sediments in Tables 1, 2 and 5; TM and organochlorinated contaminants are provided for mussel and fish in Tables 3 and 5 and PAHs are provided for mussel in Table 4.

A proposal of a new methodology to derive EAC values specific for the Mediterranean Sea is described in Section 4.

2.3.3 European Union regulations (EC)

The EAC values for TM and PAHs in biota as endorsed by Decisions IG.22/7 and IG.23/6 (Table 3) are the concentrations in fish and seafood recommended as dietary limits for human consumption concerning human health (EC). EC values are derived from the following EU Directives regulating maximum levels for certain contaminants in foodstuffs: EC/EU 1881/2006, 1259/2011, 488/2014 and 1005/2015. Section 4.3 gives more details about EC values. It should be mentioned that these values were set up to protect human health and may be too lenient to protect the environment.

A proposal of new methodology to derive EAC values for the Mediterranean Sea is described in Section 4.

2.4 The assessment criteria for IMAP Common Indicator 18

Biomarkers are used to infer on a cause-effect relationship between a stressor and a biotic effect. The biotic effects can be biochemical, physiological, toxicological and/or be detected at the ecological/community level. The World Health Organization (WHO, 1993) further defined biomarkers as: (1) a biomarker of exposure (effect measured within an organism) and (2) a biomarker of effect (effect measured as a health impairment or disease) (Lomartire et al. 2021).

By Decisions IG.22/7 and IG. 23/6, the Contracting Parties endorsed BAC and EAC values for the following biomarkers for the mussel (*Mytilus galloprovincialis*): Acetylcholinesterase activity (AChE), Metallothioneins (MT), Micronuclei frequency (MN), Lysosomal membrane stability (LMS-NRR and LMS-LP methods) and Stress on Stress (SoS). These values are indicative and serve as the initial assessment criteria.

The two following general methods can be used to derive BCs for biomarkers:

- Use data from a "pristine'/undisturbed site (or a site with very minor disturbance)" with proper statistical analysis. As for contaminants, in this method there should be no temporal trend on the parameters measured.
- Use data from monitoring programs, excluding known polluted sites in conjunction with rigorous statistical analysis to eliminate outliers, and with the aid of expert judgement.

By Decisions IG.22/7 and IG. 23/6, the Contracting Parties endorsed BACs and EACs for the following biomarkers for the mussel *Mytilus galloprovincialis* (MG): Acetylcholinesterase activity (AChE), Metallothioneins (MT), Micronuclei frequency (MN), Lysosomal membrane stability (LMS-NRR and LMS-LP methods) and Stress on Stress (SoS) (Table AI.1). The proposed values are indicative and serve as the initial assessment criteria.

In 2016, MedBCs both for the whole Mediterranean Sea and two sub-regions were determined using the selected reference stations datasets (Table AI.1). MedBCs were determined as the 10^{th} or 90^{th} percentile value, the former when the response is a decrease in value and the latter when the biomarker response is an increase in value.

Table A1.1. Mediterranean EAC levels for biomarkers in mussel (M. galloprovincialis) as agreed upon during COP19 and COP 20. The values calculated in 2016 BCs and BACs from the Mediterranean Sea, and BC for two sub regions are given as well.

Biomarker/Bioassay		Decisions IG.22/7 and IG.23/6 (COP 19 and COP 20)				UNEP/MAP (2016)			
		BAC	EAC	BAC	EAC	BC	BAC	BC	BC
	Units	IG.22/7	IG.22/7	IG.23/6	IG.23/6	Med	Med	WMS	ADR
Stress on Stress (SoS)	days	10	5	11	5	11	11		
Metallothioneins	ug/g (digestive gland)			247		192	247	191.3	200.5
Lysosomal membrane stability Neutral Red Retention Assay (LNS-NRR)	minutes	120	50	120	50	45	120	45	47.4
Lysosomal membrane stability Cytochemical method (LNS-LP)	minute	20	10	20	10	13	20		16.8
Acetylcholinesterase (AChE) activity in gills (French Mediterranean waters	nmol/min/ mg protein	29	20	29	20				

Biomarker/Bioassay		Decisions IG.22/7 and IG.23/6 (COP 19 and COP 20)				UNEP/MAP (2016)			
		BAC	EAC	BAC	EAC	BC	BAC	BC	BC
	Units	IG.22/7	IG.22/7	IG.23/6	IG.23/6	Med	Med	WMS	ADR
Acetylcholinesterase (AChE) activity in gills (Spanish Mediterranean waters)	nmol/min/ mg protein	15	10	15	10				
Acetylcholinesterase (AChE) activity in gills	nmol/min/ mg protein					21	15	20.86	12.2
Micronuclei frequency	0/00 in haemocytes	3.9		1		0	1	0	0.5

Peric et al. (2017) measured the changes of acetylcholinesterase activity (AChE), metallothioneins content (MTs), catalase activity (CAT) and lipid peroxidation (LPO) in *M. galloprovincialis* after 4 days exposure to a wide range of sublethal concentrations of chlorpyrifos (CHP, 0.03-100 μg/L), benzo(a)pyrene (B(a)P, 0.01-100 μg/L), cadmium (Cd, 0.2-200 μg/L) and copper (Cu, 0.2-100 μg/L). The control values, a proxy for BCs, ranged from 4 to 13 nmol/min/mg protein for AChE activity in gills and from 90 to 200 ng/g ww for MT in the digestive gland.

Presently there are no new data that can be used to update the biomarkers` assessment criteria. Therefore, they were not addressed in Section 4. More information on biomarkers and related criteria derivation are given in Annex I.

3 Survey of relevant data not used previously neither for preparation of the Mediterranean Quality Status Report (2017 MED QSR) nor for the State of Environment and Development Report (2019 SoED)

New relevant data not used previously neither for the 2017 MED QSR nor for update of the assessment for EO9 within preparation of the 2019 SoED were collected from the following 4 data sources:

1. New data from IMAP Pilot Info System that include national monitoring data uploaded in the system during its testing phase, and in particular after launching formal call for reporting of data in June 2020.
2. New data from the MEDPOL Database not used previously for calculation of assessment criteria;
3. The EU data center (European Marine Observation and Data Network - EMODnet);
4. Published papers collected from the scientific literature.

Details of the available data from these sources are given below.

3.1 IMAP Pilot Info System and MEDPOL Database

Tables 6 and 7 provide a detailed examination of the new available data sorted by matrix, country and sampling year. The datasets used in the 2017 and 2019 assessments are given in UNEP/MAP WG.492/inf 11.

It can be seen that the IMAP and MEDPOL data included only TM and organic contaminants in sediment and biota (CI17). No new data were available for biomarkers (CI18). New biomarker data were not available also for assessments that contributed to 2019 SoED.

Table 6: An overview of available new data from IMAP Pilot Info System. The numbers next to the years are the number of observations for each parameter, sorted by country and sampling year. The number of below detection limit (BDL) observations is given in parenthesis.

Trace metals	**Species**	**Year**	**Cd**	**Hg**	**Pb**
Bivalve/mollusc					
Lebanon	*Patella sp.*	2019	16 (0)	16 (0)	16 (0)
Morocco	*Callista chione*	2016	10 (0)	10 (0)	10 (0)
		2017	10 (0)	10 (0)	10 (0)
		2018	5 (0)	5 (0)	5 (0)
Slovenia	*M. galloprovincialis*	2018	3 (0)	3 (0)	3 (0)
		2019	3 (0)	3 (0)	3 (0)
Fish					
Croatia	*Conger conger*	2012	4 (4)	4 (0)	4 (0)
Lebanon	*Diplodus sargus*	2019	11 (0)	11 (0)	11 (0)
	Euthynnus alletratus	2019	15 (0)	15 (0)	15 (0)
	Mullus barbatus	2019	14 (0)	14 (0)	14 (0)
Sediment					
Cyprus		2013	2 (0)	2 (2)	2 (0)
		2014	4 (1)	4 (4)	4 (3)
		2015	3 (0)	3 (3)	3 (1)
		2016	2 (0)	2 (2)	2 (0)
		2017	7 (0)	7 (6)	7 (0)
		2018	4 (1)	4 (4)	4 (1)
Lebanon		2019	17 (0)	17 (10)	17 (0)
Morocco		2016	11 (9)	0	11 (4)
		2017	11 (1)	11(11)	11 (7)
		2018	11 (0)	11(11)	11(1)
Slovenia		2019	1(1)	1(0)	1(0)

PAHs and Organochlorinated contaminants										
Bivalve/mollusc	Species	Year	Total PAH	Total PCB	HCB*	CB101	CB138	CB153	CB180	CB52
Lebanon	*Patella sp*	2019	15 (0)	15 (8)						
Morocco	*C.chione*	2016			7 (0)	1 (0)	7 (0)	7 (0)	5 (0)	0
		2017			7(0)	0	2(0)	3 (0)	7(0)	0
		2018			5 (0)	5 (0)	6 (0)	5 (0)	6 (0)	1
Slovenia	*M. galloprovincialis*	2019	3 (3)							
Fish					HCB*	Dieldrin	Aldrin	DDE(p,p’)	DDT(p,p’)	DDD(p,p’)
Croatia	*C. conger*	2012			4 (3)	8 (2)	8 (8)	8 (0)	8 (0)	8 (0)
Lebanon	*D.sargus*	2019	3 (0)	3 (0)						
	E. alletratus	2019	10 (0)	13 (0)						
	M. barbatus	2019	6 (0)	3 (0)						
Sediment										
Lebanon		2019	19 (0)	19 (9)						
Slovenia		2019	1 (1)	1 (1)	1 (1)					

* HCB- Hexaclorobenzene

Table 7: New data available in MEDPOL Database. The numbers next to the years are the number of observations for each parameter, sorted by country and sampling year. The number of below detection limit (BDL) observations is given in parenthesis.

	Species[15]	Year	Cd	Hg	Pb	Total PAHs	Hydrocarbons
Bivalves							
Israel	*MC*	2017	2 (0)	2 (0)	0		
Montenegro	*MG*	2018	8	8	8	9 (5)	
Slovenia	*MG*	2017	3 (0)	3 (0)	3 (0)		
Tunisia	*ML*	2014	0	3 (0)	0		
	RD	2014	0	11(0)	0		
Fish							
Israel	*DS*	2017	13(12)	13(0)	0		
	LM	2017	28(27)	28 (0)	0		
	SR	2017	11(12)	11 (0)	0		
	SRB	2017	10(10)	10 (0)	0		
	DS	2018	9 (4)	9 (0)	0		
	SRB	2018	10 (10)	10 (0)	0		
SEDIMENT							
Israel		2017	14 (0)	14 (0)	14(0)		
Montenegro		2018	6 (0)	6 (0)	6 (0)	5 (0)	5 (5)
Slovenia		2013				7 (0)	
		2014				6 (0)	
		2015				6 (0)	
		2016				7* (0)	
		2018				1* (0)	
Tunisia		2014	9 (9)	9 (0)	9 (9)		6 (0)

* data for 16 individual PAHs.

