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Development and Implementation of Marine Contaminant Threshold Values

MSFD Expert Network on Contaminants

Tornero, V, Deviller, G, Hanke, G, Coatu, V, do Carmo Alves Martins, I, Fryer, R, Hjermann, D, Iglesias Campos, A, Knezevic, J, Künitzer, A, Maggi, C, Mauffret, A, McHugh, B, Mil-Homens, M, Munch Christensen, A, Oros, A, Parmentier, K, Pirntke, U, Raimundo, J, Rowe, O, Smit, E, Van der Stap, I, Viñas, L, Zalewska, T

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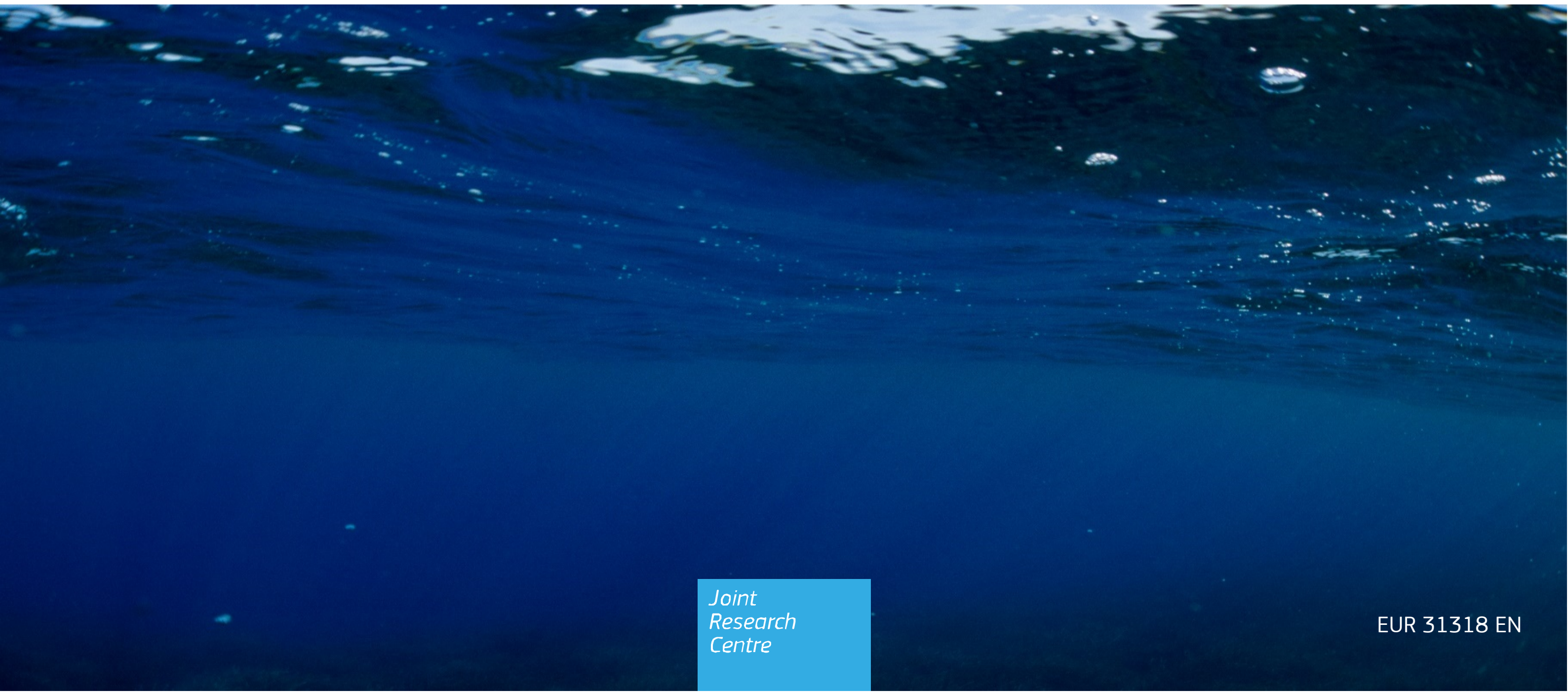

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Contents

Abstract

This report compiles available Threshold Values (TVs) for marine chemical contaminants at EU, regional and beyond EU level, provides relevant information and discussion points for TV derivation and implementation, and outlines the main hindrances and potential approaches to fill the gaps. This document is a product of the MSFD Expert Network on Contaminants and is intended as a background guidance document to support developments to improve consistency in marine contaminant assessments.

The report highlights the reality of the lack of knowledge about reference values (whether they are background, threshold or Environmental Quality Standard values) for many contaminants in the marine environment. Although regulations and frameworks are in place, and new ones are being implemented, the assessment of Good Environmental Status will remain difficult without high quality environmental and toxicological data. The variety of applied TVs is hindering a comparable assessment of problematic substances and the necessary reduction/phase-out measures. Considering the huge work needed to develop TVs and the high number of potential contaminants, current approaches need to be reviewed. Furthermore, the concerns on the environmental significance of TVs when they are not based on sufficient data and relevant assessment factors, and the difficulty to generalise TVs for all matrix/species monitored, call for discussions on resource-efficient TV development and potential alternative ways forward.

Foreword

The Marine Directors of the European Union and all EU Member States have jointly developed a common strategy for supporting the implementation of Directive 2008/56/EC, the "Marine Strategy Framework Directive" (MSFD). The focus of the strategy is on methodological questions relating to a common understanding of the technical and scientific implications of the MSFD. In particular, one of the objectives of the strategy is the development of non-legally binding technical guidance, such as this report, on various technical issues under the Directive.

The MSFD Expert Network on Contaminants led by the European Commission Joint Research Centre, is delivering thematic technical reports such as "Marine chemical contaminants – support to the harmonization of MSFD D8 methodological standards" and "Guidance on potential exclusion of certain WFD priority substances from MSFD monitoring beyond coastal and territorial waters". These thematic reports are targeted at those experts who are directly or indirectly implementing the MSFD in the marine regions.

This Technical Report should further support EU Member States in their development and implementation of threshold values concerning chemical contaminant assessments.

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1 Introduction

European Member States (MS) are collaborating in the context of the Marine Strategy Framework Directive 2008/56/EC (MSFD) (1) for the protection of the Ocean. The holistic approach, needed to consider different anthropogenic pressures and the complexity of the marine ecosystem, requires agreement on technical issues among EU MS and with neighbouring frameworks. The MSFD Expert Network on Contaminants, led by the European Commission Joint Research Centre, has therefore been set-up to compile, discuss and agree on technical scientific aspects of the MSFD implementation. Through the MSFD Commission Decision (EU) 2017/848 (2), adopted in June 2017, MS committed to abide by common criteria and methodological standards when defining the concept of 'Good Environmental Status' (GES) in quantitative terms for the marine waters.

Marine Pollution, including chemical contaminants, is among the pressures that can hinder achieving GES. The input of contaminants into the marine environment is considered under MSFD descriptor 8 (Concentrations of contaminants are at levels not giving rise to pollution effects) and descriptor 9 (Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards).

According to the MSFD GES Decision, for each contaminant under criterion D8C1, MS shall express its concentration, the matrix used for monitoring (water, sediment, biota), whether the threshold values set have been achieved, and the proportion of contaminants assessed which have achieved the threshold values. For the contaminants already identified under the Water Framework Directive 2000/60/EC (WFD) (3), the threshold values should be the values set in accordance with that Directive (Environmental Quality Standards, EQS) (4). For contaminants measured in a matrix for which no value is set under the WFD, as well as for additional contaminants, the threshold values for a specified matrix should be established through regional or subregional cooperation, as long as they provide at least the same level of protection.

MSFD D9 requests MS to assess the level of contaminants in edible tissues of fish and other seafood against regulatory levels established by Union legislation or other relevant standards. MS shall provide for the contaminants listed in Food Regulation (EC) No 1881/2006 (5) and may assess additional contaminants and establish their threshold levels through regional or subregional cooperation.

Environmental assessments of chemical contaminants require fit-for-purpose toxicological and exposure data:

a) The monitoring of environmental concentrations in relevant matrices with agreed protocols, to provide large-scale comparable data.
b) Threshold Values (TVs) that are scientifically based and provide a societal agreement on trigger values to launch mitigation actions against chemical contamination.

Besides the need to derive such TVs for understanding potential harmful effects, they are also crucial in a policy context as they are required for compliance checking, enabling an enforced implementation of environmental protection legislation.

The successful implementation of the MSFD requires thus the availability of TVs for relevant chemical contaminants in the marine environment.

TVs are typically derived through experimental studies that comprise the exposure of model organisms to establish the levels at which chemical substances have effects on the animals, their organs or biochemical pathways.

(1) Directive 2008/56/EC of the European Parliament and of the council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).
(2) Commission Decision (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU.
(3) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy.
(4) Directive 2013/39/EU of the European parliament and of the council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy.
(5) Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs.

Mesocosm studies provide a more complex set-up, where different organisms are studied in a simulated natural environmental setup. These practical studies are performed according to agreed protocols and guidelines (e.g., OECD) ([6]), in the context of chemical regulations (e.g., REACH) ([7]). Also, the modelling of Quantitative Structure-Activity Relationship (QSAR) between functional groups of the investigated chemicals and the harmful effects through biochemical receptors for the different pathways has emerged as an alternative to experimental tests for the derivation of TVs.

This report is compiling relevant information and outlining the issues on marine TV development and implementation. It has been prepared within the MSFD Expert Network on Contaminants and aims at providing a common position in support of comparable assessments of chemical contaminants under MSFD, reaching equal levels of protection across European Seas. Recommendations on specific topics will then need further communication and discussion with relevant groups and frameworks, namely the WFD Working Group Chemicals, which is the primary forum for discussions on EQS, the Regional Sea Conventions (RSC) in shared marine basins, and regulatory agencies implementing chemical regulations, such as the European Chemicals Agency (ECHA) ([8]) and the European Food Safety Authority (EFSA) ([9]) for human health related issues.

([6]) https://www.oecd.org/chemicalsafety/testing/oecdguidelinesforthetestingofchemicals.htm.
([7]) Regulation (EC) No 1907/2006 of the European parliament and of the council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC.
([8]) https://echa.europa.eu/home.
([9]) https://www.efsa.europa.eu/.

2 Threshold values for Contaminants in the marine Environment

2.1 Overview on available/proposed threshold values

This section discusses the available marine contaminant TVs established under main EU legislation, RSC and other relevant international regulatory frameworks and which are compiled below in Annex I (thresholds in water), Annex II (thresholds in biota), and Annex III (thresholds in sediment). Although other thresholds may exist, for example, there are national standards set for a number of contaminants, these have not been included in the annexes.

2.1.1 EU Water Framework Directive (WFD)

Article 16 of the WFD sets out the strategy against chemical pollution of waterbodies including inland waters (freshwater) and transitional, coastal and territorial waters (marine). Environmental Quality Standards (EQS) have been derived at EU level and apply to all MS for assessing the chemical status of waterbodies. The EQS is the concentration of a particular pollutant or group of pollutants in water, sediment or biota which should not be exceeded in order to protect human health and the environment. The EQS Directive (EQSD, 2008/105/EC) ([10]) established EQS in surface waters for 33 Priority Substances (PS) ([11]) (Annex X substances of the WFD) and 8 other pollutants which, if met, allow(s) the chemical status of the waterbody to be described as 'good'. This Directive was updated in 2013 (2013/39/EU), extending the number of PS and Priority Hazardous Substances (PHS)[12] to 45 substances or groups of substances and introducing biota standards for some of them. Currently, EQS_{water} have been set for 44 PS and EQS_{biota} for 11 of those PS. Furthermore, the directive included a provision for a watch-list mechanism designed to allow targeted EU-wide monitoring of substances of possible concern to support the prioritisation process in future reviews of the PS list.

In addition, the WFD establishes the principles to be applied by MS to develop EQS for River Basin Specific Pollutants (RBSP) that "are discharged in significant quantities" (Annex VIII substances of the WFD) as part of the assessment of the ecological status.