3.2 Data from the EU data center (European Marine Observation and Data Network - EMODnet)

Data from EMODnet used to complement data available in IMAP Pilot Info System and MEDPOL Database are summarized in Table 8.

Table 8. Data from EMODnet used for present update of BC/BAC values, complementing data available in IMAP Pilot Info System and MEDPOL Database . “n” is the number of observations.

Country	Year	Matrix	n	Parameters available*
France	2016	S	33	Cd, Hg, Pb
Croatia	2016	S	35	Cd, Hg, Pb
Italy	2016	S	5	Cd, Hg, Pb
France	2017	B (MG)	3	Cd, Hg, Pb
Italy	2015-2018	B (MG)	61	Cd, Hg, Pb
France	2016	S	29	PAHs, PCBs, Pesticides
Italy	2015-2016	S	5	PAHs, Pesticides
France	2017	B (MG)	2	PAHs, PCBs
Italy	2016-2017	B (MG)	18	PAHs
Italy	2017	B (MG)	2-33	Pesticides

* Not all parameters available for all samples. S-Sediment, B-Biota, MG- *M. galloprovincialis*

3.3 Data from the scientific literature

Below Table 9 lists the available scientific papers used in the preparation of this document. It is important to note that the papers are usually limited in scope, both spatially and temporally. Moreover, they usually include contaminated and reference sites, so care should be taken when

[15] *MC – M. corralina, MG – M. galloprovincialis, RD - R.ruditapes*, , DS - *D. sargus, LM - L. mormyrus, SR- S. rivulatus, SRB-S. rubrum.*

utilizing the data for BC calculation or verification. The search was geared towards finding recent data, from samples collected since 2012, and towards data from the southern Mediterranean countries. Detailed elaboration of relevant scientific literature is provided in Annex I.

Table 9. Data available from the scientific literature. The characterization of information provided in table is as follows: Data – all data could be retrieved from the paper; BC – paper specifies the background concentrations; Statistics – only statistics of the data are given (i.e. mean, standard deviation)

Country	Sampling year	Matrix	Parameter	Data	Reference
Algeria	2015	S	Cd, Pb	Statistics, BC	(Ahmed et al. 2018)
Algeria	2014	B (MG)	Cd, Pb	Statistics	(Benali et al. 2017)
			PCB, PAH	Data*	
Egypt	ng	S	Cd, Pb	range	(El Baz and Khalil 2018)
France	2014	B (MG)	Hg	Data*	(Briant et al. 2017)
Greece	2016-2018	S	Pb	Data*	(Karageorgis et al. 2020)
Italy	2012	B (Fish)	Hg	Data**	(Bonsignore et al. 2015)
Lebanon	2017	S, B (mollusc)	Cd, Hg, Pb	Statistics	(Ghosn et al. 2020b)
Lebanon	2017	B (fish)	Cd, Hg, Pb	Statistics	(Ghosn et al. 2020a)
Morocco	2016	B (MG)	Cd, Pb	Statistics	(Azizi et al. 2016)
Spain	2011,2012, 2015	S	Cd, Hg, Pb	BC	(Martínez-Guijarro et al. 2019)
Tunisia	2011	B	Cd, Hg, Pb	Statistics	(Rabaoui et al. 2014)
Tunisia	2016	S	Cd, Pb	Statistics, BC	(Naifar et al. 2018)
Tunisia	2018-2019	S, B	Org. contam.	Data*	(Jebara et al. 2021)

S-Sediment, B-Biota, ng- not given; *- data used for present update of BC/BAC values; **- data not used since were related to polluted sites

3.4 Examination of the new data

The new data available were examined and used for BC and BAC`s calculation, as appropriate. The computed values were then compared with the environmental criteria for the Mediterranean Sea as endorsed in Decision 23/6 (COP 20). Those are presented in section 4.

Data were very limited, therefore data from different years were aggregated per country and outliers identified (using box plots) and not considered in the calculation of the median values. When needed, data were transformed to the concentration units requested by IMAP. It should be mentioned that sediment data were not normalized.

In addition, for biota, it was not always clear if the concentrations were reported in dry or wet weight. When not specified, it was assumed that the data were reported to IMAP Info System/MEDPOL database as requested by IMAP.

This comparison was undertaken in order to confirm data relevance for computing the updated BC and BAC values (Section 4). An in-depth examination of the data is presented in Annex II

4 Critical examination of recommended environmental criteria and proposals for their update

In line with Decision 22/7 (COP 19), the assessment criteria for the Mediterranean Sea should follow the “traffic light” system for both contaminant concentrations and biological responses where two thresholds and three status categories are defined. As explained above, the two values defined were the Background Assessment Concentration (BAC) (T_0) and the Environmental Assessment Criteria (EAC) or EC values (T_1), (see Section 2).

4.1 Updated BC and BAC values for IMAP CI 17

The new data presented and critically analyzed above in Section 3 and Annex III were used to calculate BC values for the sub-regional areas of the Mediterranean and for the whole Mediterranean Sea using the same methodology as initially applied in 2016/2017 and replicated in 2019 (see detail explanation in Section 2). BAC values are calculated by multiplying the BCs by a factor, as follows: MedBAC=1.5 x MedBC (for mussel and sediment matrices); MedBAC=2.0 x MedBC (fish). When most of the data originated from one sub-region, and there were significant differences among them, the BC values were calculated for the sub-region(s) only.

Tables 10-12 present the new updated BC and BAC values. The tables include also the values of the assessment criteria as endorsed in Decision 23/6 (COP 20), as well as their values updated in 2019.

Table 10. BC and BAC values for trace metals in sediments, calculated from the new data. The table shows also the previously endorsed/updated values. Concentrations are given in µg/kg dry wt, as requested by IMAP. The number of data points (n) taken to calculate the BCs appear below the values.

BCs							
TM	Med (cores)	Med (surf)	Med	WMS	ADR	CEN	AEL
	2011[16]		**2019**				
Cd	100	20	85	91.2	92.3		56
Hg	30	10	53	60	106.8		31.2
Pb	20000	2310	16950	20465	13932		4920
Proposed new updated BC values (2021)							
Cd			116	115	166		113
n			*135*	*56*	*41*		*38*
Hg			32.6	25.0	54.1	2-69*	50.3
n			*113*	*33*	*37*	*6*	*37*
Pb			15900	12000	27066		17700
n			*229*	*58*	*44*		*127*
BACs							
		IG.23/6	Med	WMS	ADR	CEN	AEL
		2017	**2019**				
Cd		127.5	127.5	136.8	138.5		84.0
Hg		79.5	79.5	90.0	160		46.8
Pb		25425	25425	30698	20898		7380
Proposed new updated BAC values (2021)							
Cd			174	173	249		169
Hg			48.9	37.5	81.2		75.5
Pb			23850	18000	40599		26550

It can be seen that the updated regional Mediterranean BC values for Cd and Hg are very similar to the ones calculated in 2011 from sediment cores while value for Pb is lower. Comparison to the BCs values updated in 2019 shows that presently updated regional BC values for Cd is higher, Hg is lower and Pb slightly lower (4%). Comparison of the sub-regional BC values calculated in 2019 and 2021 shows differences as well. Possible reasons for these differences could be due to different sediment mineralogical composition and the location of the sampling stations. In addition, for the regional BC values, an unbalanced number of data points among the sub-regions taken for the calculation, possibly gives an unproportionate weight.

Table 11. BC and BAC values for PAHs in sediments, calculated from the new data. The table presents also the previously endorsed/updated values. Concentrations are given in µg/kg dry wt, as requested by IMAP. The number of data points (n) taken to calculate the BCs appear to the right of the values. No data were available for the AEL sub-region.

	UNEP/MAP (2011)		**Proposed new updated BC values (2021)**							
PAH compounds	BC, Sed cores	BC, Sur sed	Med	*n*	WMS	n	ADR	*n*	CEN	n
Naphthalene	4		8.0	*36*	8.8	29	2.0	*5*	2.5	*2*
Acenaphthylene	0.5	1.05	0.4	*34*	0	29	1.5	*4*	0.4	*5*

[16] The values calculated in 2011 are shown for comparison. The values were calculated from data compiled from the scientific literature (UNEP/MAP 2011) and need no recalculation

PAH compounds	UNEP/MAP (2011)		Proposed new updated BC values (2021)							
	BC, Sed cores	BC, Sur sed	Med	*n*	WMS	n	ADR	*n*	CEN	n
Acenaphtene	0.38	0.45	4.7	*29*	4.7	29	11.5	*8*		
Fluorene	0.75	0.33	7.5	*41*	7.5	29	6.0	*3*	0.4	*5*
Phenanthrene	4.55	3.95	16.8	*42*	22.5	29	15.0	*7*	0.8	*5*
Anthracene	0.8	1.56	3.4	*40*	5.0	29	8.5	*6*	0.7	*7*
Fluoranthene	5.6	6.7	22.1	*43*	32.2	29	12.0	*13*	2.0	*2*
Pyrene	10.28	2.1	15.9	*42*	22.4	29	12.5	*8*	0.4	*5*
Benzo[a]anthracene	3.45	1.28	19.1	*37*	20.9	29	23.0	*13*		
Chrysene	1.3	6.64	25.0	*37*	37.6	29	6.0	*3*	1.6	*5*
Benzo(b)fluoranthene	1.1	8.32	12.8	*44*	9.3	29	9.6	*13*	50	*2*
Benzo(k)fluoranthene	0.53	6.03	8.4	*44*	7.8	29	19.5	*8*	27	*2*
Benzo[a]pyrene	2.55	3.71	2.4	*42*	2.6	29	17.6	*13*	1.8	*7*
Benzo[g.h,i]perylene	1.25	3.25	6.9	*44*	5.0	29	9.0	*8*	100	*2*
Dibenzo[a,h]anthracene	0.18	1.37	0	*37*	0	29	7.0	*12*		
Indeno[1,2,3,c,d]pyrene	1.7	4.49	1.0	*44*	0	29	12.5	*8*	2.0	*2*
Total PAHs			165	*71*	166	29	218	*32*	6.6	*7*

PAH compounds	**IG.23/6 (2017) MedBAC**	**Proposed new updated BAC values (2021)**			
		Med	WMS	ADR	CEN
Naphthalene		12	13	3	3.8
Acenaphthylene		0.6	0	2.3	0.6
Acenaphtene		7.1	7.1	17	0
Fluorene	2.5	11	11	9	0.6
Phenanthrene	17.8	25	34	23	1.2
Anthracene	1.2	5.1	7.5	13	1.1
Fluoranthene	7.4	33	48	18	3
Pyrene	5.0	24	34	19	0.6
Benzo[a]anthracene	1.9	29	31	35	0
Chrysene	2.4	38	56	9.0	2.4
Benzo(b)fluoranthene		19	14	14	75
Benzo(k)fluoranthene	1.4	13	12	29	41
Benzo[a]pyrene	1.2	3.6	3.9	26	2.7
Benzo[g.h,i]perylene	2.3	10	7.5	14	150
Dibenzo[a,h]anthracene	1.3	0	0	11	0
Indeno[1,2,3,c,d]pyrene	2.9	1.5	0	19	3
Total PAHs		248	249	327	9.9

Concentrations of PAH compounds in the sediments were available for 29 - 44 data points, while for Total PAHs, 71 data points were available. The calculated BC values for some of the compounds were higher than the BC concentrations measured in sediment cores and surficial sediments of the Mediterranean Sea in 2011, while for other compounds they were similar. This could be due to the limited number of datapoints used for the calculation both in 2011 and 2021. Therefore, it is proposed to use presently updated values of BC/BAC for preparation of input assessments for 2023 MED QSR, along with further update of the assessment criteria if more data will be reported by the CPs[17]. Moreover, it is recommended to add the concentration of Total PAHs to the list of parameters.