The WFD Article 16 requires the Commission to review periodically the PS list, and come forward with proposals as appropriate. There are several ongoing activities within the WFD (available at CIRCABC) ([13]), which might have implications on future MSFD assessments. In particular:

- EQS dossier development for candidate PS (substances short-listed in previous WFD prioritisation exercises and substances included in the WFD Watch List 2015-2019):
  - Pesticides: Neonicotinoids (imidacloprid, acetamiprid, clothianidin, thiacloprid, thiamethoxam), Pyrethroids (bifenthrin, deltamethrin, esfenvalerate, permethrin), Glyphosate, Triclosan, Nicosulfuron.
  - Industrial substances: Per- and polyfluoroalkyl substances (PFAS) (including the identification of PFAS/group of PFAS for which an EQS dossier should be drafted), Bisphenol-A.
  - Metals: Silver.
  - Pharmaceuticals: Estrogenic hormones (ethinylestradiol (EE2), 17-beta-estradiol (E2), estrone (E1)), Macrolide antibiotics (azithromycin, erythromycin, clarithromycin), Diclofenac, Carbamazepine, Ibuprofen.
- Revisions of EQS dossiers for some existing PS:
  - Pesticides: Hexachlorobenzene (HCB), Heptachlor/ Heptachlor epoxide, Dicofol, Tributyltin compounds (TBT), Diuron, Chlorpyrifos, Cypermethrin.

([10]) Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on Environmental Quality Standards in the Field of Water Policy, Amending and Subsequently Repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and Amending Directive 2000/60/EC of the European Parliament and of the Council.

([11]) Substances shown to be of major concern for European Waters.

([12]) Substances subject to cessation or phasing out of discharges, emissions and losses within an appropriate timetable not exceeding 20 years.

([13]) https://circabc.europa.eu/ui/group/9ab5926d-bed4-4322-9aa7-9964bbe8312d/library/73b2d635-4cb1-4d7d-975c-da1b5db594d8.

- Industrial substances: Hexachlorobutadiene (HCBD), Nonylphenol, Perfluorooctane sulfonic acid (PFOS), Polyaromatic hydrocarbons (PAHs), Polibrominated diphenylethers (PBDEs), Dioxins, Fluoranthene.
- Metals: Mercury, Nickel.

— Deselection of existing PS based on a number of predefined criteria: Alachlor, Simazine, Chlorfenvinphos, Trichlorobenzenes and Carbon tetrachloride are the substances identified as suitable candidates for the deselection from the PS list (JRC, 2022).

2.1.2 European Regional Sea Conventions (RSC)

2.1.2.1 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)

For OSPAR purposes, hazardous substances are defined as substances that are persistent, liable to bioaccumulate and toxic (PBT substances), or which give rise to an equivalent level of concern as the PBT substances (e.g., endocrine disruptors). OSPAR maintains a List of OSPAR Chemicals for Priority Action ([14]) and a List of Substances of Possible Concern ([15]) that are undergoing review and revision in 2021/22, considering e.g., progress on the evaluation of substances under the REACH Regulation and on the prioritisation of substances under the WFD.

Contaminant monitoring data form the basis of environmental assessments, which aim to characterise the status or quality of the marine environment with regard to chemical pollution. This means that measured concentrations are compared with assessment concentrations describing cut-offs for categories of environmental quality. If the upper confidence limit on the mean concentration of a given data set is significantly below the Background Assessment Concentration (BAC), the concentration is considered “near background” or “close to zero” in case of man-made substances, fulfilling the ultimate aim of the OSPAR Hazardous Substances Strategy. Environmental Assessment Criteria (EACs) represent the concentration below which no chronic effects are expected to occur in the marine environment, including the most sensitive species. In this sense, EACs are in most cases considered analogous to the EQS applied to concentrations of contaminants in water or biota, for example under the WFD.

A first set of EACs was proposed by OSPAR in 2004 (OSPAR, 2004), with updates for polychlorinated biphenyls (PCBs) and PAHs that became available in 2008. However, EACs have not been developed for all contaminants/matrix combinations required for OSPAR assessments (marine sediments and biota) and thus alternatives or EAC proxies have been used in OSPAR status assessments. For the 2010 Quality Status Report (QSR), the EC maximum levels in foodstuff (EC 1881/2006) were used as alternatives to EACs to assess heavy metals in biota and the Effects Range-Low (ERL) levels, developed by the US National Oceanic and Atmospheric Administration (NOAA), for PAHs and metals in sediments (OSPAR, 2009a). As a follow-up, the 2017 Intermediate Assessment (IA) ([16]) on hazardous substances incorporated data up to year 2015 and new EACs were set for PCBs congeners in all biota. In total, 19 and 21 EAC or EAC proxies in biota and sediment, respectively, were used for PAHs, PCBs and heavy metals for the 2017 IA. The next OSPAR QSR is to be published in 2023 (QSR 2023).

([14]) https://www.ospar.org/work-areas/hasec/hazardous-substances/priority-action.
([15]) https://www.ospar.org/work-areas/hasec/hazardous-substances/possible-concern.
([16]) https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/contaminants/.

Table 1. Hazardous substances common indicators for OSPAR QSR 2023.

Common indicator name	**Latest assessment (IA2017)**
Heavy metals inputs	Inputs of Mercury, Cadmium and Lead via Water and Air to the Greater North Sea.
Metals	Status and Trends for Heavy Metals (Mercury, Cadmium, and Lead) in Fish and Shellfish. Status and Trends for Heavy Metals (Mercury, Cadmium and Lead) in Sediment.
Organotin sediment	Status and Trends of Organotin in Sediments in the Southern North Sea.
Imposex	Status and Trends in the Levels of Imposex in Marine Gastropods (TBT in Shellfish).
PAH	Status and Trends in the Concentrations of PAHs in Shellfish. Status and Trends in the Concentrations of PAHs in Sediment.
PCB	Status and Trends in the Concentrations of PCBs in Fish and Shellfish. Status and Trends in the Concentrations of PCBs in Sediment.
PBDE	Trends in Concentrations of PBDEs in Fish and Shellfish. Trends in Concentrations of PBDEs in Sediments.

Source: OSPAR.

OSPAR has recognized that robust assessment values are very important for OSPAR indicator assessments for the QSR 2023 and for assessing progress towards GES under the MSFD, so the needs for updated OSPAR background documents of the priority chemicals have been evaluated. The experts of the Working Group on Monitoring and on Trends and Effects of Substances in the Marine Environment (MIME) have focused much of their efforts on assessment values for contaminant concentrations in sediment, fish and shellfish. The OSPAR report (2019) presented generalised groupings of suggested OSPAR actions for each of the background documents and in particular, the need for additional assessment criteria was raised for:

— Heavy metals in sediments: ecotoxicological data for the development of new assessment criteria based on the EAC principles to replace the US EPA ERL criteria.

— PAHs in sediments: there is need to develop EACs, for both parent and alkylated PAHs instead of using the US EPA ERL.

Moreover, as there were no EAC for the status assessment of PBDEs, MIME has proposed the Canadian Federal Environmental Quality Guidelines (FEQGs) to be applied as EAC-proxies in the OSPAR assessment of PBDE concentrations in biota (fish and bivalves) and sediment (OSPAR, 2020a).

The North-East Atlantic Environmental Strategy (NEAES) 2030 ([17]) is how OSPAR's 16 Contracting Parties will implement the OSPAR Convention until 2030. Within the implementation plan of this strategy, an operational objective considers thresholds for hazardous substances, i.e. S2.O2: OSPAR will develop and identify marine-relevant assessment criteria for hazardous substances, for use in the QSR2023 and subsequently further develop these, including for emerging contaminants, working closely with relevant experts, particularly the WG Chemicals under the WFD. In order to fulfill this objective, a specific task is currently suggested, i.e. S2.O2T1: Acceptance of national Environmental Quality Standard values. Within this task, national EQS under development or developed by contracting parties will be shared. The scope is to review the current OSPAR thresholds considering any new and updated information and also work towards using harmonised threshold values across MSFD-WFD-RSC.

As explained further below, a new approach is currently applied in OSPAR, where two sets of thresholds are used for biota, i.e. thresholds for the protection of human health and biota, respectively. This is a compromise in order to fulfill the needs for a number of Contracting Parties where EU EQS are applied nationally for marine waters. Hence, OSPAR assessments can in these cases only be used in national marine strategy assessments if threshold values correspond to the ones applied elsewhere.

2.1.2.2 Baltic Marine Environment Protection Commission (HELCOM)

A list of priority substances was released in HELCOM Recommendation 31E/1 and adopted in 2010 in the framework of the Baltic Sea Action Plan. HELCOM core indicators for biodiversity and hazardous substances were first developed in the CORESET projects. The CORESET I (2010-2013) expert group on hazardous substances proposed 13 core indicators for concentrations of hazardous substances and their biological effects. The core indicators were selected based on their policy relevance, adverse effects to the environment, cost-efficient analyses and existing targets from the WFD and OSPAR. CORESET II (2013-2015) worked to operationalize these indicators and develop additional indicators. Substances in the Baltic Sea are defined as

([17]) north-east_atlantic_environement_strategy_compiled.pdf (ospar.org).

hazardous by HELCOM if they are (i) toxic, persistent and bioaccumulate or very persistent and very bioaccumulating (PBT/vPvB), or (ii) have effects on hormone and immune systems in marine organisms, or (iii) certain radionuclides. The most recent HELCOM 'State of the Baltic Sea' holistic assessment (HOLAS 2) assessment of hazardous substances is based on seven core indicators, encompassing twelve substances or substance groups. The overall assessment is supported by additional assessments (e.g., diclofenac as a pre-core test indicator).

Regionally agreed threshold values are derived from a number of sources to select values that have been scientifically tested and developed with the purpose of assessing environmental status or ensuring human safety. If several threshold values are available, thresholds based on EQS and the sampling matrix biota are preferred. Each monitored matrix (namely biota, water and sediment) has specific threshold values defined for each substance or substance group. Primary threshold values identify the matrix deemed to be most appropriate for monitoring the specific substance or substance group, though secondary threshold values are commonly established and used where monitoring in the primary matrix is not available. In total, 11, 5 and 6 thresholds values for hazardous substances were agreed in biota, water and sediment, respectively, for the last thematic assessment of hazardous substances 2011-2016 (HELCOM, 2018).

HELCOM is currently carrying out the third holistic assessment (HOLAS 3) of the Baltic Sea, covering the period 2016-2021. The results are expected to be published in 2023.There have been discussions regarding the need for a review of the EQS for PBDE in biota and the establishment of threshold values for diclofenac. The use of TVs for those substances for HOLAS 3 assessment is pending any move under EU processes for EQS. Moreover, a copper indicator has been recently developed and a TV for this substance agreed upon, and there have been updates on some TVs, for instance, for TBT in biota. Additionally, TVs for caesium-137 have been recently developed and approved for HOLAS-3 (40 Bq m^{-3} in sweater and 20 Bq kg^{-1} ww in fish).

Table 2. HELCOM indicators for HOLAS 3 assessment.

Indicator	Matrix (primary, secondary)
Metals: Cadmium	Water, biota, sediment
Metals: Copper	Sediment
Metals: Lead	Water, biota, sediment
Metals: Mercury	Biota
HBCDD	Biota, sediment
PBDEs	Biota, sediment
PFOS	Biota, water
dl-PCBs, dioxins and furans	Biota
Non dl-PCBs (PCBs)	Biota
PAHs	Biota
PAHs (fluoranthene)	Biota, sediment
PAHs (anthracene)	Sediment
PAH Metabolite: 1-hydroxypyrene	Biota
TBT	Sediment, water
TBT and imposex	Biota
Caesium-137	Fish, seawater

Source: HELCOM.

2.1.2.3 Barcelona Convention (UNEP-MAP)

Currently, the Barcelona Convention Chemicals List includes 28 substances or group of substances of concern under the protocol for the protection of the Mediterranean Sea from Land-Based Sources and Activities (LBS Protocol). Recently, candidate emerging chemicals have been proposed as a complementary target to be monitored in mussel and sediment matrices; the current MED POL monitoring strategies (UNEP MAP, 2017a).

The first estimates of Mediterranean background concentrations (BC) and both BAC and EAC were made for trace metals in sediments and biota and PAHs in sediments in 2011, following the OSPAR methodology approach. Later in 2014, an informal online expert group on contaminants was established and delivered a first report on assessment criteria (UNEP MAP, 2015). This group made a preliminary proposal regarding the Mediterranean BAC for specific Contracting Parties for major chemical pollutants (in sediment and biota) and biomarkers and recommended as a first step the use of a number of BAC and EAC values adopted by OSPAR. They also pointed out the need to undertake an analysis of additional datasets from reference stations in order to adjust (or to develop) appropriate assessment criteria for the Mediterranean region. In 2016, refined assessment criteria (BC, BAC and EAC) were proposed for the Mediterranean Sea as a whole. The EAC followed the OSPAR methodological approach, i.e. same substances (PAHs, PCBs and heavy metals) and values as under the OSPAR 2010 QSR, plus five additional EAC (ERL) for the organochlorine compounds lindane, (γ -HCH), pp'DDE, HCB and dieldrin (UNEP MAP, 2016)

The initial targets of GES for the Integrated Monitoring and Assessment Programme (IMAP) Common Indicator (CI) 17 (Concentration of key harmful contaminants measured in the relevant matrix) are based upon data for 10 priority substances, reflecting the scope of the current Mediterranean Pollution Assessment and Control Programme (MED POL) and the availability of suitable agreed assessment criteria. However, the first pollution assessment against assessment criteria (UNEP MAP, 2017b) was performed only for three heavy metals (cadmium, lead and mercury) in the Mediterranean Sea biota and coastal sediments. Recently, new updated BC and BAC values have been proposed for mandatory contaminants related to CI 17 (heavy metals, PAHs, PCBs and pesticides in biota and sediments) as well as new EAC values have been proposed for heavy metals, PCBs and dioxins for CI 20 (Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood) (UNEP MAP, 2022).

2.1.2.4 Bucharest Convention

The Black Sea Commission implements the provisions of the Convention for the Protection of the Black Sea of 1992 (Bucharest Convention). The Black Sea Strategic Action Plan (BS SAP) was adopted in 1996 and amended in 2009 in order to resolve transboundary environmental problems, including chemical pollution, according to MSFD provisions. The Black Sea Integrated Monitoring and Assessment Program (BSIMAP) aims at producing a quality assessment of the Black Sea status according to the ecosystem quality objectives (EcoQOs). The EcoQO4 "to reduce pollutants originating from land-based sources, including atmospheric emissions" provides a list of contaminants to be assessed, both mandatory (e.g., petroleum hydrocarbons and heavy metals) and optional (e.g., detergents and organochlorine pesticides). The BSIMAP 2017- 2022 ([18]) entails screening for new pollutants with a view to updating the list of Black Sea specific/priority pollutants.

The Advisory Group on Pollution Monitoring and Assessment (AG PMA) is involved in drafting the recommendations and policies for BSC to establish regional environmental quality objectives, criteria and, where possible, standards for assessing the state of the environment considering the holistic approach. In the Black Sea State of Environment Report (BSC, 2019), various thresholds values were used for a comparison assessment with monitored concentrations in water (WFD EQS for chlorinated organics and metals; Ukrainian and Russian maximum acceptable concentration for metals), sediment (national maximum allowed limit of total PAHs and metals; OSPAR EAC for chlorinated organics; US EPA ERL for metals) and biota (OSPAR BAC/EAC and EC maximum levels for certain contaminants in foodstuffs).

2.1.3 Other relevant thresholds at international level beyond the EU

Some (not exhaustive) examples of relevant thresholds set beyond the EU are summarised here, noting that the guidance used for setting them not necessarily corresponds to the EU guidance for EQS derivation.

2.1.3.1 United States: Environmental Protection Agency (US EPA)

2.1.3.1.1 National Recommended Water Quality Criteria

Under Clean Water Act section 304(a), US EPA is required to develop and publish water quality criteria that reflect the latest scientific knowledge. Aquatic life criteria for toxic chemicals are the highest concentration of specific pollutants or parameters in water that are not expected to pose a significant risk to most species in a given environment or a narrative description of the desired conditions of a water body being "free from" certain negative conditions. EPA's recommended water quality criteria don't automatically become part of a state's water quality standards but they must be adopted to protect the designated uses of their water bodies. National water quality criteria are derived for freshwater or saltwater or both to protect aquatic organisms and their uses from unacceptable effects due to exposures to high concentrations for short periods of time (Criterion Maximum Concentration or CMC), lower concentrations for longer periods of time (Criterion Continuous Concentration or CCC) and combinations of the two. Currently, recommended Aquatic Life Criteria are available for 36 individual substances or mixtures of congeners (i.e. PCBs) in saltwater (https://www.epa.gov/wqc/national-recommended-

([18]) http://www.blacksea-commission.org/_bsimap.asp.

water-quality-criteria-aquatic-life-criteria-table) together with an additional table on Conversion Factors for Dissolved Metals.

2.1.3.1.2 Sediment quality guidelines Effects Range system

Through its National Status and Trends (NS&T) Program, the National Oceanic and Atmospheric Administration (NOAA) generates considerable amounts of chemical data on sediments. Thus, the sediment quality guidelines (SQGs) were developed as informal, interpretive tools to evaluate whether a concentration of a contaminant in sediment might have toxicological effects (NOAA, 1999). Based on the large database assembled by Long et al. (1995) in only saltwater, Effects Range-Low (ERL) and Effects Range-Median (ERM) values were calculated as specific chemical concentrations of a toxic substance in marine sediment. The ERL indicates the concentration below which toxic effects are scarcely observed or predicted, while the ERM indicates that above which effects are generally or always observed (Long et al., 1995). These guidelines are used by public agency in the US for screening sediments in particular for trace metals and organic contaminants but they are not regulatory criteria. The US EPA acknowledges them as valuable benchmarks that assist in providing a uniform context for evaluating contaminant levels within estuaries (EPA, 2012). Categories have been characterised as "good" for zero ERL exceedances, "intermediate" if there are ERL exceedances but zero ERM exceedances, and "poor" for any ERM exceedance. ERL and ERM values were calculated for 9 trace metals, 13 individual PAHs, 3 classes of PAHs, and 3 classes of chlorinated organic hydrocarbons.

2.1.3.2 Canada

2.1.3.2.1 Canadian Environmental Quality Guidelines (CEQGs)

CEQGs, developed by the Canadian Council of Ministers of the Environment (CCME), are nationally endorsed, science-based goals for the quality of atmospheric, aquatic and terrestrial ecosystems. Marine thresholds have been developed to address the protection of marine water quality, marine sediment quality and tissue quality for the protection of wildlife consumers of aquatic life.

Canadian water quality guidelines for the protection of aquatic life have been developed for 90 anthropogenic stressors such as chemical inputs, nutrients or changes to physical components (e.g., pH, temperature, and debris) among which 78 on chemical substances. Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota have been developed for 5 substances or groups of substances and Sediment Quality Guidelines for the Protection of Aquatic Life have been developed for 18 substances or groups of substances.

2.1.3.2.2 Canadian Federal Environmental Quality Guidelines (FEQGs)

The Minister is required under section 54 of CEPA 1999 to issue environmental quality guidelines. In the past, these commitments were, in essence, met solely by Environment and Climate Change Canada's cooperative work with the Canadian Council of Ministers of the Environment (CCME) representing federal, provincial and territorial interest by developing Canadian Environmental Quality Guidelines. Currently, under the Chemicals Management Plan, there is an additional need to develop FEQGs to support federal environmental quality monitoring and risk assessment and risk management activities on substances for which CCME guidelines do not yet exist.

FEQGs may be used directly as evaluation tools in environmental monitoring to assess whether ambient concentrations of pollutants may pose risks to aquatic life. When the concentration of a given chemical is at or below the FEQG, it is expected low likelihood of direct adverse effects on aquatic life exposed via the water or sediment, or where chemicals may bioaccumulate in wildlife. In addition, they may also be used as risk management tools and performance measures. They also provide a science-based starting point to derive site-specific effluent limits and risk management targets. The use of FEQGs is voluntary unless prescribed by regulation or binding agreements. FEQG have been derived for 17 substances or group of substances and are under development for perfluorooctanoic acid, siloxanes, naphthenic acids, selenium, and aluminium.

2.1.3.3 Australia and New Zealand

2.1.3.3.1 Water Quality Guidelines

Under the oversight responsibility of the Water Quality Policy Sub Committee (WQPSC) and National Water Reform Committee (NWRC), Default Guideline Values (DGVs) are proposed in the water quality guidelines for aquatic ecosystem protection. They are recommended to provide a generic starting point for assessing water quality in the absence of more relevant guideline values (jurisdictional, site specific).

The objective of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000) is to provide authoritative guidance on the management of water quality in Australia and New Zealand. Revised in 2018, the Water Quality Guidelines are now presented in an interactive online platform that water managers can use for water quality planning, approvals, licensing and compliance, monitoring and assessment. The guidance includes quality objectives designed to sustain current, or likely future, community values for natural and semi-natural water resources and provide quantitative guideline values for water and sediment quality and guidance on their derivation ANZ, 2018a, 2018b). DGVs are not mandatory and have no formal legal status and their publication on the Water Quality Guidelines website involves a publication approval process that includes initial approval to develop a DGV, development of the DGV and final approval. Currently, there are DGVs for 57 and 21 substances of different chemical categories in marine water and sediment, respectively.

2.1.3.4 Japan Environmental Quality Standards

The Basic Environment Plan was drawn up in December 1994 based on the Basic Environment Law, implemented in 1993, which outlines the general direction of Japan's environmental policies. This law takes a perspective that it is important that all the actors perform to reduce contaminant loads and to promote environmental conservation, and clarifies the responsibilities of the State, local governments, corporations and citizens.

With regard to the environmental conditions related to air, water and soil pollution, the Government shall respectively establish environmental quality standards (EQS). In water, EQS for protecting human health have been established for 26 substances and other 27 substances have been designed as “monitoring substances”, i.e. no EQS set yet, but identified as needing further observation. For protecting the living environment, standards in coastal waters include total zinc (since 2003) as well as other parameters (e.g., N-hexane extract). Different standard values are set for different water uses and fishery classes. Moreover, 3 other substances have been designated as “monitoring substances”.

3 Threshold values used by MS for assessing contaminants in the last MSFD reporting cycle

The reports submitted by MS for MSFD Art. 8, 9 and 10 in the last reporting cycle (2018-2020) were reviewed in order to analyse consistency and comparability among MS and marine regions (Tornero et al., 2021). The main findings related to the use of TVs for the chemical contaminant assessments under descriptors 8 and 9 are summarised below.

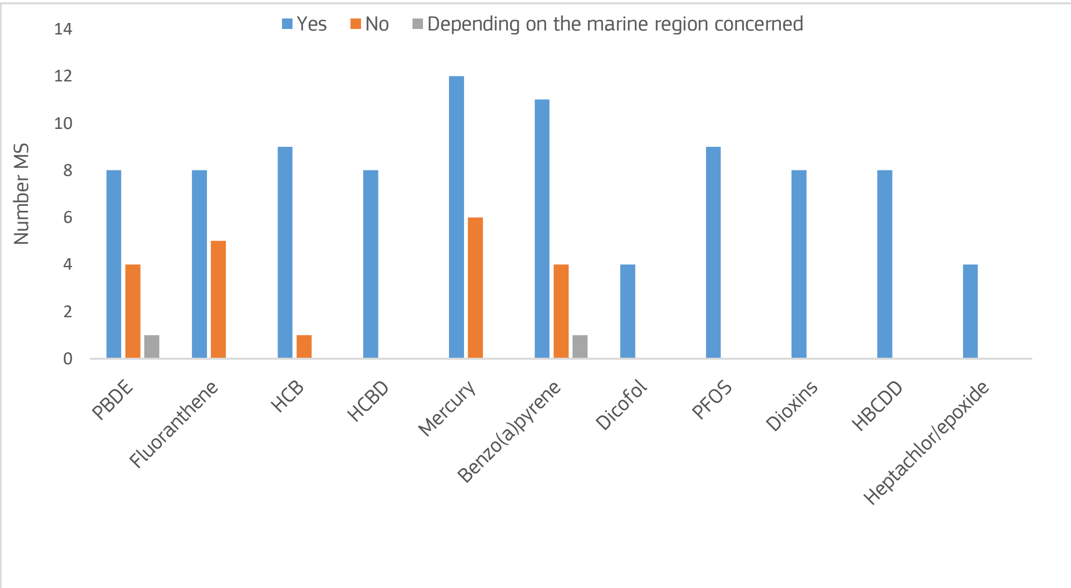
3.1 MSFD Descriptor 8

3.1.1 Assessment of WFD PS

Water is the most reported matrix for most PS and the WFD EQS are the threshold values typically used for their assessment. In some cases, MS select the annual average value (AA-EQS) and the maximum allowable concentration (MAC-EQS) in others. National standards are also set by some MS. For instance, Portugal in the subdivision of Madeira applies national thresholds for trace metals in water (cadmium, lead, mercury and nickel). These national thresholds are more than one order of magnitude higher than the WFD EQS_{water}. Germany also used a national standard for dichlorvos in water according to the national regulation (German Surface Waters Ordinance (OGewV, 2011) in force at that time. The national regulation has been updated (OGewV, 2016) and is the current basis for assessment.