Table 12. BC and BAC values for trace metals in mussel (*M. galloprovincialis*) and BC values for trace metals in other biota species calculated from the new data[18]. The table presents also the previously endorsed/updated values. The units of concentrations are given as requested by IMAP. The number of data points (n) taken to calculate the values appear below the values.

BCs						
TM		**Med**	**WMS**	**ADR**	**CEN**	**AEL**
Mussel soft tissue (*M. galloprovincialis*), µg/kg dry wt						
		2019				
Cd		730	660.5	782		942
Hg		115.5	109.4	126		110
Pb		1542	1585	1381		2300
TM		**Proposed new updated BC values (2021)**				
Cd		490	1010	88	77.8	>
n		*51*	*30*	*17*	*4*	
Hg		83	118	43	12.3	>
n		*110*	*53*	*49*	*8*	
Pb		1090	1245	100	250	>
n		*51*	*30*	*17*	*4*	
BACs						
TM	**Med**	**Med**	**WMS**	**ADR**	**CEN**	**AEL**
	IG.23/6 (2017)	**2019**				
Cd	1095	1095	991	1173		1413
Hg	173.2	173.2	164.1	189		165
Pb	2313	2313	2378	2072		3450
Proposed new updated BAC values (2021)						
Cd		735	1515	132	117	>
Hg		124	177	64.5	18.5	>
Pb		1635	1868	150	375	>

BCs						
TM		Med	WMS	ADR	CEN	AEL
Bivalves, soft tissue (various species)[19] µg/kg dry wt, calculated in 2021						
Cd			0.65			
n			*25*			
Hg			0.15		41.5	
n			*25*		*14*	
Pb			1.65			
n			*25*			
Fish muscle (*Mullus barbatus*) µg/kg wet wt, calculated in 2019						
Cd	*3.7#	*3.7				
Hg	101.2#	50.6	68	150.5		44.6
Pb	*31#	*31	38			20
Fish muscle (*Mullus barbatus*) µg/kg wet wt, calculated in 2021						
Cd						2.5
n						*39*
Hg						29.2
n						*60*

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[17] The values for a few of the compounds in Table 11 are 0, meaning that the concentrations measured were BDL. Paragraph 46 below addresses the topic of BDL concentrations.

[18] BAC values were calculated just for *M galloprovincialis*. Data for the other mandatory species (*M. barbatus*) were not enough to calculate Med BACs. To calculate BACs from the BCs the following factors should be applied: BAC=1.5 x BC (mussel); BAC=2.0 x BC (fish).

[19] *C. chione* in the WMS, *ML and R.ruditapes* in the CEN, *M.corralina* in the AEL. See section 4.

BCs						
TM		Med	WMS	ADR	CEN	AEL
Pb						*13.5*
n						*39*
Fish muscle (*various species*)[20] µg/kg wet wt, calculated in 2021						
Cd		0.38		51.8		0.31
n		*37*		*4*		*33*
Hg		32.2		20.1	340^	33.4
n		*110*		*4*	*20*	*106*
Pb				224		0.46
n				*3*		*22*

#MedBAC in Decision IG.23/6; * Most values BDL; ^ questionable values, may be related to hot spot stations, therefore not taken for the calculation of regional MedBC; > it is recommended to use the values calculated in 2019.

The regional MedBC values for Cd, Hg and Pb in *M. galloprovinciallis* calculated in 2021 were lower than those calculated in 2019. The subregional BCs for the WMS and the ADR were also different: WMS BC for Cd was higher and for Pb lower in 2021 compared to 2019, while WMS BC for Hg was similar. In the Adriatic the BC concentrations were much lower in 2021 than in 2019: ADR BC for Cd and Pb decreased by about one order of magnitude, while for Hg it was about 3 times lower. The differences in the Adriatic could be due to different locations of the sampling stations and to a temporal decrease. However, the most important point is the differences in concentrations between the WMS and the other sub-regions. The BC concentrations in the WMS were much higher for all three trace metals. Therefore, it is recommended to use the sub-regional BCs for *M. galloprovinciallis*. Since new data were not available in the AEL to update BC/BAC values for *M. galloprovinciallis*, it is recommended to use the values calculated in 2019. Comparison of BC concentrations calculated in 2021 for Cd and Pb in M. barbatus from the AEL to the BCs in Decision IG23/6 showed that they are low and similar. Calculated Hg concentrations calculated in 2021 were lower than the concentration in Decision IG23/6

The mussel *M. galloprovinciallis* and the fish *M. barbatus* are agreed as IMAP mandatory species. However, they may not be always found in all the areas of the Mediterranean Sea. Therefore, the addition of other (mandatory area specific) species to the monitoring program is recommended for further consideration. The species should be chosen based on their presence in the sub-regions, and relevance as pollution indicators, what will allow a better environmental assessment. Data from different species are presented in Table 12. It should be noted that the concentrations measured are specific to each species and comparison should be made within the same species (see Section 2).It may be useful to consider in the future an upgrade of IMAP in order to include larger number of species.BC concentrations of organochlorinated contaminants (PCBs and pesticides) in sediments and biota were not calculated either in 2011, 2016 or in 2019. The availability of new data is not sufficient to calculate BC values for these contaminants (see section 3).

For determination of BC values for CI17, the following key findings can be provided:

- For some parameters there is a marked difference among the Mediterranean sub-regions. Therefore, it is proposed in those cases (i.e. Pb in sediments, Cd and Pb in *M. galloprovincialis*, sum of PAHs in sediments), to consider using the sub-regional Mediterranean Sea assessment criteria.
- A statistical treatment of BDL data should be agreed upon. It is recognized that the different BDLs make it hard to use half of the BDL concentration for these values. However, it is not reasonable not to take BDL values into consideration.
- An in-depth examination of more data points, that need to be reported by CPs, should be performed in particular when large differences were observed between the BC values calculated in 2016 and in 2021. This is true for TM in sediment and biota in all sub-regions. The examination should include, among others, characterization of the stations used (hot spot, reference, other), analytical methodology, normalization, temporal trends.

[20] *S. pilchardus, B. boops, T. trachurus, S. sphyraena, D. annularis, P. acarne, P. erythrinus, M. barbatus, M. surmuletus, S. notata, S.scrofa, C. conger, D. sargus, L. mormyrus, S. rivulatus, S. rubrum.* See Section 3.

- For the other parameters, such as PAHs in biota, and organochlorinated contaminants in sediment and biota, new additional data are needed to recalculate the BCs. Before new data availability will allow their recalculation, present values remain valid for preparing assessment inputs for the 2023 QSR.

4.2 An upgraded approach for updating EAC values for IMAP CI 17

As explained above (see Section 2), the EAC values endorsed for use in the Mediterranean Sea were NOAAs ERLs (for TM, PAH and pesticides in sediments) and the ECs from EU Directives to protect human health (for TM and organic contaminants in biota). They may be too lenient if the goal is to achieve and maintain GES where the contaminants cause no significant impact on coastal and marine ecosystems. However, EAC values cannot be updated based on existing monitoring data. It needs a very specific in-depth research of the ecotoxicological and environmental scientific literature.

Therefore, the methodology detailed in European Commision Guidance Document (2018) and in Long et al. (1995) is recommended for the update of Mediterranean EAC values. It includes a thorough examination of the scientific literature conducted to study where data on no effect or adverse biological effects are given in conjunction with chemical data in the environment and in the biota at the same site and time. Briefly, those include but are not limited to sediment toxicity tests, aquatic toxicity tests in conjunction with equilibrium partitioning (EqP) and field and mesocosm studies. The data should be assembled into a detailed database and analyzed, as well as the extent of the effect determined. The emphasis should be given to Mediterranean biota species.

The EU Guidance 27 provides a detailed procedure on how to derive Environmental Quality Standards (EQS) to achieve good surface water chemical status. It also addresses the derivation of EQS for benthic biota and sediments and how to back calculate EQS for seawater from them. EQS for biota and sediments are necessary for substances with low water solubility and a tendency to bioaccumulate through the food web. Due to their very low concentrations in water, their analysis is more feasible in biota and sediment matrices. The WFD (Directive 2008/105/EC and its update, 2013/39/EU) lists 45 substances identified as EU's Priority Substances (PSs) and Priority Hazardous Substances (PHSs) and gives maximum acceptable concentrations and/or annual average concentrations EQS for them. For 11 very hydrophobic substances, EQS are given for biota as well. WFD requires the EQS to protect predators and top predators (such as predatory fish, birds and mammals) from risks of secondary poisoning brought about by consuming contaminated prey ($QS_{biota, secpois}$)[21].

In contrast to the EQS chemical status, the UNEP/MAP EACs aim to protect against undesirable biotic effects. Some of the adopted EACs were those derived by Long et al., (1995) as the Effects Range Low (ERLs), the concentrations that are associated with biotic effects occasionally (the lower 10^{th} percentile of the data). The methodology described in the EU Guidance 27 is more didactic and extensive, while Long et al. (1995) takes a more hands-on empirical approach, but with similar methodology.

The recommended steps to update MedEACs, adapted from the EQS and ERL derivations, are as follows:

1) Assemble available data on laboratory ecotoxicity data, mesocosm and field studies. For laboratory ecotoxicity data it is preferable to choose studies that report on dietary and oral exposure with developmental or reproductive endpoints that are more sensitive than survival endpoints. Long term mesocosm experiments are preferable to short term experiments. For field studies, measures of any adverse biological effects (such as altered benthic community (species richness, total abundance), histopathological disorders) should be given together with chemical concentration in sediments or other relevant matrix measured at the same time.
2) Each study should include all relevant auxiliary information: citation, type of test, type of biological effect, approach used, study area, test duration, species tested or the benthic

[21] An additional biota EQS that can be derived is to protect humans from adverse effects resulting from the consumption of chemical contaminated seafood ($QS_{biota, hh food}$) corresponding to UNEP/MAP CI20.

community considered, TOC, Acid volatile sulphide (AVS), chemical concentrations, among others.

3) Each study should be assigned an effects/no effect descriptor. Only when concordance is apparent between the observed biological and the measured chemical concentration, the study is considered as an effect study. All the effects data were given equal weights in the guidelines derivation.
4) Extrapolate all available data to estimate the thresholds or criteria. The extrapolation should take into account the uncertainties such as species variations (laboratory test species to wildlife species), laboratory to field conditions extrapolation, short to long term effects. There are two approaches to extrapolate the data to criteria: deterministic and probabilistic. The deterministic approach takes the lowest credible toxicity datum and applies an Assessment factor (AF) to extrapolate to a QS. The higher the uncertainty of the available data, the higher the AF that is used to compensate for it. The probabilistic approach for extrapolation adopts a species sensitivity distribution modelling in which all reliable toxicity (usually no observed effect concentration (NOEC)) data are ranked and a model fitted. This approach is the preferred approach but when data are insufficient, a deterministic approach needs to be adopted.
5) An empirical approach was used by Long et al (1995). The incidence of adverse effect within each range was quantified by dividing the number of effects entries by the total number of entries and expressed as a percent. The ERL and ERM (effects range medium) values were derived with only the effects data and set as the concentration of the 10^{th} and 50^{th} percentile of the data, respectively.
6) Criteria for sediments should account for TOC and mineralogical composition. The criteria for biota should account for lipid contents (hydrophobic substances), individual’s dry weight (metals), trophic level (when a substance biomagnifies through the food web). Decision on which trophic level to use for the criteria depends on the purpose – protection of the environment, specific biota species, human health, etc. Emphasis should be given to Mediterranean Sea species.

To summarize, the difference between EQS and EAC is in the stated purpose: EQS to protect predators from ingesting contaminated prey and EAC (or ERL) to prevent undesirable biotic effects. The EQS are derived based on a particular predator in the food web, that needs to be chosen based on the specific location/environment. Once the specific EQS is derived, it is possible to calculate the EQS for other species/taxa and to back calculate to concentrations in water (EU Guidance 27). The ERLs, that were adopted as EAC for the Mediterranean Sea, were derived based on data of all available undesirable biotic effect and statistical analysis. The EQS and the ERL derivations are similar: both use the same available studies (such as sediment toxicity tests, aquatic toxicity tests in conjunction with equilibrium partitioning (EqP) and field and mesocosm studies) for which biotic data are given together with chemical data. EQS applies an Assessment Factor (AF) to account for uncertainty. For example, there is a high uncertainty estimating *in situ* criteria from short term laboratory toxicity tests and the AF will be large. ERLs were developed with a more empirical/pragmatic approach.

Upgrade of the EAC values for Mediterranean Sea as recommended above is a long-term task that needs a dedicated, very specific, scientific research.

4.3 Proposal of new EAC values for IMAP CI 20

Proposal of the EAC values for IMAP CI 20 related to actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed sea food is based on a survey of existing sources, including Directives of EU related to the maximum permitted levels for contaminants in fish and seafood for the protection of human health. Table 13 details the concentrations cited at different sources for TM (Cd, Hg and Pb) and for organic contaminants (PCBs, dioxin).

From Table 13 it is possible to see that the criteria are taxa specific (fish, mussel, crustacean), as well as species specific. For example, maximum allowable Hg concentration in fish muscle is 0.5 mg/kg ww, excluding listed species such as bonito, marlin, halibut, mullet species, among others, in which the maximum allowable Hg concentration in the muscle is 1.0 mk/kg ww (see EC/EU Directive 1881/2006).

In addition, Decision IG.23/6 details the indicative regional EAC values for PAHs in mussels (*Mytilus galloprovincialis*) and for organic contaminants in mussel (*Mytilus galloprovincialis*) and fish (*Mullus barbatus*) that are considered biota matrix of IMAP Common Indicator 17. These values are given in Tables 4 and 5. As these values were set up to protect human health, they may be too lenient to protect the environment (see paragraph 22). However, since the values are based on the maximum levels for certain contaminants in foodstuffs as provided in EC/EU Directives 1881/2006, 1259/2011 and amendments 488/2014 and 1005/2015, they are proposed to be also used for IMAP CI 20.

Table 13. Compilation of maximum levels for trace metals in fish and seafood for the protection of human health[22]. The concentrations are presented in mg/kg ww.

Source	matrix	Cd	Hg	Pb
		mg/kg ww		
NOAA (see countries below)	fish	0.2	0.5-1	1.5-2
	canned fish (*tuna)		1*	2.5, 5*
	mollusc	2	0.5	2.5
	finfish	0.1		0.5
EU 1881/2006 directive and 488/2014 and 1005/2015 amendments	fish muscle	0.05-0.25	0.5-1	0.3
	cephalopods	1		0.3
	crustaceans	0.5	0.5	0.5
	bivalve mollusc	1		1.5
CODEX Alimentarious (2019)	mollusc, cephalopod	0.05-2		
	fish			0.3
	fish- species dependent		1.2-1.7*	
#MedEAC IG.23/6	Mussel	1	0.5	1.5
	fish	0.05	1	0.3
OSPAR 2017	All species - biota	1	0.5	1.5
Minimum		**0.05**	**0.5**	**0.01**
Maximum		**2**	**1.7**	**2.5**

* methyl-mercury, # Concentrations recalculated in mg/kg wet wt

The maximum levels of organic contaminants in fish and seafood for the protection of human health are as follows: NOAA, 0.5 and 2 PCB (mg/kg ww) in fish and other seafood, respectively; EU Directive 1881/2006, 2-5 and 6 (mg/kg ww) of benzo(a)pyrene and 12-30 and 35 (mg/kg ww) for the sum of benzo(a)- pyrene, benz(a)anthracene, benzo(b)fluoranthene and chrysene in smoked fish muscle and on smoked bivalve mollusc, respectively; EU Directive 1259/2011 – 3.5 pg/g ww for the sum of dioxins in fish muscle and liver and in eel muscle; 6.5, 10 and 20 pg/g ww for the sum of dioxins and dioxin like PCBs in fish muscle, in eel muscle and in fish liver, respectively; and 75, 300 and 200 ng/g of the sum of PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180 in fish muscle, in eel muscle and in fish liver, respectively. As for TM, the maximum allowable concentrations are taxa specific.

The values as established by above EU Directives are submitted for consideration to present meeting in order to guide the Secretariat and the Parties on their application as EAC values for IMAP CI 20. These values are in the low and mid-range of criteria used around the world and has the advantage to be consistent with regulations of EU. Their consistent application across the region is necessary. It should also be highlighted that these values were agreed at EU level also considering the ecosystem characteristics of Mediterranean Sea.

[22] The following sources are used in Table 13 and paragraph 52:
NOAA (National Oceanic and Atmospheric Administration) tabulation of the export requirements by country for fish and seafood (among others) (https://www.fisheries.noaa.gov/export-requirements-country-and-jurisdiction-f). Requirements by Australia, Brazil, Chile, China and Equador for trace metals.
EU directives for maximum levels for certain contaminants in foodstuffs (EC/EU 1881/2006 , 1259/2011 Directives and amendments 488/2014 and 1005/2015) .
CODEX Alimentarius international food standards, guidelines and codes of practice. Joint FAO/WHO Food Standards Programme

4.4 The concept for GES assessment regarding Ecological Objective 9

As indicated in this document the work on the assessment criteria is a long way that requires very good quality of data and long time series. There is good progress in the last ten years in developing the assessment criteria, whereby better progress for BC/BAC has been achieved than for EAC. There is room for further reflection on how to upgrade work for calculation of Mediterranean EAC values for IMAP CIs 17 and 18, including by creating a database of scientific literature, as a long-term task, with support of the Online Working Group (OWG) for Contaminants (EO9), in order to complement real-time monitoring data to be reported from the Contracting Parties into IMAP Pilot Info System.

Scientific and expert contribution of the OWG for Contaminants is necessary to ensure analysis of the proposed updated sub-regional and regional BC and BAC values, against the new data to be provided by the members of the OWG or all CPs in the IMAP Info System.

The criteria presently used for IMAP assessments are single parameter criteria. Each parameter is analysed separately to decide if the concentration is above or below the threshold. Considering preparation of the assessment inputs for 2023 MED QSR, it is recommended to aggregate thresholds, that would better describe the environmental status and be a step towards determination of the overall environmental status.

The term aggregation is used for the combination of comparable elements across temporal and spatial scales, indicators and criteria, within IMAP Ecological Objective/Common Indicator (UNEP/MAP WG.509/10.Rev2). Aggregation increases the interpretive value of the individual measurements and may improve the assessment of the overall environmental status of an area or region and is the first step in GES assessment. It is therefore recommended to aggregate the parameters of CI 17 in line with the description in the above-mentioned document and as described below.

The aggregation process starts by assessing the status for an individual element (addressed also as measured parameter or determinant), in one specific matrix, at a specific area. In the case of CI17, there are 3 group of contaminants (TMs, PAHs and organochlorine contaminants) measured in 2 matrices i.e. sediment and biota. All the CI17 elements belong to the contamination category, in contrast to those in CI18, that belong to the bioassay/effects category. The first aggregation step requires a threshold, or assessment criteria against which to compare the measured concentration. The criteria used UNEP/MAP are the MedBACs and the EACs. Comparison of the measured concentration to the criteria can be performed in at least two similar ways: 1) comparison of the measured value to the criteria and flag it as above or below them; 2) calculation the ratio Cmeasured/Cthreshold/, where C is the concentration of the individual element; when the ratio is < 1, the measured concentration is below the threshold and when the ratio is >1, the measured concentration is above it.

Following this initial analysis, a classification is given for each element. (Vethaak et al. 2017) following the "traffic light" system, used also by UNEP/MAP, to classify each element as blue (below BAC value), red (above EAC value) and green (between BAC and EAC values). In addition, the percentage of each classification was calculated for a specific element and matrix in the assessment area and presented graphically. Next, all elements of one category (i.e. group of contaminants in the case of CI 17) were aggregated and classified, followed by aggregations across all matrices and further classified as blue, red or green. In this stepwise way it is possible to follow the individual elements contributions to the final assessment.