Biota is mostly used for the PS for which there is a WFD EQS_{biota}. However, as seen in Figure 1, some MS do not always apply these EQS for their MSFD assessments, as required by the MSFD Commission Decision (EU) 2017/848 and to ensure consistency in the assessments across EU, but use instead other TVs agreed at national or regional level or sometimes trends.

Figure 1. Number of MS applying the available WFD EQS_{biota} for their MSFD D8 assessments in the last (2018) reporting cycle.



Source: Tornero et al. (2021).

Table 3 shows the sources of the TVs or assessment criteria used by MS for assessing WFD PS in biota under MSFD assessments. The corresponding concentration values can be found in Tornero et al (2021).

MS use TVs applicable to the group of species they monitor, for instance, OSPAR EAC for bivalves and fish and EcoQO for birds. MS may also use OSPAR or Med BAC to acknowledge the different biogeochemical background in their region. Unfortunately, from the MSFD Article 8 reporting, it is not always possible to understand why a national standard is derived for PS or the existing ones at EU or regional level are not used, for example, if it is because the assessment is performed in species that are not covered by the WFD or RSC. For mercury and fluoranthene, however, it is clear there is more than one TV used by MS for the same protection goal, leading to divergent assessment approaches across the EU.

Table 3. Number of MS applying biota TVs from different sources for assessing WFD PS under MSFD D8 assessments.

WFD PS	**WFD EQS**	**Maximum limits Food Reg. 1881/2006**	**OSPAR EAC**	**OSPAR BAC**	**OSPAR Ecological Quality Objectives (EcoQOs)**	**Mediterranean BAC**	**National thresholds**	**Canadian Federal Environmental Quality Guidelines (FEQGs)**	**Trend**	**None** (1)
Brominated diphenylethers	9							1	2	2
Cadmium		6		2		1	2		1	1
Cyclodiene pesticides			2 (dieldrin)							1 (diedlrin)
DDTs				2	1		1			1
Dicofol	4									
Dioxins/dioxin-like compounds	8		3 (PCB 118)						1 (PCB 118)	
HBCDD	9									
HCB	8			1						
HCBD	8									
HCH			2		1		1			
Heptachlor/ heptachlor epoxide	4									
Lead		6		4		1	1		1	1
Mercury	12	4			1		1		1	
Nickel							1		1	
PAHs (2)	12	1	3 (BaP) 3 (BghiP) 2 (BkF)	1 (IcdP)					1 (BaP) 2 (IcdP)	
Anthracene			4				1		1	
Fluoranthene	8		4						1	
Napththalene			1				1			
PFOS	9									
TBT	1 (3)		2				1		1	

(1) The substance is reported in biota, but not assessed due to the lack of agreed thresholds.
(2) BaP (benzo(a)pyrene); BghiP (benzo(g,h,i)perylene); BkF (benzok)fluoranthene; IcdP (indeno(1,2,3-cd)pyrene).
(3) Quality standard (QS) in biota from the WFD TBT dossier (it is not a legally binding TV).

Source: Tornero et al. (2021).

The assessment methodology is also particularly relevant. As explained below, according to the WFD TGD-EQS (EC, 2018), the application of an EQS_{biota} requires a stepwise process: the concentration in biota has to be normalised to specified lipid or dry weight %, and then, for biomagnifying compounds, the concentration has to be adjusted according to trophic level (TL) and trophic magnification factor (TMF) before being compared to the EQS. As far as we know, TL and TMF data adjustments have not been carried out by any MS for MSFD D8C1 assessments. Some work on this has been started by countries like Sweden, which is expected to be in the agenda under the HELCOM Expert Group on Hazardous Substances (EG HAZ) for HOLAS 4.

Moreover, the tissue to be used for biota monitoring is not specified by the WFD and, there is also no consistent picture across EU. While most MS are using the filet, also the whole fish and liver are being used, depending on the substances. The WFD TGD-EQS indicates it is not advised to only measure in the liver, but for MSFD D8 (with the goal of protecting wildlife, including secondary poisoning), the liver can provide the highest concentrations (i.e. preferred matrix), even though the sample size (i.e. availability of material) is sometimes hindering. The "whole fish" is often used for practical reasons in sampling and sample preparation for small fish.

For MSFD D8 assessments, sediment is the most reported matrix for some PAHs (including fluoranthene, for which there is an EQS_{biota}), metals like cadmium and lead, and also TBT. The WFD does not set EQS in sediments, although there are Quality Standards (QS) in the dossiers for some substances that are sometimes applied by MS, even if those standards are not legally binding TVs. According to the MSFD Commission Decision, MS shall agree on the threshold values in this matrix through (sub)regional cooperation. However, it is important to highlight that this can be challenging in cases where countries belong to more than one marine region that follow different procedures for deriving TVs.

Table 4 shows the sources of the TVs or assessment criteria used by MS for assessing WFD PS in sediments under MSFD assessments. The corresponding concentration values can be found in Tornero et al (2021).

Table 4. Number of MS applying sediment TVs from different sources for assessing WFD PS under MSFD D8 assessments.

PS	OSPAR EAC (EAC for PCB or US ERL (1))	QS from WFD EQS dossiers (2)	HELCOM standards	National thresholds	Trends	None (3)
Anthracene	4	5		2 (4)	1	
Brominated diphenylethers			1	4 (4)	3	1
Cadmium	6	4		4 (4)	1	2
C10-C13 Chlroalkanes				2 (4)		
Cyclodiene pesticides	2 (dieldrin)			1 (aldrin, dieldrin)		1
Cypermethrin					1	
DDTs	3 (p,p' DDE)			1		1
DEHP				1	1	1
Dicofol						1
Dioxins/dioxin-like compounds	2 (PCB 118)			2 (4)	1	
Fluoranthene	5	2		3 (4)	1	1
HBCDD					1	
HCB	1			2		
HCBD				2 (4)	1	1
HCH	3 (γ-HCH)			2		1
Heptachlor/ heptachlor epoxide					1	1
Lead	5	4		5 (4)	1	
Mercury	3			5 (4)	1	3
Naphthalene	3			2	1	1
Nickel	1			4		1
PAHs (5)	6 (BaP) 4 (BghiP) 5 (IcdP)			6 (4)	1	1
Pentachlorobenzene				1		
PFOS				1 (4)	1	
TBT			3 (6)	5 (4)	1	1

(1) Sediment Quality guidelines agreed within OSPAR: Effects Range Low (ERL).
(2) Quality standard (QS) in biota from the WFD substance's dossier (it is not a legally binding TV).
(3) The substance is reported in sediments, but not assessed due to the lack of agreed thresholds.
(4) Within the MS that have developed and applied standards at national level, this also refers to the use by Croatia of the sediment quality criteria from the Norwegian system for classification of sediments (Bakke et al., 2010).
(5) BaP (benzo(a)pyrene); BghiP (benzo(g,h,i)perylene); IcdP (indeno(1,2,3-cd)pyrene).
(6) QS developed by Sweden (recently updated) and used by some HELCOM Contracting Parties for MSFD assessments.

Source: Tornero et al. (2021).

3.1.2 Assessment of additional contaminants

There are 142 substances other than WFD PS reported by MS, merely in water, and most of them (88) are reported by only 1 MS. Only some metals/metalloids (arsenic, chromium, copper and zinc), polychlorinated biphenyls (PCBs), some PAHs (chrysene and pyrene) and the radionuclide Cesium-137 are considered by at least 5 MS (in water, sediments and/or biota). Table 5 compiles the few available thresholds used by MS for the MSFD assessment of those substances most frequently reported by MS. It can be seen that, except for PCBs and Cs-137, there is little comparability among MS.

Table 5. TVs used for assessing substances other than WFD PS under MSFD D8 and number of MS applying them.

	Water		Biota		Sediment	
	TV (µg/l, unless specified)	Source and number of MS applying it (1)	TV	Source and number of MS applying it	TV	Source and number of MS applying it (1)
Arsenic	10	National (1 MS)	None (2)	(2 MS)	8.2 mg/kg dry weight	US ERL (3) (1 MS)
	50	National (1 MS)			40 mg/kg dry weight	National (1 MS)
	7	National (1 MS)			3 mg/kg dry weight	National (1 MS)
	5	National (1 MS)			12 mg/kg dry weight	National (1 MS)

	Water		Biota		Sediment	
	TV (µg/l, unless specified)	**Source and number of MS applying it ([1])**	**TV**	**Source and number of MS applying it**	**TV**	**Source and number of MS applying it ([1])**
					1.9 [As]/[Al] X10-4	National (1 MS)
					None ([2])	(1 MS)
Chromium	5	National (1 MS)	None ([2])	(3 MS)	81 mg/kg dry weight	US ERL ([3]) (3 MS)
	50	National (1 MS)			640 mg/kg dry weight	National (1 MS)
	100	National (1 MS)			30 mg/kg dry weight	National (1 MS)
	10	National (1 MS)			50 mg/kg dry weight	National (1 MS)
	12	National (1 MS)			8.9 [Cr]/[Al] X10-4	National (1 MS)
	4	National (1 MS)			None ([2])	(1 MS)
Copper	15	National (1 MS)	6 mg/kg dry weight bivalves	OSPAR (1 MS)	34 mg/kg dry weight	US ERL ([3]) (2 MS)
	5	National (1 MS)	None ([2])	(3 MS)	160 mg/kg dry weight	National (1 MS)
	50	National (1 MS)			40 mg/kg dry weight	National (1 MS)
	30	National (1 MS)			52 mg/kg	National (1 MS)
	10	National (1 MS)			10 mg/kg dry weight	National (1 MS)
	8.2	National (1 MS)			2.7 [Cu]/[Al] X10-4	National (1 MS)
	99	National (1 MS)			None ([2])	(1 MS)
Zinc	10	National (1 MS)	63 mg/kg dry weight bivalves	OSPAR (1 MS)	150 mg/kg dry weight	US ERL ([3]) (2 MS)
	40	National (1 MS)	None ([2])	(3 MS)	60 mg/kg dry weight	National (1 MS)
	1000	National (1 MS)			12 [Zn]/[Al] X10-4	National (1 MS)
	100	National (1 MS)			800 mg/kg dry weight	National (1 MS)
	52	National (1 MS)			None ([2])	(1 MS)
Non-dioxin like PCB (sum of 6 PCB: 28, 52, 101, 138, 153 and 180)	None ([2])	(1 MS)	75 µg/kg wet weight fish muscle	Food Reg ([4]) (5 MS)	None ([2])	1
Sum of 7 PCB: 28, 52, 101, 118,138, 153 and 180)					7 µg/kg dry weight	National (1 MS)
					11.5 µg/kg dry weight	US ERL ([3]) (1 MS)
					None ([2])	(1 MS)
PCB28	0.0005	National (1 MS)	67 µg/kg lipid weight all biota	OSPAR (4 MS)	1.7 µg/kg dry weight	OSPAR (4 MS)
PCB52	0.0005	National (1 MS)	108 µg/kg lipid weight all biota	OSPAR (4 MS)	2.7 µg/kg dry weight	OSPAR (4 MS)
PCB101	0.0005	National (1 MS)	121 µg/kg lipid weight all biota	OSPAR (5 MS)	3.0 µg/kg dry weight	OSPAR (4 MS)
PCB 118	0.0005	National (1 MS)	25 µg/kg lipid weight all biota	OSPAR (3 MS)	0.6 µg/kg dry weight	OSPAR (3 MS)
PCB138	0.0005	National (1 MS)	317 µg/kg lipid weight all biota	OSPAR (5 MS)	7.9 µg/kg dry weight	OSPAR (4 MS)
PCB153	0.0005	National (1 MS)	1585 µg/kg lipid weight all biota	OSPAR (5 MS)	40 µg/kg dry weight	OSPAR (4 MS)
PCB180	0.0005	National (1 MS)	469 µg/kg lipid weight all biota	OSPAR (5 MS)	12 µg/kg dry weight	OSPAR (4 MS)
Chrysene			8.1 µg/kg dry weight	OSPAR (1 MS)	384 µg/kg dry weight	US ERL ([3]) (3 MS)
			None ([2])	(2 MS)		
Pyrene			100 µg/kg dry weight mussels and oysters	OSPAR (4 MS)	665 µg/kg dry weight	US ERL ([3]) (3 MS)
			None ([2])	(1 MS)	None ([2])	(1 MS)
Cs-137	15 Bq/m3	HELCOM Pre-Chernobyl level (5 MS)	2.5 Bq/kg herring	HELCOM Pre-Chernobyl level (4 MS)	250TBq	1
			2.9 Bq/kg flounder	HELCOM Pre-Chernobyl level (3 MS)		
			0.159 Bq/kg wet weight fish	National standard North Sea (1 MS)		
			15 Bq/kg dry weight plants	National (1 MS)		

([1]) The MS using national values and the source of those are specified in the Art. 8 review report (Tornero et al., 2021).
([2]) The substance is reported, but TV is not used or has not been specified in the MSFD report.