A similar approach is given in the CHASE+ (Chemical Status Assessment Tool) methodology used by the European Environmental Agency to assess environmental status categories for the European Seas (Andersen et al. 2016, Anon 2019). The first step towards aggregation is to calculate the ratio Cmeasured/Cthreshold called the contamination ratio (CR) for each assessment element in a matrix. Then a contamination score (CS) is calculated as follows:

$$CS=\frac{1}{\sqrt{n}}\sum_{i=1}^{n}CR_i$$

where n is the number of elements assessed for each matrix.

Based on the contamination score, the elements assessed and the area can be classified into non problem area (NPA) and problem area (PA),by applying 5 categories: NPAhigh (CS=0.0-0.5), NPAgood (CS=0.5-1.0), PAmoderate (CS=1.0-5.0), PApoor (CS=5.0-10.0) and PAbad (CS > 10.0).

Both approaches need to define decision rules to determine the quality status. One decision rule used is the "One out all out approach" (OOAO) that says that if one element of the assessment is not in good status, the area is described as not in GES. This decision rule is very stringent. An additional approach is to set a threshold, such a proportion (%) of elements, that should have < EAC to achieve GES.

In addition to the aggregation of elements, it is necessary to define the spatial extent (spatial assessment units – SAU) and the habitats present in an assessment area. NEAT (Nested Environmental Status Assessment Tool) uses a combination of high-level integration of habitats and spatial units and an averaging approach, allowing for specification on structural and spatial levels, applicable to any geographical scale. The analysis provides an overall assessment for each case study area and a separate assessment for each of the ecosystem components included in the assessment (UNEP/MAP WG.509/10.Rev2). In NEAT, the status of each element is normalized into a scale of 0 to 1, independently of their original scale. Specific boundaries of the indicators (e.g. boundary between moderate and good status) are also normalized. By default, aggregation is done across all indicators belonging to a SAU.

The GES assessment follows specific methods which aggregate and integrate the monitoring data/parameters that are subject of assessmnet (i.e. CHASE+) at appropriate assessment scales and areas (i.e. NEAT). Although GES is not within the scope of the present document and will be elaborated during 2021, at conceptual level it is recommended to apply the first two steps of the GES assessment to the data submitted to IMAP Info System as follows: 1) comparison to thresholds/criteria for each individual element, and 2) computation of the contamination score (CS). The calculations are straightforward and can be done automatically when data are uploaded into IMAP Info System, based on application of present assessment criteria of UNEP/MAP. Once the values are calculated, they can be used with the "traffic light" approach and give an immediate picture of the environmental condition in the monitored area by individual elements and by the aggregated ones. Detailed elaboration of the GES assessment approach will take place after present Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring.

4.5 The way forward

Further to above elaborations, the following actions are recommended:

- The work on the assessment criteria is a long way that requires very good quality of data and long time series. There is good progress in the last ten years in developing the assessment criteria, whereby better progress for BC/BAC has been achieved than for EAC. There is room to further reflect on how to upgrade work for calculation of Mediterranean EAC values for IMAP CIs 17 and 18, including by creating a database of scientific literature, as a long-term task, with support of the Online Working Group (OWG) for Contaminants (EO9), in order to complement real-time monitoring data to be reported from the Contracting Parties into IMAP Pilot Info System.
- Scientific and expert contribution of the OWG for Contaminants is necessary to ensure analysis of the proposed updated sub-regional and regional BC and BAC values, against the new data that are expected to be provided by the members of the OWG or all the Contracting Parties in the IMAP Info System.
- Collection and examination of more monitoring data is needed to proceed with further data aggregation for control of the regional and sub-regional BC and BAC values. The most needed data are for organic contaminants in sediment and biota for all 4 sub-regions, followed by trace metals in biota *(Mytilus galloprovincialis and Mullus barbatus)*. Data for all the parameters are needed for the Central Mediterranean sub-region that is underrepresented in the IMAP database.
- In that respect, it is important to note that one of the directions for future work of the Online Working Group (OWG) for Contaminants (EO9) needs to be related to the analysis of proposed values of the assessment criteria assessing them against the new data that are expected to be

provided by the members of the OWG or all the Contracting Parties in the IMAP Info System. That work will be undertaken in close coordination with the MEDPOL after the present Meeting of the Ecosystem Approach Correspondence Group on Pollution Monitoring.

- Meanwhile, presently updated values of the assessment criteria are proposed for their use within preparation of the inputs for 2023 MED QSR.
- In order to undertake further work aimed at upgrade of the EAC values for IMAP CIs 17 and 18, a long-term task needs to be undertaken as to create database of scientific literature that will complement real time monitoring data to be reported from the Contracting Parties into IMAP Pilot Info System.
- Scientific and expert contribution of the Online Working Group (OWG) for Contaminants (EO9) is also needed to progress towards creating the database of ecotoxicological scientific literature needed for further upgrade of EAC values.
- The criteria presently used for IMAP assessments are single parameter criteria. Each parameter is analysed separately to decide if the concentration is above or below the threshold. In view of the preparation of the assessment inputs for 2023 MED QSR, it is recommended to aggregate thresholds, that would better describe the environmental status and be a step towards determination of the overall environmental status. To that effect the NEAT and CHASE+ approaches should be considered, taking also into account their additional merit to achieve consistency with the EU MSs.
- The mussel *M. galloprovinciallis* and the fish *M. barbatus* are agreed as IMAP mandatory species. However, they may not be always found in all the areas of the Mediterranean Sea. Therefore, the addition of other both mandatory and area specific species to the monitoring program is recommended for further consideration. The species should be chosen based on their presence in the sub-regions, and relevance as pollution indicators, what will allow a better environmental assessment.
- Known contaminants of concern, such as As and Cu, and emerging contaminants of concern, such as pharmaceuticals and flame retardants should be considered for inclusion into IMAP monitoring in the future. Their addition will improve the assessment of the environmental status of the Mediterranean Sea and contribute to a more robust analysis. The decision on which contaminant to add should be based on pilot studies checking the probability of their presence in the Mediterranean Sea and sub-regions. UNEP/MED WG.463/Inf.4 reviewed the literature on the Mediterranean Sea (2014-2019) to draft an update on the priority pollutants for further consideration.
- Infaunal community structure could be also used to detect impacts on biota. It could integrate EO9 with EO1, CI2 – Condition of the habitat's typical species and communities. This could be done in conjunction with the CI2 monitoring, by including the infauna community structure as a required parameter. For example, if based on CI2 monitoring an effect on the benthic community is found, CI17 can be useful to complement the findings, in terms of identification of pressures. Conversely, if contamination is identified based on CI17 monitoring, it could guide the selection of monitoring areas for the species and communities within EO1. Moreover, any impact on the infaunal community structure can be considered a biological effect and be integrated with CI18.

Annex I
Relevant data from the scientific literature

Review of relevant scientific literature

The papers that include data relevant for this document are summarized below. The specific data retrieved from the documents and used for criteria calculation or as comparison to the criteria are detailed in the tables of Annex III. It is important to note that the scientific papers are usually limited in scope, both spatially and temporally. Moreover, they usually include contaminated and reference sites, so care should be taken when utilizing the data for BC calculation or verification. The search was geared towards finding recent data, from samples collected since 2012, and towards data from the southern Mediterranean countries. The review below is organized by the Mediterranean sea sub-regions and within them, by COPs in alphabetical order. Only parameters relevant to IMAP were elaborated.

Western Mediterranean Sea (WMS)

Algeria

Ahmed, I., B. Mostefa, A. Bernard, and R. Olivier. 2018. Levels and ecological risk assessment of heavy metals in surface sediments of fishing grounds along Algerian coast. Marine Pollution Bulletin 136:322-333.

Trace metals (Cd, Pb) were measured in fifty-one sediment samples collected from the Algerian coast in May-June 2015, from 18 to 562 m depth. The study covered the whole Algerian coast, that was divided into 3 regions. Only the results statistics (average, standard deviation, minimum and maximum concentration) are available for each of the 3 areas along the Algerian coast. In addition, the authors proposed reference background concentrations for the area, derived from the analysis of 3 three sediment cores collected in the Bay of Algiers, between 40 and 100m water depth. The proposed backgrounds for Pb and Cd were higher than the average concentrations measured in the surficial sediments along the coast. The data were used for comparison to the MedBCs in this document.

Benali, I., Z. Boutiba, D. Grandjean, L. F. de Alencastro, O. Rouane-Hacene, and N. Chèvre. 2017. Spatial distribution and biological effects of trace metals (Cu, Zn, Pb, Cd) and organic micropollutants (PCBs, PAHs) in mussels *Mytilus galloprovincialis* along the Algerian west coast. Marine Pollution Bulletin 115:539-550.

Organic contaminants (PCBs, PAHs) and trace metals (Pb, Cd) were measured in wild mussel populations of *M. galloprovincialis* collected from 6 stations along the Algerian West coast during the 2014 winter season. Out of the 6 stations, two were described as possible references and were used in the calculation or comparison of BCs in this document. All data for organic contaminants were available, while for TM only ranges, averages and standard deviations were reported.

France

Briant, N., T. Chouvelon, L. Martinez, C. Brach-Papa, J. F. Chiffoleau, N. Savoye, J. Sonke, and J. Knoery. 2017. Spatial and temporal distribution of mercury and methylmercury in bivalves from the French coastline. Marine Pollution Bulletin 114:1096-1102.

Hg and methyl-Hg concentrations were measured in the mussel *M. galloprovincialis* collected from 17 stations located along the French Mediterranean coast. Sampling took place during the first semester (February and March) of 2014, to avoid seasonal variations of concentrations. The authors also address the possible size dependence of the concentrations. Data were available and used in the calculation of BC in this document.

Italy

Esposito, G., A. G. Mudadu, M. C. Abete, S. Pederiva, A. Griglione, C. Stella, S. Ortu, A. M. Bazzoni, D. Meloni, and S. Squadrone. 2021. Seasonal accumulation of trace elements in native Mediterranean mussels (Mytilus galloprovincialis Lamarck, 1819) collected in the Calich Lagoon (Sardinia, Italy). Environmental Science and Pollution Research.

Trace metals (Cd, Hg, Pb) were measured in the mussel *M. galloprovincialis* collected from the euthrophic Calich Lagoon, northwest Sardinia, in 2017. Samplings were conducted in spring, summer and autumn of 2017. The data were given as range, mean and standard deviation for each season. Hg concentrations were higher in the summer, while no significant seasonal variation was found for Cd and Pb. The concentration ranges reported were: Cd – 0.014-0.20 mg/kg ww; Hg- 0.011-0.021 mg/kg ww and Pb- 0.041-0.71 mg/kg ww. Possible seasonal variability in concentrations is an additional factor to be taken into account during BC determination. Data were used for comparison in this document

Morocco

Azizi, G., M. Layachi, M. Akodad, D. R. Yáñez-Ruiz, A. I. Martín-García, M. Baghour, A. Mesfioui, A. Skalli, and A. Moumen. 2018. Seasonal variations of heavy metals content in mussels (*Mytilus galloprovincialis*) from Cala Iris offshore (Northern Morocco). Marine Pollution Bulletin 137:688-694.

Trace metals (Cd, Pb) concentrations were measured in soft tissues of *M. galloprovincialis* collected from an aquaculture farm in Cala Iris sea of Al Hoceima. The mussels were sampled monthly from January to December 2016. Cd concentrations depended on the season, and ranged from an average 0.89 mg/kg dw in winter to 0.65 mg/kg dw in summer. Pb concentrations were <0.03 mg/kg dw. Data were used for comparison in this document

Spain

Martínez-Guijarro, R., M. Paches, I. Romero, and D. Aguado. 2019. Enrichment and contamination level of trace metals in the Mediterranean marine sediments of Spain. Science of the Total Environment 693:133566.

Trace metals (Cd, Hg, Pb) were measured in sediment samples collected along the Valencian community coastline, in 2010-2012 and 2015. Most of the data were not recent. However, the authors provided the baseline concentrations for the area: Cd- 0.24 mg/kg; Hg- 0.06 mg/kg; Pb- 8.6 mg/kg. Cd concentrations in the North-central areas were higher than in the southern area of the Valencian coast, probably due to natural differences due to different natural minerology. Hg and Pb concentrations were not significantly different among the areas. Data were used for comparison in this document.

Campillo, J. A., B. Fernández, V. García, J. Benedicto, and V. M. León. 2017. Levels and temporal trends of organochlorine contaminants in mussels from Spanish Mediterranean waters. Chemosphere 182:584-594.

Organochlorine contaminants (PCBs and Pesticides) were measured in the mussel *M. galloprovincialis* collected along the Spanish Mediterranean coast from, 2000 to 2013. Sampling took place in 24 areas, with varying degrees of contamination during the months of May and June. The designated reference areas were the protected marine reserves (Medas and Columbretes Islands) or the marine protected area of La Herradura. The determinations were performed in pooled samples of 8 specimens within one size interval, 3.0-3.9 cm, showing that size may influence concentration. Most of the data were not recent, but they were used to determine the temporal trends in the concentrations of these contaminants. The authors provided calculated background concentrations for PCBs and p,p'-DDE in the mussel. Those were used for comparison in this document.

Central Mediterranean Sea (CEN)

Italy

Bonsignore, M., S. Tamburrino, E. Oliveri, A. Marchetti, C. Durante, A. Berni, E. Quinci, and M. Sprovieri. 2015. Tracing mercury pathways in Augusta Bay (southern Italy) by total concentration and isotope determination. Environmental Pollution 205:178-185.

Hg concentrations were measured in sediment and fish from the Augusta Bay, Sicily, during June 2012. The bay was considered extremely polluted with Hg due to the discharges from a chlor-alkali plant. The data were available from the paper. However, the concentrations in the sediments were very high (14.7 ± 12.3 mg/kg) and not taken into consideration. The concentrations in the various fish species (median of 340 mg/kg ww) were also high. They are mentioned in Annex III but were not taken into the BC calculation.

Tunisia

Zaghden, H., M. Tedetti, S. Sayadi, M. M. Serbaji, B. Elleuch, and A. Saliot. 2017. Origin and distribution of hydrocarbons and organic matter in the surficial sediments of the Sfax-Kerkennah channel (Tunisia, Southern Mediterranean Sea). Marine Pollution Bulletin 117:414-428.

Polycyclic aromatic hydrocarbons (PAHs) and organic matter (OM) were measured in surficial sediments of the Sfax- Kerkennah channel in the Gulf of Gabès. OM and PAH concentrations ranged 2.3–11.7% dw and 175–10,769 ng/g sed. dw, respectively. The sampling took place in January 2005 therefore the data were not taken for the calculation of the updated BC. The study is mentioned here as it could be used for temporal assessment.

Naifar, I., F. Pereira, R. Zmemla, M. Bouaziz, B. Elleuch, and D. Garcia. 2018. Spatial distribution and contamination assessment of heavy metals in marine sediments of the southern coast of Sfax, Gabes Gulf, Tunisia. Marine Pollution Bulletin **131**:53-62.

Trace metals (Cd, Pb) were measured in surface marine sediments collected from the Southern coastal line of Sfax to the northern edge of the Gabes Gulf (south-east of Tunisia) in March 2016. The study was localized, covering an area approximately of 4.3 km^2. Chemical analysis was performed on the particle size fraction of<63 µm. Only ranges, averages and standard deviations were reported. Most of the sites studied were polluted. The authors also report background values for the area, calculated from the concentrations in marine sediments collected 8 km away from the study area. Those were used for comparison in this document.

Jebara, A., V. Lo Turco, A. G. Potortì, G. Bartolomeo, H. Ben Mansour, and G. Di Bella. 2021. Organic pollutants in marine samples from Tunisian coast: Occurrence and associated human health risks. Environmental Pollution 271:116266.

Organic contaminants (PAHs, PCBs and pesticides) were measured in sediments and in fish (*Sparus aurata* and *Sarpa salpa*) muscle tissue collected from five stations along the Tunisian coast between May 2018 and March 2019. No station was characterized as reference or hot spot. The data were presented as an average and standard deviation for each sampling station and compound. In this document, the concentrations reported are the averages of the station's averages for each compound (Tables A3.4-A3.5, Annex III).

Aegean Levantine Sea (AEL)

Egypt

El Baz, S. M., and M. M. Khalil. 2018. Assessment of trace metals contamination in the coastal sediments of the Egyptian Mediterranean coast. Journal of African Earth Sciences 143:195-200.

Trace metals (Cd, Pb) were measured in sediments from the central Egyptian coast, from El Mex to Port Said. The sampling date was not mentioned. The data were reported as ranges and averages. Cd ranged from 0.06 to 0.42 mg/kg with average of 0.16 mg/kg and Pb from 5.3 to 57 mg/kg with average 14.8 mg/kg. The authors used the concentrations in shale as background values. Data were given for comparison in this document.

Greece

Karageorgis, A. P., F. Botsou, H. Kaberi, and S. Iliakis. 2020. Geochemistry of major and trace elements in surface sediments of the Saronikos Gulf (Greece): Assessment of contamination between 1999 and 2018. Science of the Total Environment 717:137046.

Pb was measured in sediments from the Saronikos Gulf, Greece. The paper presents data on a long time series, from 1999 to 2018. For this document, only data since 2016 were taken into account (2016: n = 14; 03/2017: n = 13; 09/2017: n =22; 10/2017: n = 15; 11/2017: n = 23; 01/2018: n = 28). The authors also determined background concentrations using sediment cores. The BCs were different and specific for each of the 5 areas of the Saronikos Gulf.

Lebanon

Ghosn, M., C. Mahfouz, R. Chekri, B. Ouddane, G. Khalaf, T. Guérin, R. Amara, and P. Jitaru. 2020. Assessment of trace element contamination and bioaccumulation in algae (*Ulva lactuca*), bivalves (*Spondylus spinosus*) and shrimps (*Marsupenaeus japonicus*) from the Lebanese coast. Regional Studies in Marine Science 39:101478.

Trace metals (Cd, Hg, Pb) were measured in 3 sediment samples and in the soft tissue of bivalve (*Spondylus spinosus*) collected from 3 sites along the Lebanese coast during the dry and wet seasons in 2017. Saida (site 3) is less impacted and possible reference, however, concentrations in sediments from all 3 stations were taken for the calculation of BCs in this document.

Ghosn, M., C. Mahfouz, R. Chekri, G. Khalaf, T. Guérin, P. Jitaru, and R. Amara. 2020. Seasonal and Spatial Variability of Trace Elements in Livers and Muscles of Three Fish Species from the Eastern Mediterranean. Environmental Science and Pollution Research 27:12428-12438.

Trace metals (Cd, Hg, Pb) were measured in liver and muscle tissue of two demersal fish species (*Siganus rivulatus* and *Lithognathus mormyrus*) and one pelagic species (*Etrumeus teres)* collected from 3 sites along the Lebanese coast during the dry and wet seasons in 2017. Data was given as statistics per site and season. The data presented in Table A3.3, Annex III, are the average of averages concentrations reported for the muscle tissue.

Annex II
Critical examination of the new data used to calculate and propose updated BC and BAC values

New relevant data not used previously neither for the 2017 MED QSR nor for update of the assessment for EO9 within preparation of the 2019 SoED were collected from the following 4 data sources:

1. New data from IMAP Pilot Info System that include national monitoring data uploaded in the system during its testing phase, and in particular after launching formal call for reporting of data in June 2020;
2. New data from the MEDPOL Database not used previously for calculation of assessment criteria;
3. The EU data center (European Marine Observation and Data Network - EMODnet);
4. Published papers collected from the scientific literature.

Details of the available data from these sources, sorted by parameters (trace metals, organic contaminants, organochlorine contaminants) and matrices (sediment, mussel and fish) are given below.

In general, and if sufficient, all data from IMAP, MEDPOL and EMODnet were used in the calculation of proposed updated MedBC. Values identified as outliers and BDL values were not used in the calculation. Data from the scientific literature were used only if the values were given in the manuscript. Statistical values (range, mean, standard deviation) could not be used in the calculation but were given in the tables below for comparison.

Trace metals (Cd, Hg, Pb) in sediments

A summary of the new data available for the determination of background concentrations (BC) of trace metals in sediments is presented in Table A3.1. The concentrations of Cd in Cyprus were much higher than the MedBACs and even higher than the MedEAC agreed upon in Decision IG.23/6. Although the concentrations are natural, they are anomalously high, probably due to specific local minerology. Therefore, they were not used in the BC calculation. The same is true for PB. The Hg concentrations in all samples were BDL (<15 µg/kg dw).

Cd in Montenegro, Morocco and Lebanon were higher than MedBACs agreed upon in Decision IG.23/6 and the respective sub-regional values (Table 1, Section 2). However, the data were used in the calculation of proposed updated BC/BACs. All Hg available data were below the MedBAC as well as data for Pb (except for Cyprus).