([3]) Sediment Quality guidelines agreed within OSPAR: Effects Range Low (ERL).
([4]) Food Regulation EC 1881/2006 and 1259/2011.

Source: Tornero et al. (2021).

Box 1. Threshold values for assessing contaminants under MSFD D8

The lack of threshold values for many substances or the concerns by some MS with regard to the applicability of the existing ones for some WFD PS, for instance mercury (either because they are not considered entirely suitable for the marine environment or because there are different values agreed at regional and EU levels), are the main reasons for the high number of element and/ or criteria status that have been reported under MSFD as “unknown” or “not assessed”.

Threshold values for contaminant assessments in the marine environment need to be developed and better harmonised across MS and marine regions. Interaction of marine experts (e.g., through the MSFD Expert Network on Contaminants and RSC) with the WFD Working Group Chemicals is essential in order to ensure that marine data are used for EQS derivation. Developing EU-agreed thresholds for more contaminants in biota and also in sediments would be beneficial to improve consistency and avoid conflicting assessments between MSFD-WFD-RSC.

3.2 MSFD Descriptor 9

MSFD D9 reporting is basically focused on the contaminants and threshold values set under the Food regulation 1881/2006 (Table 6). Despite the limited number of substances covered in that Regulation, most MS do not report on all of them. Moreover, very few additional contaminants are reported and by very few MS.

Table 6. TVs used for assessing substances other than WFD PS under MSFD D8.

Contaminant	TV
Contaminants Food Regulation Cd, Pb, Hg, Sum of dioxins, Dioxins + dl-PCBs, Non dl-PCBs, Benzo(a)pyrene, Sum of 4PAHs	Maximum level set in Regulation 1881/2006
Cyclodiene pesticides (aldrin, endrin, dieldrin), Heptachlor, HCB, DDTs	National standards
PBDE, HBCDD, TBT, PFOs	WFD EQS
Cs 134, Cs 137	EC 733/2008 (1)

([1]) Council Regulation (EC) No 733/2008 of 15 July 2008 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station.

Source: Tornero et al. (2021).

4 Overview on rationale for contaminant threshold setting

4.1 WFD EQS

The methodology to derive EQS under the WFD is described in the technical guidance documents developed under the WFD (EC, 2011, 2018). The key technical aspects are summarised here.

The EQS cover several objectives of protection or receptors:

- Pelagic organisms.
- Benthic organisms.
- Top predators against consumption of contaminated prey (secondary poisoning).
- Human health against contamination via drinking water or seafood.

Not all receptors and compartments (water, biota, sediment) are considered for each substance. This depends on the environmental fate and behaviour of the substance and the criteria to help identify which of the assessments are needed for a particular substance are given in the TGD-EQS (EC, 2011). A specific Quality Standard (QS) is derived for each receptor and compartment at risk and if several assessments are performed for the same compartment, the lowest (most stringent) of the thresholds will be selected as an 'overall' EQS. By ensuring that the most sensitive receptor is protected, risks from other routes of exposure should automatically be addressed.

The main steps to derive an EQS are:

- Identification of receptors and compartments at risk.
- Collation and quality assessment, according to the Klimisch or CRED methods (Kase et al., 2016), of physicochemical properties, fate and behaviour data (i.e. bioaccumulation and adsorption) and (eco)toxicity data for use as input to standard-setting process.
- The deterministic approach is used for derivation of an EQS based on the lowest toxicity value divided by an assessment (safety) factor (AF) to account for the greater uncertainty, or extrapolation to threshold concentration using the probabilistic distributional approach (SSD) where data are log-transformed and fitted to a distribution function from which a percentile (often the 5th percentile, HC5) is used as the basis for an EQS.
- Proposition of specific quality standards (QS) that apply to water column, sediment and biota.
- Identification of key assumptions and uncertainties.
- Selection of an overall EQS.

4.1.1 Data for deriving QS

Data are not restricted to Good Laboratory Practices (GLP) studies, but only the data that can be considered as relevant and reliable may be used as 'critical' data in deriving an EQS. Non-experimental data (QSAR predictions) cannot replace experimental data but can serve as supporting information to select the key study. Field and mesocosm data, whilst rarely being suitable as critical data, can be used to corroborate or challenge the choice of a suitable AF.

4.1.1.1 Combining freshwater and marine datasets for EQS derivation

To derive EQSs for transitional, coastal and territorial waters, ecotoxicity datasets of marine and freshwater species are normally combined for organic compounds since current marine risk assessment practice suggests a reasonable correlation between ecotoxicological responses of freshwater and saltwater biota. Where there are sufficient toxicity data in both the freshwater and saltwater datasets, a statistical comparison should be made to substantiate pooling of data. Datasets for metals are separated, unless there is no demonstrable difference in sensitivity. In general, a higher AF is applied to address additional uncertainties associated with greater diversity and vulnerability of the marine ecosystem, unless data for specific marine taxa are present.

The marine dataset used to derive each EQS is indicated in Table 7 below (water) and Annex II (biota).

Box 2. Freshwater and marine datasets for EQS derivation

For most of the EQS_{water}, the datasets have been combined (the most sensitive organisms being freshwater species in most cases, as showed in Table 7). However, the statistical difference between the two datasets was assessed only in few cases (e.g., lead, naphthalene, nickel, cybutryne) mainly because the lack of enough marine data made the statistical analysis rather unfeasible. No justification was provided for some substances (e.g., octylphenols, benzo(a)pyrene, cypermethrin, heptachlor). A similar observed sensitivity together with the known mode of action have been used in many cases to justify not to use an additional assessment factor as recommended in the TGD-EQS (EC, 2011). For few substances (e.g., aclonifen, bifenox, dicofol), the marine EQS have been derived based only on freshwater data in the absence of reliable marine data.

For metals, the freshwater and saltwater datasets must in theory always be kept separated, but this has not been the case for the derivation of AA-EQS and MAC-EQS for lead and for the derivation of MAC-EQS for mercury and nickel. Although a justification for pooling the data is provided in the EQS dossiers, it is true that these EQS were derived before the publication of the TGD-EQS, so it seems necessary to re-evaluate them (as is currently being done within the WFD WG Chemical processes). For cadmium, a separate dataset is used for the AA-QS, for the MAC-QS a hardness correction is applied.

4.1.1.2 Background concentrations and metal bioavailability

The information on background levels for naturally occurring substances, such as metals and some organic contaminants like PAHs and some cyanides, could also affect the final EQS. The size of the assessment factor (AF) should not normally result in an EQS that is below the natural background level. The EQS might also correspond to the Maximum Permissible Addition (MPA) to the background concentration ($EQS_{water} = C_{background} + MPA$) (for cadmium and mercury but not lead). In the last version of the TGD-EQS (EC, 2018), natural background concentrations (NBC) are mentioned in some chapters, but their possible effects on the definition of EQS are not addressed in detail.

Guidance for implementing EQS for metals, considering metal bioavailability and NBC in assessing compliance is given in additional guidance (EC, 2021) where it is stated "MS may, when assessing the monitoring results against the relevant EQS, take into account the NBC for dissolved metals and their compounds where such concentrations prevent compliance with the applied EQS…". However, MS should strive to reach an estimate of NBC that approximates undisturbed conditions, because the WFD and EQS Directive refer to "natural background" concentrations and they are necessary to assist in the appropriate interpretation of monitoring results. If NBC are overestimated (because of significant anthropogenic contributions), an exceedance of the EQS can be falsely assumed to be natural. At the same time, if NBC are underestimated for a particular area, the EQS will never be met in that area".

Box 3. Background concentrations and metal bioavailability

The EQS derivation guidance specifies that derivation of QS for metals requires an explicit consideration of (bio)availability using speciation models or, failing that, to utilise dissolved concentrations instead of total concentrations. However, while bioavailability has been taken into account to derive the AA-EQS for some metals in freshwater (lead, nickel and, cadmium based on hardness correction), it has not been the case for marine waters, mainly due to the lack of toxicity data for this compartment. For lead, the influence of abiotic factors, including dissolved organic carbon (DOC), on its bioavailability and toxicity to saltwater species was judged unclear and not comparable to the freshwater environment. The AA-EQS and MAC-EQS in waters are expressed in dissolved concentrations for all metals.

4.1.2 Calculation of QS

The TGD-EQS addresses single contaminants as well as groups of substances, e.g., when contaminants occur in the same product (e.g., many pesticides) or as a result of a particular process (e.g., PAHs following combustion). In those cases, an EQS for a group of substances or mixture may be preferable to deriving EQSs for the individual constituent substances. Currently, EQS have been derived for the following groups or mixtures of isomers: PBDEs, DDT total, nonylphenol, octylphenol, PAHs, dioxins and dioxin-like compounds, cypermethrin, hexabromocyclododecanes (HBCDD), HCH, trichlorobenzenes and cyclodiene pesticides (aldrin, dieldrin, endrin, isodrin).

4.1.2.1 EQS water

An assessment to protect pelagic (i.e. water column) organisms from direct toxicity of chemicals is always undertaken. Separate EQS are derived for freshwater and saltwater (as a default, a salinity of 5‰ is recommended as the cut-off between freshwaters and salt waters, unless other evidence suggests that a different one is appropriate for a particular water body). In order to cover both long- and short-term effects resulting from exposure, two water column EQS are normally derived:

(i) a long-term standard, expressed as an annual average concentration (AA-EQS) and normally based on chronic toxicity data, and

(ii) a short-term standard, referred to as a maximum acceptable concentration EQS (MAC-EQS) which is based on acute toxicity data.

The deterministic method relies on a minimum of acute toxicity dataset for aquatic organisms from three taxonomic groups usually algae, invertebrates and fish (basic set). The database used in the species sensitivity distribution method (SSD), which is used for some compounds (Table 7), should contain preferably more than 15, but at least 10 NOECs/EC10s ("no observed effect concentration"/"concentration at which 10% effect is observed compared to the control group), from different species covering at least 8 taxonomic groups.

Where biota standards are 'back-calculated' to the corresponding water concentration, the lowest standard calculated for the different objectives of protection will normally be adopted as the overall quality standard AA-EQSwater. This has been the case for DEHP, C10-13 chloroalkanes, dicofol, HBCDD, pentachlorobenzene to protect predators and fluoranthene, PFOS, heptachlor and PAHs to protect humans from the consumption of fishery products.

Biota concentration (µg/kg biota) are converted in water concentration (µg/l) using bioaccumulation data. Most of the experimental data are available for the bioconcentration factor (BCF) and for few PS also for the bioaccumulation factor (BAF), the biomagnification factor (BMF), and the TMF. When no biomagnification data were available, default BMFs, calculated according to the octanol–water partition coefficient (log Kow), were used for the conversion. In practice, marine and freshwater experimental datasets are often pooled due to the scarcity of reliable data.