Table A3.1. Summary of the new data available for trace metals (Cd, Hg, Pb) in sediments. The table presents also the criteria endorsed by UNEP/MAP and the proposed updated BCs as also given in Table 10 (Section 4). n is the number of available data points, and the column "data used for update" indicates if the data were used in the calculation of the proposed updated BCs. The concentrations are given in µg/kg dw, as requested by IMAP.

SEDIMENT	**Data used for update**	**Cd**			**Hg**			**Pb**		
		Mean	Median	n	Mean	Median	n	Mean	Median	n
IMAP, MEDPOL										
Cyprus, 2013-2018	N	2632	2700	22	BDL <15		22	31523	37500	22
^Israel, 2015	Y	81.3		1	36.1	22.5	10	4305	4233	10
Israel, 2017	Y	37.9	37.5	11	40	25	10	6038	5837	12
Montenegro, 2018	Y	265	265	4	44.5	44.2	4	5875	6350	4
Morocco, 2016-2018	Y	290#	290#	21				5614	3900	25
Morocco, 2016-2018	N				BDL <20		21			

SEDIMENT	Data used for update	Cd			Hg			Pb		
		Mean	Median	n	Mean	Median	n	Mean	Median	n
Tunisia, 2014	N	BDL <20		9				BDL <50		9
Tunisia, 2014	Y				16.8	6.3	6			
^Turkey, 2015	Y	80.2	86.9	7	66.4	56.5	7	19025	18977	7
EMODNet										
Croatia, 2017	Y	124	112	35	40.2	36.6	29	21439	21852	35
[&]France, 2016	Y	80	80	35	40.8	25.0	34	18512	16000	33
Italy, 2016 (ADR)	Y				60	50	4	22600	23050	4
Italy, 2016 (ADR)	N	BDL		2						
Literature										
Algeria (Ahmed et al. 2018)	N	200± 90						27300± 8400		
Idem, BC	N	500± 200						34000± 7000		
Egypt (El Baz and Khalil 2018)	N	160						14750		
Greece (Karageorgis et al. 2020)	Y							27544	23950	78
Idem, BC	N							5000-46000		
Lebanon (Ghosn et al. 2020b)	Y	225	225	2	87	70	3	9300	7250	3
Idem, BC	N		130			70		3350		
Spain (Martínez-Guijarro et al. 2019) BC	N	240				60		8600		
Tunisia (Naifar et al. 2018) BC	N	140						4680		
Proposed updated MedBCs			**116**			**32.6**			**15900**	
***Med BCs**			**85**			**53**			**16950**	
*Med BACs			127.5			79.5			25425	
*Med EACs			1200			1500			46700	

Y – yes; N- no, # without data for 2016. Most data below detection limit of 400 µg/kg, ^ used in 2019 SoED, [&]23 out of 37 data points used in 2019 SoED; * Decision IG.23/6. MedBCs were calculated by dividing MedBAC by 1.5.

Trace metals (Cd, Hg, Pb) in biota

A summary of the new data available for the determination of background concentrations (BC) of trace metals in biota is presented in Table A3.2 for molluscs and in Table A3.3 for fish muscle. Proposed updated MedBCs were calculated only for the IMAP mandatory species *M. galloprovincialis* and *M. barbatus*. Data for other species were given for comparison.

Cd concentrations in the soft tissue of the mussel (*M. galloprovincialis)* were higher than the MedBACs agreed upon in Decision IG.23/6 for France (2015, median), as well as the maximal concentration in Algeria. They were also higher than the sub-regional WMS BC calculated in 2019. Median Hg concentrations in Montenegro and Slovenia were higher than the MedBAC agreed upon in Decision IG.23/6. The maximal Pb concentration in Algeria was higher than the MedBAC. All data available from IMAP and MEDPOL for M. galloprovincialis and Hg from the literature (Briant et al., 2017) were used in the calculation of the proposed updated BCs. Additional data from the literature could not be used because only the statistics were available.

Table A3.2. Summary of the new data available for trace metals (Cd, Hg, Pb) in molluscs[23]. The table presents also the criteria endorsed by UNEP/MAP and the proposed updated BCs for the soft tissue of the mussel (*M. galloprovincialis)* as given in Table 12 (Section 4). n is the number of available data points, and the column “data used for update” indicates if the data were used in the calculation of the proposed updated BCs. The concentrations are given in μg/kg dry wt, as requested by IMAP.

Country	Data used for update	Species	Values	dw/ ww	Cd	n	Hg	n	Pb	n
M. galloprovincialis										
IMAP, MEDPOL										
^France, 2015	Y	MG	Mean	dw	1020	24	119	24	1309	24
			Median	dw	1105		132		1270	
Montenegro 2018	Y	MG	Mean	#	47.4	8 (4)	398	8	107	8
		MG	Median	#	40		370		100	
Slovenia 2017-2018	Y	MG	Mean	#	96	6	215	3	159	3
			median	#	92		250		123	
EMODNet										
France, 2017	Y	MG	Mean	dw	603	3	BDL	3	1430	3
			Median	dw	680				1190	
Italy, 2015-2017		MG								
WMS	Y		Mean	dw	125	3	48.1	11		
			Median	dw	0.5		30.0			
CEN	Y		Mean	dw	263	4	33.9	8	250	4
			Median	dw	78		12.3		250	
ADR	Y		Mean	dw			61.9	32		
			Median	dw			42.0			
Literature										
Algeria (Benali et al. 2017) BC	N	MG$	Range		530-1770				1270-2910	
France (Briant et al. 2017)	Y	MG	Mean	dw			143			
			Median	dw			140			
Italy (Esposito et al. 2021)										
Spring	N		Mean	dw	410±275		65±0.5		950±700	
Summer	N		Mean	dw	165±30		105±0.5		355±65	
Autumn	N		Mean	dw	250±360		55±0.5		1000±1255	
Proposed updated MedBCs		**MG**		dw	**490**		**82.8**		**1090**	
***MedBC**		**MG**		dw	**730**		**115.5**		**1542**	
*MedBAC		MG		dw	1095		173.2		2313	
*MedEAC		MG		dw	5000		2500		7500	
Molluscs (not MG) from IMAP and MEDPOL										
^Israel 2015	N	MC	Mean	dw	187		200			
			Median	dw	106		188			
Israel 2017	N	MC		dw	<55, 403		468, 609			

[23] It should be noted that the BC concentrations may be species specific

Country	**Data used for update**	**Species**	**Values**	**dw/ ww**	**Cd**	**n**	**Hg**	**n**	**Pb**	**n**
Morocco 2016-2018	N	CaCh	Mean	ww	0.133		0.03		0.363	
		CaCh	Median	ww	0.130		0.03		0.33	
		CaCh	Median	dw&	0.65		0.15		1.65	
Tunisia 2014	N	ML	Mean	#			36			
			Median	#			36			
	N	RD	Mean	#			49			
			Median	#			46			

MC – *Mactra corralina*, MG- *Mytilus galloprovincialis ;* CaCh- *Callista chione*; RD- *Ruditapes decussatus;*
*Decision IG.23/6, MedBC calculated by dividing MedBAC by 1.5; # Dry or wet wt not specified. Assumed the concentrations were given in dry wt as requested by IMAP. &dry wt calculated assuming 20% dry wt, as for MG; ^ used in 2019 SoED; $Concentrations are given for gills, digestive gland and mantle in separate. concentration ranges include data from the 3 organs.

Data for TM (Cd, Hg and Pb) in the muscle of *M. barbatus,* were available only for Israel (2015), Turkey (2015) and Lebanon (2019). Therefore, a proposed BC could be calculated just for the AEL sub-region (See Table 12, Section 4). Data for species other than *M. barbatus* are given in Table A3.3 for comparison.

Table A3.3. Summary of the new data available for trace metals (Cd, Hg, Pb) in fish. Criteria endorsed for the muscle tissue of the fish *M. barbatus* in Mediterranean Sea are also presented in the table, for comparison. The concentrations are given in µg/kg wet wt, as requested for IMAP. Updated BCs were proposed only for *M. barbatus*, the mandatory species, for the AEL sub-region. No data were available for the other sub-regions

Country	Species	Values	Cd	n	Hg	n	Pb	n
IMAP, MEDPOL, *M. barbatus.*								
^Israel, 2015	MB	Mean	BDL<5.3	28	30.3	28		
		Median			25.1			
Lebanon, 2019	MB	Mean	0.30	14	6.67	12	6.46	14
		Median	0.19		4.27		5.07	
^Turkey, 2015	MB	Mean	4.1		36.5	48	17.1	25
		Median	4.0		32.2		16.4	
***MedBC**	MB		**#3.7**		**50.6**		**#31**	
*MedBAC	MB		#3.7		101.2		#31	
*MedEAC	MB		50		1000		300	
IMAP, MEDPOL, other fish species								
Croatia 2012	CC		BDL<5.8	4	BDL<3.8	4	bdl<8.7	4
Israel 2017-2018	DS	Mean	23.0	6	123	22		
		Median	BDL<5.3	16	113			
	LM	Mean	BDL<5.3	27	39	28		
		Median	52.2	1	35			
	SR	Mean	BDL<5.3		6.3	11		
		Median			5.6			
	SRD	Mean	22.3, 20.5		68	20		
		Median	BDL<5.3	18	84			
Lebanon, 2019	DS	Mean	0.67	11	28.6	10	1.15	9
		Median	0.35		30.1		0.97	
	EA	Mean	0.21	13	11.4	15	0.34	13
		Median	0.19		7.63		0.26	

Country	Species	Values	Cd	n	Hg	n	Pb	n
Literature								
&Italy (Bonsignore et al. 2015)	Various	Mean			615			
		Median			340			
Lebanon (Ghosn et al. 2020a)	SR	Mean	0.6		2.5		15.4	
	LM	Mean	0.1		13.4		2.1	
	ET	Mean	1.5		20.1		15. 2	

MB- *Mullus barbatus*; CC- *Conger conger* ; DS- *Diplodus sargus*, EA- *Euthynnus alletratus* , ET- *Eturmeus teres*, LM- *Lithognathus mormyrus*, SR- *Siganus rivulatus*, SRD- *Sargocentrum rubrum.* - *Decision IG.23/6, MedBC calculated by dividing MedBAC by 2; #most data BDL, ^ used in 2019 SoED, &polluted area

Organic contaminants (PAHs) in sediments

A summary of the new data available for the determination of background concentrations (BC) of PAHs in sediments is presented in Table A3.4. The mean and median concentrations were calculated without values identified as outliers. The new data from IMAP /MEDPOL consisted mainly of the sum of 16 PAHs congeners. The sum of PAHs is not a parameter endorsed by UNEP/MAP but it is recommended to add it as a mandatory IMAP CI monitoring parameter. The sum of PAHs measured in Montenegro in 2018 had an average and median concentrations of 6158 and 5675 µg/kg dry wt, respectively and in Slovenia (2013-2016, 2018) an average and median concentrations of 283 and 224 µg/kg dry wt, respectively. The concentrations in Montenegro, whose stations were classified as hot spot, were higher than the ERL for the sum of PAHs of 4022 µg/kg dry wt. However, as mentioned, this ERL value is not recommended as an assessment criteria for the Mediterranean. Slovenia reported concentrations of specific PAHs compounds in the sediments in 2016 (7 stations) (Table A3.4). All the reported concentrations were lower than the proposed EACs; the concentrations of most the compounds were higher than the respective MedBCs. Data from France (2016) from EMODNet, showed concentrations higher than the MedBCs for most compounds while the data from the literature for Tunisia was lower than the MedBCs for the 7 compounds measured. Table A3.4 shows, for comparison, the proposed BC concentrations for the Atlantic coast of Spain. The values computed from samples taken from sediment cores sampled from Spain's Atlantic coast are mostly similar to those calculated from sediment cores from the Mediterranean Sea. The data were very limited and updated BCs could not be proposed for the Mediterranean Sea.

Table A3.4. Background concentrations (BC) calculated for PAHs in sediments for the Mediterranean Sea in 2011. Concentrations are given in µg/kg dry wt, as requested by IMAP. The BC concentrations proposed for the Atlantic coast of Spain are given for comparison.

PAH compounds	UNEP/MAP (2011) BC		MEDPOL data	EMODnet	Literature	Literature
	Sed cores	Sur sed	$Slovenia 2016	#France, 2016	^Tunisia, 2018-19	&Spain, 2011-2012
Naphthalene (N)	4		BDL	8.8		2.81
Acenaphthylene (ACY)	0.5	1.05	BDL	0.0	0.39	0.35
Acenaphtene (ACE)	0.38	0.45	BDL	4.7		0.29
Fluorene (F)	0.75	0.33	15	7.5	0.35	1.47
Phenanthrene (P)	4.55	3.95	18	22.5	0.77	4.55
Anthracene (A)	0.8	1.56	BDL	5.0	0.65	1.2
Fluoranthene (FL)	5.6	6.7	7	32.2		4.62
Pyrene (PY)	10.28	2.1	12	22.4	0.39	4.23
Benzo[a]anthracene (BaA)	3.45	1.28	11	20.9		2.01

PAH compounds	UNEP/MAP (2011) BC		MEDPOL data	EMODnet	Literature	Literature
	Sed cores	Sur sed	$Slovenia 2016	#France, 2016	^Tunisia, 2018-19	&Spain, 2011-2012
Chrysene (C)	1.3	6.64	6	37.6	1.47	3.02
Benzo(b)fluoranthene (BbF)	1.1	8.32	23	9.3		5.44
Benzo(k)fluoranthene (BkF)	0.53	6.03	12	7.8		2.76
Benzo[a]pyrene (BaP)	2.55	3.71	BDL	2.6	2.12	2.61
Benzo[g.h,i]perylene	1.25	3.25	18	5.0		2.47
Dibenzo[a,h]anthracene	0.18	1.37	9	0.0		1.04
Indeno[1,2,3,c,d]pyrene	1.7	4.49	12	0.0		2.26
Sum 16 PAHs*	10.3	51.2	143	186	6.0	41.1

$ Median of 7 data points, not including BDLs # Median of 29 data points, including BDLs set as 0. ^(Jebara et al. 2021), median of 5 data points; &(Pérez-Fernández et al. 2019), Sediment cores from the Spanish Atlantic coast; *calculated from concentrations of individual compounds.

Organic contaminants (PAHs) in biota

A summary of the new data available for the determination of background concentrations (BC) of PAHs in biota is presented in Table A3.4. The data in biota are even more lacking than the data for sediments, and updated BCs could not be proposed for the Mediterranean Sea. PAHs were measured in only 6 samples of *M. galloprovincialis*, and in fish muscle. The latter has no endorsed criteria for the Mediterranean Sea.

Table A3.4. Background concentrations (BC) calculated for PAHs in mussel (*Mytilus galloprovincialis*) soft tissue for the Mediterranean Sea and sub-regions in 2016 and 2019. The table also presents the MedBAC and EAC values endorsed in Decisions IG.22/7 and IG.23/6. Concentrations in mussel are given in μg/kg dry wt, as requested by IMAP. The concentrations in fish muscle are in wet weight.

	Decisions IG.22/7 and Decision IG.23/6		BC, UNEP/MAP (2019)				EMODNet	Literature	Fish	
	MedBAC	MedBC*	Med	WMS	ADR	AEL	France 2017 (n=2)_	^Algeria, n=4	#Tunisia, n=5	
PAH compounds									SAU	SS
Naphthalene			(2.4) #	2.24		2.80		20.2		
Acenaphthylene			(0.6) #					0.8		
Acenaphtene			(0.6) #					1.9	BDL	BDL
Fluorene	2.5	1.7	1.0	0.96	1.07	0.60		7.9	2.13	1.56
Phenanthrene	17.8	11.9	7.1	4.93	9.04	7.55	7.7	23.6	2.03	1.82
Anthracene	1.2	0.8	0.5	0.52	0.38	0.30	0.7		2.56	1.89
Fluoranthene	7.4	4.9	3.0	3.38	2.03	6.60	11.3	6.9		
Pyrene	5.0	3.3	2.0	3.02	0.85	5.90	7.2	9.0	2.68	1.53
Benzo[a]anthracene	1.9	1.3	0.8	1.20	0.53	1.60	3.1	2.1		
Chrysene	2.4	1.6	1.0	1.24	0.27	5.20	7.1	6.3	BDL	BDL
Benzo(b)fluoranthene							5.0	4.3		
Benzo(k)fluoranthene	1.4	0.9	0.6	1.27	0.29	1.50	2.7	0.7		
Benzo[a]pyrene	1.2	0.8	0.5	0.60	0.32	0.70	1.6	2.1	BDL	BDL
Benzo[g.h,i]perylene	2.3	1.5	0.9	0.90		1.20	2.5	4.0		
Dibenzo[a,h]anthracene	1.3	0.9	0.5	0.53			0.4			
Indeno[1,2,3,c,d]pyrene	2.9	1.9	1.2	1.23		0.90	2.5	1.8		

	Decisions IG.22/7 and Decision IG.23/6		BC, UNEP/MAP (2019)				EMODNet	Literature	Fish	
	MedBAC	MedBC*	Med	WMS	ADR	AEL	France 2017 (n=2)_	^Algeria, n=4	#Tunisia, n=5	
Sum 16 PAHs							51.8	84.6		

* Calculated as MedBC=MedBAC/1.5; SAU -Sparus aurata and SS- Sarpa salpa; ^ (Benali et al. 2017) ; #(Jebara et al. 2021).

Organochlorine contaminants (PCBs and pesticides) in sediments and biota

A summary of the new data available for the determination of background concentrations (BC) of organochlorine contaminants (PCBs and pesticides) in sediment and biota are presented in Tables A3.5-A3.6. As for the PAHs, the data were very limited and updated BCs could not be proposed for the Mediterranean Sea. The concentrations given in Table A3.5 are lower than the MedEACs for all compounds except for CB118 in France, that was much higher and as a result, also the sum of 7 PCBs was higher than the EAC.

Table A3.5. Summary of the new data available for organochlorine contaminants in sediments. Criteria endorsed by Decisions IG.22/7 and Decision IG.23/6 for in Mediterranean Sea are also presented in the table, for comparison. The concentrations are given in µg/kg dry wt, as requested for IMAP.

	EMODNet	Literature		
	France 2016, n=28	#Tunisia, n=5	EAC* IG.22/7	MedEAC* IG.23/6
CB28	BDL	0.11		1.7
CB52	BDL	0.11		2.7
CB101	BDL	BDL		3
CB118	17.1	BDL		0.6
CB138	0.1	0.10		7.9
CB153	0.2	0.17		40
CB156[%]	2.6			
CB180	BDL	0.13		12
Sum 7 PCBs	17.4	0.62	11.5	
Pesticides				
γ-HCH (Lindane)	0.12[&]		3	
DDE(p,p')	0.25[^]	0.37	2.2	
Hexachlorobenzene			20	
Dieldrin		0.63	2	

[&]average of 2 results, without 26 BDLs, [^]median of 22 results with 6 BDLs as 0. Median without BDL is 0.30 µg/kg dw), [%] not one of the 7 PCBs included in sum; # Jebara et al., 2021

Organochlorine contaminants in *M. galloprovincialis* were lower than the MedEACs, except for CB118 (France, 2017) that was two orders of magnitude higher than the criteria. However, as stated, BC cannot be calculated based on the low number of data points, and the localized area of sampling. Table A3.6 summarizes also the available data in fish muscle, not normalized for lipid content.

Table A3.6. Summary of the new data available for organic contaminants in molluscs and fish. Criteria endorsed by Decisions IG.22/7 and Decision IG.23/6 for the soft tissue of the mussel (*M. galloprovincialis)* in Mediterranean Sea are also presented in the table, for comparison. The concentrations units are specified in the table.

PCBs	Mussel MG	IMAP MG	EMODnet MG	Mussel CaCH	Fish	CC	SAU	SS
	EAC IG.22/7 and IG.23/6	^France, 2015 n=8-23,	France, 2017 n=2	Morocco, 2016-2018 medians	EAC IG.22/7 and IG.23/6	Croatia 2012 n=2	#Tunisia n=4	#Tunisia n=5
	µg/kg dw				µg/kg lipid	µg/kg dw	µg/kg ww	
CB28	3.2	BDL	0.02	0.16 (n=2)	64		0.64	0.78
CB52	5.4	0.34	0.1	0.537 (n=1)	108		0.31	0.32
CB101	6	0.59	0.3	0.112	120		0.23	0.28
CB118	1.2	0.53	233		24		0.46	0.36
CB138	15.8	1.76	0.5	0.158	316		0.50	0.46
CB153	80	2.82	1.6	0.349	1600		0.65	0.55
%CB156			28.2					
CB180	24	0.4	0.1	0.202	480		0.63	0.50
Sum 7 PCBs		6.44	235				3.36	2.89
Pesticides								
γ-HCH (Lindane)	1.45				11 µg/kg ww			
DDE(p,p')	5-50					0.66	0.18	0.08
Hexachlorobenzene						<0.05		
Dieldrin	5-50					0.14 (n=2)	9.09	14.7

MG – *Mytillus galloprovincialis*, CaCh- *Callista chione* , CC- *Conger conger*; SAU -*Sparus aurata* and SS- *Sarpa salpa* ; ^Used in SoED, 2019; Median calculated without BDLs # Jebara et al., 2021

Annex III
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