Table 7. Toxicity data used for the derivation of EQS_{water} of WFD PS (fw: freshwater; sw: saltwater; hh: human health; AF: assessment factor).

WFD PS	Year of the dossier	AA-EQS origin	SW dataset (1)	Combining FW/SW ecotoxicological datasets	Most sensitive organism	Additional AF for SW organisms
1,2 Dichloroethane	2005	Human health (drinking water) (2)	Acute: 1 Algae 2 Crustaceans 1 Fish Chronic: 1 Algae 1 Annelida	Yes	Crustacea (fw)	No
Aclonifen	2011	Pelagic community	No data available	Yes	Macroalgae (fw)	Yes (10)
Alachlor	2005	Pelagic community	Acute: 1 Algae	Yes	MAC-EQS: Mesocosm (fw) AA-EQS: Algae (fw)	No
Anthracene	2011	Pelagic community	Acute: 3 Algae 2 Molluscs 2 Crustaceans Chronic: 2 Molluscs	Yes	Invertebrate (fw)	No
Atrazine	2005	Pelagic community	Acute and chronic data available for various fish, invertebrates and algae	Yes	MAC-EQS: Algae (fw) AA-EQS: SSD approach	No
Benzene	2005	Pelagic community	Acute: 2 Algae 4 Invertebrates 3 Fish	Yes	Fish (fw)	Yes (10)
Bifenox	2011	Pelagic community	No data available	Yes	Algae (fw)	Yes (10)
Brominated diphenylethers	2011	Pelagic community	Acute: 1 Algae Chronic: 1 Algae	Yes	Invertebrate (fw)	Yes (10)

WFD PS	Year of the dossier	AA-EQS origin	SW dataset ([1])	Combining FW/SW ecotoxicological datasets	Most sensitive organism	Additional AF for SW organisms
			1 Fish			
Cadmium	2005	Pelagic community	Acute and chronic data for various fish, crustaceans, algae, shellfish, annelids, nematoda, and cyanobacteria	Yes for MAC-EQS; No for AA-EQS	SSD approach	No
C10-C13 Chloroalkanes	2005	Predators (secondary poisoning)	<u>Acute</u>: 1 Fish <u>Acute&Chronic</u>: 1 Algae 2 Invertebrates	Yes	MAC-EQS: Invertebrates (fw=sw) AA-EQS: birds (fw)	No
Chlorfenvinphos	2005	Pelagic community	<u>Acute</u>: 1 Crustacean 2 Molluscs 2 Fish	Yes	Crustacea (fw)	No
Chlorpyrifos	2005	Pelagic community	<u>Acute</u>: ? Algae 6 Fish <u>Chronic</u>: ? Algae 1 Crustacean 4 Fish	Yes	Mesocosms (fw)	No
Cybutryne	2011	Pelagic community	<u>Acute</u>: 15 Algae 1 Cynobacteria 2 Macrophyte 1 Ascidia 2 Cridaria 5 Crustaceans 1 Echinoderm 2 Mollusc 2 Fish <u>Chronic</u>: 7 Algae 1 Macrophyte 1 Crustacean 1 Mollusc 1 Fish <u>Micro/mesocosm</u>: 3 Periphyton 1 Phytoplankton community 1 Plankton, macrophytes, macro-invertebrates 1 Eal grass and phytoplankton 1 Mollusc	Yes (statistic test)	SSD approach	No
Cypermethrin	2011	Pelagic community	<u>Acute</u>: 2 Crustaceans 3 Copepods 1 Fish <u>Chronic</u>: 1 Crustacean	Yes (not justified)	MAC-EQS: SSD approach AA-EQS: Crustacea (sw)	Yes (10)
DEHP	2005	Predators (mussels as prey)	Various data on algae, invertebrates and fish, including microcosm studies, but effects measured at concentrations > water solubility. Chronic toxicity to 5 fish exposed via the diet	Yes	Rat	No
Dichlorvos	2011	Pelagic community	<u>Acute</u>: 1 Crustacean 1 Fish <u>Chronic</u>: 1 Crustacean 1 Fish	Yes (not justified)	Crustacea (fw)	Yes (10)

WFD PS	Year of the dossier	AA-EQS origin	SW dataset ([1])	Combining FW/SW ecotoxicological datasets	Most sensitive organism	Additional AF for SW organisms
Dichloromethane	2005	Human health (drinking water) ([2])	Acute: 1 Algae 3 Crustaceans 2 Fish	Yes	Fish (fw)	No
Dicofol	2011	Predators (fw fish as prey)	No data available Conversion $QS_{biota\ hh}$ (AA-EQS) BCF: experimental but no sw data BMFs: calculated based on phys-chem properties		Bird (terrestrial)	BMF_2=42
Diuron	2005	Pelagic community	Acute: 2 Fish 1 Mollusc 1 Crustacean Chronic: 1 Algae 1 Crustacean 1 Mollusc	Yes	Algae (fw)	No
Endosulfan	2005	Pelagic community	Acute: 5 Fish 2 Molluscs 1 Echinodermata 7 Crustaceans Chronic: 1 Algae 1 Crustacean 1 Mollusc 1 Fish	Yes	MAC-EQS: Invertebrates (sw) AA-EQS: Fish (fw)	Yes (10)
Fluoranthene	2011	Human health (consumption of crustaceans)	Acute: 1 Bacteria 2 Fish 16 Crustaceans 1 Echinoderm 2 Molluscs 1 Annelida Chronic: 2 Crustaceans 2 Molluscs 1 Echinoderm 1 Tunicate Conversion $QS_{biota\ hh}$ (AA-EQS) BCF: 3 Molluscs, 2 Crustaceans, 1 Polychaeta BMFs: estimated based on BCF data	Yes (MAC)	MAC-EQS: SSD approach AA-EQS: Rat	No
HBCDD	2011	Top predators	Acute: 2 Algae Chronic: 1 Algae 1 Mollusc Conversion $QS_{biota\ hh}$ (AA-EQS) BCF: no marine data BMFs: 5 marine biomagnification studies and food chain scenarios based on monitoring data	Yes	MAC-EQS: Algae (sw) AA-EQS: Birds (terrestrial)	MAC-EQS: Yes (10) AA-EQS: Yes (BMF_2=2)
HCB	2005	Top predators	Acute: 4 Crustaceans 1 Mollusc 1 Annelida 6 Fish Chronic: Algae	Yes	Invertebrates (fw)	No
HCBD	2005	Pelagic community	Acute: 2 Fish 1 Mollusc 1 Echinodermata	Yes	Crustaceans (sw)	No

WFD PS	Year of the dossier	AA-EQS origin	SW dataset [1]	Combining FW/SW ecotoxicological datasets	Most sensitive organism	Additional AF for SW organisms
			2 Crustaceans			
HCH	2005	Pelagic community	Acute: 1 Fish 2 Molluscs 1 Echinodermata 1 Nematoda 2 Crustaceans Chronic: 1 Algae 1 Crustacean 2 Fish	Yes	MAC-EQS: Fish (fw) AA-EQS: Insects (fw)	Yes (10)
Heptachlor/ heptachlor epoxide	2011	Human health (fish consumption)	Acute: 1 Crustacean 1 Fish Chronic: 1 Fish Conversion $QS_{biota\ hh}$ (AA-EQS) BCF: No marine data BMFs: various marine biomagnification studies but not all considered reliable	Yes (not justified)	MAC-EQS: Crustacean (fw) AA-EQS: Dog	MAC-EQS: Yes (10) AA-EQS: Yes (BMF_2=19.8)
Isoproturon	2005	Pelagic community	Acute: 1 Algae 1 Mollusc 1 Echinodermata Chronic: 3 Algae 1 Mollusc 1 Echinodermata	Yes	MAC-EQS: Algae (sw) AA-EQS: Algae (fw)	No
Lead	2011	Pelagic community	Acute: 4 Algae 1 Crustacean 4 Molluscs 4 Echinodermata 1 Protozoan 1 Fish Chronic: 2 Algae 3 Molluscs 2 Echinodermata 1 Annelida 1 Fish	Yes	SDD approach	Yes for AA-EQS (3 instead of 2)
Mercury	2005	Pelagic community	Acute: 1 Algae 2 Crustaceans 2 Molluscs 2 Annelida 1 Fish Chronic: 1 Algae 3 Macroalgae 1 Crustacean 1 Fish	Yes (not justified)	Fish (fw)	No
Naphthalene	2011	Pelagic community	Acute: 1 Micro-organism 1 Algae 1 Macroalgae 15 Crustaceans 1 Mollusc 1 Annelida 3 Fish Chronic: 1 Macroalgae 1 Mollusc 2 Crustaceans 4 Echinodermata 2 Fish	Yes	MAC-EQS: SSD approach AA-EQS: Fish (fw)	No
Nickel	2011	Pelagic community	Acute: 3 Algae	Yes for MAC-EQS No for AA-EQS	SDD approach	AA-EQS: Yes (AF=2)

WFD PS	Year of the dossier	AA-EQS origin	SW dataset ([1])	Combining FW/SW ecotoxicological datasets	Most sensitive organism	Additional AF for SW organisms
			1 Macroalgae 5 Crustaceans 5 Molluscs 1 Annelida 1 Cnidarian 1 Echinodermata 4 Fish Chronic: 3 Algae 1 Macroalgae 3 Molluscs 2 Crustaceans 3 Echinodermata 1 Polychaete 2 Fish			MAC-EQS: No
Nonylphenols	2005	Pelagic community	Acute: 1 Algae 1 Crustacean 1 Echinodermata 1 Fish Chronic: 1 Crustacean 1 Fish	Yes for MAC-EQS No for AA-EQS	MAC-EQS: Invertebrates (fw) AA-EQS: Algae (fw)	No
Octylphenols	2005	Pelagic community	Acute: 1 Crustacean 2 Fish	Yes (not justified)	Fish (fw)	Yes (10)
PAHs Benzo(a)pyrene	2011	Human health (based on foodstuff maximum level for molluscs)	Chronic: 1 Mollusc 2 Echinodermata 1 Fish Conversion $QS_{biota\ hh}$ (AA-EQS) BCF: 1 Mollusc, 2 Crustaceans BMFs: estimated based on BCF data	Yes (not justified)	MAC-EQS: Invertebrates (fw) AA-EQS: No	Yes for MAC-EQS (10)
Pentachlorobenzene	2005	Predators (fw fish as prey)	Acute: 1 Algae 1 Crustacean 1 Mollusc 1 Echinodermata Chronic: 1 Fish	Yes	Rat	Yes (10)
Pentachlorophenol	2005	Pelagic community	Acute: 1 Algae 1 Crustacean 1 Mollusc 1 Rotatoria 2 Fish Chronic: 1 Algae 1 Crustacean 1 Nematoda 1 Annelida 2 Fish	Yes	MAC-EQS: Fish (fw) AA-EQS: SSD approach	No
PFOS	2011	Human health (fish consumption)	Acute: 1 Algae 3 Crustaceans 1 Mollusc 1 Fish Chronic: 1 Algae 1 Crustacean Conversion $QS_{biota\ hh}$ (AA-EQS) BCF: 8 Fish BMFs: various TMFs with low reliability (weight of evidence (WoE) approach)	Yes	MAC-EQS: Crustacea (sw) AA-EQS: Monkey	Yes for MAC-EQS and AA-EQS (BMF_2) (5)

WFD PS	Year of the dossier	AA-EQS origin	SW dataset (1)	Combining FW/SW ecotoxicological datasets	Most sensitive organism	Additional AF for SW organisms
Quinoxyfen	2011	Pelagic community	Chronic: 1 Fish 1 Crustacean	Yes	MAC-EQS: Algae (fw) AA-EQS: Crustacea (sw)	MAC-EQS: Yes (5) AA-EQS: Yes (10)
Simazine	2005	Pelagic community	Acute: 1 Algae Chronic: 1 Algae 1 Mollusc 1 Fish	Yes	MAC-EQS: Algae (fw) AA-EQS: SDD approach	No
TBT	2005	Pelagic community	Chronic: 3 Algae 1 Echinodermata 2 Annelida 7 Molluscs 4 Crustaceans 3 Fish	Yes	AA-EQS: SDD approach	No
Terbutryn	2011	Pelagic community	Acute: 1 Bacteria 2 Algae 1 Crustacean	Yes	Algae (fw)	Yes (10)
Trichlorobenzene	2005	Pelagic community	Acute: 1 Crustacean	Yes	Fish (fw)	Yes (10)
Trifluralin	2005	Pelagic community	Acute: 1 Algae 1 Crustacean 1 Mollusc 1 Fish Chronic: 1 Crustacean 1 Fish	Yes	Fish (fw)	No

(1) Marine dataset: only reliable data with Klimisch score 1 or 2 are reported in this table.
(2) This protection goal is however not relevant for MSFD.

Source: WFD Substance's dossiers, https://circabc.europa.eu/.

Box 4. EQS based on the protection of humans from drinking water consumption

It must be noted that AA-EQS for transitional, coastal and territorial waters of dichloromethane and 1,2-dichloroethane are based on the protection of humans from drinking water consumption when these sources of water, at our knowledge, are not expected to serve for drinking water abstraction. This is also not in accordance with the most recent TGD-EQS (EC, 2018).

4.1.2.2 EQS biota

A biota standard would be required if there is a risk of secondary poisoning to top predators (e.g., mammals or birds) from eating contaminated prey ($QS_{biota, sec pois}$), or a risk to humans from eating fishery products ($QS_{biota, hh food}$). The factors triggering a $QS_{biota, hh food}$ are dominated by hazard properties, whereas a $QS_{biota, sec pois}$ is triggered by the possibility of accumulation in the food chain. The lowest standard calculated for the different protection goals will normally be adopted as the overall EQS_{biota} that, for most substances, refers to a predatory fish belonging to trophic level 4 and is expressed in terms of µg/kg (wet weight) of the whole organism. An alternative biota taxon may be monitored instead, as long as the EQS applied provides an equivalent level of protection. For fluoranthene and PAHs (benzo(a)pyrene), the EQS_{biota} refers to crustaceans and molluscs. For dioxins and dioxin-like compounds, the EQS_{biota} relates to fish, crustaceans and molluscs.

EQSs in biota are always expressed as a long-term standard because exposure will typically occur over long periods of time. As indicated above, $QSb_{iota, sec pois}$ and $QS_{biota, hh}$ will also normally be 'back-calculated' to the corresponding water concentration to define the overall EQS_{water}.

4.1.2.2.1 General approach to deriving the $QS_{biota, sec pois}$

Oral toxicity data on birds and/or mammals are considered for $QS_{biota, sec pois}$ derivation and NOAEL (No Observed Adverse Effect Level) are converted into NOEC values. One major modification in the last version of the TGD-EQS (EC, 2018), is to determine the critical food item or prey in the food chain and to convert the energy normalised endpoints of the toxicity tests into threshold concentrations in the prey. However, this methodology implies to know the biomagnification of the substance (i.e. BMF and TMF), which are still rarely available, or use modelling as an alternative. In practice, the $QS_{biota,\ sec\ pois}$ derived for the current PS have followed the methodology described in the previous version of the guidance (EC, 2011) considering an AF of 3 to account for the differences in energy content.

Box 5. EQS_{biota} for biomagnifying compounds

It must be noted that, in theory, for biomagnifying compounds, the $QS_{biota,\ sec\ pois}$ in marine waters may be lower than that in freshwaters because an additional biomagnification step is considered (BMF2) which is not the case for the $QS_{biota,\ hh}$. However, in practice it has never been taken into account and all legally binding EQS biota are applicable (and similar) to both marine and freshwater ecosystems. Based on the former TGD- EQS (EC, 2011), this is correct since the additional consideration of BMF2 was only applied when biota standards were back-calculated to corresponding water concentrations. Therefore, in 2011 the QS_{biota} expressed as concentration in fish was equal for fresh and marine waters, but the corresponding concentrations in water were different. In the 2018 guidance, the calculation of the QS_{biota} is done based on energy demands and the difference between fresh and marine waters is already included in the QS_{biota}.

4.1.2.2.2 General approach to deriving the $QS_{biota,\ hh}$

The food limits set under EU Regulation 1881/2006, where it exists, is adopted as the $QS_{biota,\ hh}$ without further assessment. Otherwise, according to the TGD-EQS, the derivation of a $QS_{biota\ hh}$ requires a toxicological assessment based on the following parameters:

1. A threshold level (TL_{hh}) of toxicity of a substance based on a relevant NOAEL, Tolerable daily intake (TDI), Acceptable daily intake (ADI) according to Regulation EEC 793/93 ([19]), Regulation 1107/2009 ([20]) or the World health Organization (WHO), Reference Dose (RfD) of the US EPA or Minimum Risk Level (MRL) of the US Agency for Toxic Substances and Disease Registry (ATSDR).
2. The amount of fish consumed each day (well documented default value= 1.6 g fish kg-1 body weight corresponding to 0.115 kg d-1 in combination with a body weight of 70 kg).
3. The proportion of the diet that comes from fishery products: conservative default allocation factor= 10% (EC, 2011) and now 20% (EC, 2018).

Box 6. EQS_{biota} based on human health protection

EQS_{biota} are based on human health protection or on secondary poisoning for protection of top predators, but these two EQS are very often different. For instance, for PBDEs, the $EQS_{biota,\ hh}$ is the limit chosen as final WFD EQS, which is five orders of magnitude lower than the $EQS_{biota,\ sec\ pois}$, and it is not adopted by the European Food Safety Agency (EFSA). For dioxins, also the $EQS_{biota,\ hh}$ is chosen, although it is higher than the $EQS_{biota,\ sec\ pois}$. This $EQS_{biota,\ hh}$ is the same as the one set under the Food Regulation, so its derivation process differs from that of several other PS. PAH EQS are also taken from the Food Regulation.

Some MS have expressed concerns regarding the use of $EQS_{biota,\ hh}$ for environmental assessments since legal food limits are not based on human toxicological information but rather on occurrence and feasibility and are not necessarily consistent with the WFD protection goals.

4.1.2.3 EQS sediment

Not all substances require an assessment for a sediment standard ($QS_{sediment}$). In general, substances likely to be sorbed to sediment with a log Koc or log Kow of ≥3 trigger the sediment effects assessment. In addition, evidence of high toxicity to aquatic organisms or sediment-dwelling organisms or evidence of accumulation in sediments from monitoring would also trigger the derivation of a sediment EQS. QSs derived for sediment are always expressed as a long-term standard because exposure will typically be over long periods of time and separate QSs are derived for freshwaters and saltwaters (i.e. salinity above 5‰). Sediment QSs are dealt with independently from water column and biota standards, because they cannot be inter-converted with confidence and this lead, in theory, to the selection of a separate, overall $EQS_{sediment}$. Legally binding EQS have not been set

([19]) Council Regulation (EEC) No 793/93 of 23 March 1993 on the evaluation and control of the risks of existing substances.
([20]) Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC.

for sediment. For some PS specific benthic QS have been derived under the WFD and some of them have been adopted as sediment thresholds in HELCOM (as showed in Annex III).

4.2 OSPAR

In OSPAR (2009a), BAC are defined in relation to the background concentrations (BC) or Low Concentrations (LC), enabling statistical testing of whether observed concentrations can be considered to be near background concentrations. BAC are calculated according to the method set out in the Section 4 of the CEMP Assessment Manual (OSPAR, 2008), and subsequently updated in OSPAR 2020b, 2021. The outcome of this method is that, on the basis of what is known about variability in observations, there is a 90% probability that the observed mean concentration will be below the BAC when the true mean concentration is at the BC. Where this is the case, the true concentrations can be regarded as "near background" (for naturally occurring substances) or "close to zero" (for man-made substances).

As indicated above, OSPAR has adopted the US ERL (indicative of concentrations below which adverse effects rarely occur) as thresholds for metals and PAHs in marine sediments.

OSPAR EAC have been set for PCBs in sediment and biota and for PAHs in bivalves, but, to our knowledge, the detailed protocol followed to develop them is not publicly available. The EAC were set such that hazardous substance concentrations in sediment and biota below the EAC should not cause chronic effects in sensitive marine species, nor should concentrations present an unacceptable risk to the environment and its living resources. However, the risk of secondary poisoning was not always considered. The development of EAC used predicted-no-effects-concentration (PNEC) derived from no-observed-effect concentrations (NOEC) or lethal concentrations (LC10) and assessment factors, i.e. a safety margin to account for uncertainty related to the transfer of laboratory results to the field.

EAC for PAHs in bivalves were derived from EAC for PAHs in water and bio-concentration factors.

EAC for PCBs in sediment with 2.5% organic carbon were derived from the EAC for PCBs in water and the partitioning coefficient for octanol-water (Koc) (OSPAR 2009a, 2009b). EAC for PCBs in biota were also derived using the partitioning theory by equating the EAC for lipid to the EAC for sediment with 100% organic carbon. This assumed that PCBs transfer totally to lipid (or organic carbon) from the (pore)water phase due to high lipophilicity and has been shown to work for silicone rubber in sediment. Some errors were found in 2013 and revised EAC for biota were adopted in 2014 (OSPAR HASEC 2014, Annex 5). These are expressed on a lipid weight basis and are applied to all fish and shellfish.

As mentioned above, OSPAR, not having yet established other EAC in biota, has adopted the EC maximum levels in fish and seafood for metals set under the EU Food Regulation as a proxy means for assessing the ecological significance of biota concentrations. However, the use of these values has the disadvantage that they have not been directly designed for all the matrix/contaminant combinations required for the assessment and OSPAR considers that the use of dietary standards is not fully satisfactory for assessing environmental risk. Therefore, EU Food standards are used in OSPAR as an interim solution to address the need for criteria until a more appropriate approach can be agreed. In particular, adoption of WFD $EQS_{biota,\ hh}$ for mercury in fish was discussed for several years, and the problems of taking trophic level into account was treated in a separate report (OSPAR, 2016). OSPAR has now implemented this threshold for mercury in its annual assessments (the OHAT tool ([21])). The mercury EQS is applied directly (no trophic adjustment) to individual time series of bivalves and fish. However, in regional assessments, mercury concentrations in bivalves are adjusted to 'fish equivalents' estimated from a statistical model that compares bivalve and fish concentrations within OSPAR regions. Other suitable EQS_{biota} for substances like PFOS, HCB or HBCDD are under consideration. Where EQS exist for both environment and human health, both are shown in the OHAT tool (OSPAR HASEC, 2019).

For the assessment of PBDE concentrations in biota (fish and bivalves) and sediment, the Canadian FEQG are applied as EAC-proxies with the following adjustments (OSPAR, 2020a):

— For sediment, the FEQG are normalised to 2.5% organic carbon by multiplying the original values by 2.5.

([21]) https://dome.ices.dk/ohat/.

— For biota, the FEQG are converted to a lipid weight basis by multiplying the original values by 20, assuming that they were derived from fish with a lipid content of 5%. If necessary, the FEQG can then be converted to a wet or dry weight basis using species / tissue conversion factors ([22]).

4.3 HELCOM

HELCOM has adopted threshold values derived under other frameworks and undergoes regular assessments to ensure that they are up to date with the latest scientific knowledge and methodological advances. In certain cases, normalisation processes are also carried out and, in the future, for threshold values related to biota, normalisation based on trophic level is an aspect that will be explored.

According to the thematic assessment of hazardous substances 2011-2016 (HELCOM 2018), the WFD EQS threshold values, with a particular focus on biota, are considered as the highest priority where possible to implement. The reasoning behind this is that even when substances may be detected at low concentrations in the environment, this approach would ensure that by preferentially targeting EQS values in biota, those thresholds designed to detect potential harm in the environment are addressed, as is the potential for the bioaccumulation of contaminants despite low environmental concentrations. When measurements in biota are used, different trophic levels of the food web are analysed depending on the substance (e.g., mussels or predatory fish), and different parts of the fish (e.g., muscle, liver or whole fish). Hence, the measured concentrations often need to be converted to conform to the environmental quality standard threshold value. For EQS values in water the annual average concentration is used. As said above, HELCOM has also adopted some $QS_{sediment}$ derived under the WFD, but that do not have the EQS legal status. However, their relevance and reliability are not always well justified. For instance, for cadmium, the $QS_{sediment}$ corresponds to the maximum permissible addition (MPA) that was derived for freshwater based on one chronic toxicity study (*Chironomus sp.*). In the EU EQS datasheet, the experts decided not to use this MPA due to some associated uncertainty and did not derive a MPA for salt waters due to the lack of toxicity data for marine benthic organisms.

4.4 US EPA

4.4.1 Aquatic life water quality criteria

The EPA uses Guidelines for deriving numerical national Water Quality Criteria for the protection of aquatic organisms and their uses (US EPA, 1985) that describe an objective way to estimate the highest concentration of a substance in water that will not present a significant risk to the aquatic organisms. This method relies primarily on acute and chronic laboratory toxicity data for aquatic organisms from eight taxonomic groups reflecting the distribution of aquatic organisms' taxa that are intended to be protected. Acute criteria are derived using short-term (48-to 96-hour) toxicity tests on aquatic plants and animals. Chronic criteria can be derived using longer-term (7-day to greater than 28-day) toxicity tests, if available, or by using an acute-to-chronic ratio procedure if chronic data are insufficient. When justified, acute and chronic aquatic life criteria may be related to other water quality characteristics such as pH, temperature, or hardness. Separate criteria are typically developed for freshwater and saltwater organisms. Other information from mesocosms and field data are considered when available and as appropriate. The Aquatic Life Guidelines recommend that criteria are lowered to protect commercially or recreationally important species, where appropriate. For metals, the criteria are typically for dissolved concentrations, with some exceptions.

The existing EPA Guidelines have not been updated since 1985, so EPA has begun the process of revising those, considering new and alternative methods and the newest most appropriate science available ([23]).

4.4.2 Sediment Quality Guidelines (SQGs)

SQGs were needed relatively quickly for interpreting the data from the ongoing National Status and Trends Program; hence the numerous existing data were used for their derivation based on a weight of evidence rather than upon only limited laboratory data. Studies performed throughout North America that included both chemical measures and biological effects were assembled and compiled into a database and SQGs were developed for as many chemicals as the data would warrant. SQGs were derived initially using a database compiled from studies performed in both saltwater and freshwater (Long and Morgan, 1990). A larger database

([22]) https://dome.ices.dk/ohat/trDocuments/2022/help_ac_biota_contaminants.html.
([23]) https://www.epa.gov/wqc/aquatic-life-criteria-and-methods-toxics.

compiled from many studies performed by numerous investigators in only saltwater was used to revise and update the SQGs (Long et al., 1995).

Compiled data included a variety of endpoints including mortality, reproduction, growth rate, and juvenile survival in sediment toxicity datasets for all organisms for which tests were conducted. Studies were screened and only those assays using standardised methods and resulting in significant effects were used for the determination of ERL/ERM guidelines. Data from each study were arranged in order of ascending concentrations. After ranking, both the 10th and 50th percentile concentrations are determined over the range of endpoint concentrations. The 10th percentile values were named the "Effects Range-Low" (ERL) values, indicative of concentrations below which adverse effects rarely occur, while the 50th percentiles were named the "Effects Range-Median" (ERM) values, representative of concentrations above which adverse effects (relatively) frequently occur.

The amount and quality of data used to derive the SQGs differed among the substances and therefore, to provide a measure of the reliability of the SQGs, the percentages of study endpoints indicating adverse effects were calculated for the chemical ranges defined by the ERL and ERM. For trace metals, the guidelines for copper, lead, and silver were the most accurate - below the ERL concentration, there was less than a 10% incidence of effects. The organic contaminant guidelines also appeared to be very accurate for all classes of PAHs and most of the individual PAHs. Contaminants that were reported as having low accuracies included nickel, mercury, chromium, total PCBs, p,p'-DDE, and total DDT.

The SQGs were neither calculated nor intended as toxicological thresholds; therefore, there is no certainty that they will always correctly predict either non-toxicity or toxicity. The derivation of ERL and ERM can also cause further misconceptions since concentrations that did not elicit a significant effect were left out of the calculation when determining the 10th and 50th percentile values. Therefore, within the ranges delineated by the ERL and ERM values, there are concentrations found not to have a significant biological effect. Many substances that are found to be very toxic do not have an associated SQG. The ability of an SQG to predict toxicity when other substances, without SQGs, are present is currently unknown. Particle size also plays an important role in chemical concentrations, and this factor is ignored in calculating the ERL and ERM. When using these values for screening contaminated sediment, it is likely that the ERL will be exceeded more often when the sediment contains a larger proportion of fine-grained material. This is due to the inverse relationship between chemical concentration and particle size. Because of sediment concentrations are measured on a dry weight basis, other geochemical factors of sediment that may also influence contaminant bioavailability are not considered. Moreover, the effects to wildlife and humans from bioaccumulation are not considered for ERL and ERM derivation.

4.5 CANADA

Canadian aquatic quality guidelines and federal environmental quality guidelines (FEQGs) are meant to protect all forms of aquatic life (vertebrates, invertebrates, and plants) and all aspects of the aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term, from the negative effects of anthropogenically altered environmental parameters or exposures to substances via the water column.

They are developed according to a consistent approach developed by the Canadian Council of Ministers of the Environment (CCME). For substances with a great amount of data, a distributional approach is used that makes the best use of all the effects data. Where less data are available, the approach uses a critical toxicity value plus an application (safety) factor to account for the greater uncertainty.

4.5.1 Water

The general development of a CWQG-PAL or a FWQG consists of seven steps described in the protocol for the derivation of Water Quality Guidelines for the protection of aquatic life (CCME, 2007):

- Step 1: the available toxicity data are compiled, evaluated, and sorted according to media (freshwater or marine) and suitability for guideline derivation.
- Step 2: the influence of exposure and toxicity-modifying factors (ETMFs) factors are identified and their influence is evaluated and prioritised (e.g., pH, temperature, hardness/alkalinity, organic matter, oxygen, and counterions). This step and the next deal with bioavailability and bioaccessibility.
- Step 3: the influences of the most important ETMFs are, to the maximum possible extent, quantified.

- Step 4: The available toxicity data are standardised to account for the quantified ETMFs Where possible and appropriate, these data are based on the bioreactivity of the bioabsorbed fraction of a substance. The standardisation (i.e. normalisation) of the toxicity data can be according to the most sensitive and/or most appropriate situation.
- Step 5: the respective guideline is derived using the specific derivation procedure selected based on the availability and quality of toxicity data (as explained above). Separate guidelines will be developed, where possible, for marine and freshwater environments, for short- and long-term exposures, and for total (total guideline) and chemical speciation-specific concentrations (bioavailable guideline). Depending on the quality and quantity of the available information, different types of guidelines are produced.
- Step 6: in order to improve the applicability of these guideline values to other environmental conditions, they are expanded in step 6. The expansion is done by employing the reverse procedure of the standardisation method(s) applied in step 4.
- Step 7: internal and external reviews of the guideline(s) and the final approval.

4.5.2 Biota

The Canadian tissue residue guidelines (TRG) or Federal Wildlife Dietary Guidelines (FWiDG) for the protection of wildlife that consume aquatic biota were developed according to the CCME protocol (CCME 1998). The principles followed are:

- In deriving dietary guidelines for the protection of wildlife, all avian and mammalian species that consume aquatic life may be considered, if data are available (i.e. Minimum Toxicological Data Set Requirements = Full Guideline). Interim guidelines are derived when data are available but limited. Guidelines derived from data on mammalian and avian species are considered protective of only mammals and birds.
- Data on amphibians and reptiles are not required, but may be considered when data are available. Guidelines derived from data on mammalian, avian, amphibian, and/or reptilian species are considered protective of all classes of species for which data are considered.
- Fish and other aquatic life, excluding amphibians and reptiles, are assumed to be protected by water quality guidelines and sediment quality guidelines.
- Dietary guidelines are set to protect the most sensitive life stage of the most sensitive wildlife species exposed to a substance through the consumption of aquatic organisms. One goal in setting a guideline is to protect all life stages of all species during a lifetime exposure to a substance in aquatic food sources.
- Dietary guidelines are single maximum concentrations of a substance in aquatic biota that would not be expected to result in adverse effects on wildlife.
- Unless otherwise specified, a guideline refers to the total concentration of a substance in an aquatic organism on a wet weight basis since wildlife tend to consume whole organisms. Lipid concentrations should be converted to whole body concentrations.
- Dietary guidelines can apply to tissue residues in dietary species including fish, shellfish, invertebrates, or aquatic plants that are consumed by wildlife (e.g., piscivores, insectivores, and herbivores). The types of food sources selected for dietary guidelines application will depend upon site specific factors such as the wildlife species requiring protection, the food preferences of those wildlife species, and the trophic level of the food source.
- The dietary guidelines are derived from the results of appropriate chronic toxicity studies that consider the most sensitive life stages and endpoints tested. The tolerable daily intake (TDI) is calculated by dividing the geometric mean of the lowest-observed-adverse-effect level (LOAEL) and the no-observed-adverse-effect level (NOAEL) by an appropriate uncertainty factor. The TDI is used, in conjunction with daily food ingestion rates (FI) and body weights (W) for wildlife species, to derive the final TRG.

4.5.3 Sediment

According to the protocol for the derivation of Canadian Sediment Quality Guidelines for the protection of aquatic life (CCME, 1995), Interim Sediment Quality Guidelines (ISQGs) for freshwater or marine sediments can be derived from the studies compiled in the Biological Effects Database for Sediments (BEDS) provided that the minimum toxicological data set requirements are met.

Full SQGs can be derived from these ISQGs if supporting information is available to link the ISQGs with specific sediment types and/or characteristics of the sediment or of the overlying water column (i.e. a weight of evidence must clearly define the relationships of these factors with adverse biological effects).

When the number of studies is insufficient to meet the minimum data requirements, the equilibrium partitioning method (Di Toro et al., 1991) is used to calculate a concentration in sediment to protect organisms exposed to sediment pore water based on a value in the water column which should be protective of all aquatic organisms.

4.6 AUSTRALIA AND NEW ZEALAND

4.6.1 Water

DGVs aim to protect ambient waters from continued exposure to toxicants, i.e. from chronic toxicity. They are based on direct toxic effects of individual toxicants from laboratory tests and were derived according to risk assessment principles described in ANZECC & ARMCANZ (2000) and in Warne et al. (2018) for all DGVs published after 2000.

The preferred data for deriving those values come from multiple-species toxicity tests, i.e. field or model ecosystem (mesocosm) tests that represent the complex interactions of species in the field. However, most DGVs have been derived using data from single-species toxicity tests on a range of test species, because these formed the bulk of the concentration–response information. No DGV for marine water were derived in the absence of marine data. Where possible, DGVs for toxicants have been derived using the species sensitivity distribution (SSD) approach but when this approach could not be used, the less preferred 'assessment-factor approach' was used. The reliability of each DGVs is provided with guidance on how the value should be used. High reliability values were calculated from chronic 'no observable effect concentration' (NOEC) data. However, the majority of DGVs were moderately reliable, derived from short-term acute toxicity data (tests ≤96 h duration) by applying acute-to-chronic conversion factors. Low reliability guideline values were derived, in the absence of a data set of sufficient quantity, using larger assessment factors to account for greater uncertainty. These are considered as interim or indicative levels and subject to more test data becoming available.

The DGVs derived using the statistical distribution method were calculated at four different protection levels, i.e. 99%, 95%, 90% and 80%, which indicate the percentage of species expected to be protected. The decision to apply a certain protection level to a specific ecosystem is the prerogative of each state jurisdiction or catchment manager, in consultation with the community and stakeholders. In most cases, the 95% protection level should apply to ecosystems that could be classified as slightly–moderately disturbed. They represent the best current estimates of the concentrations of chemicals that should have no significant adverse effects on the aquatic ecosystem. They focus on direct toxic effects of individual chemicals, but are intended to be applied at specific sites, where possible, using a decision tree. A decision scheme gives step by step guidance on how to assess test site data and tailor the guideline values according to site-specific environmental conditions.

4.6.2 Sediment

According to ANZECC & ARMCANZ (2000), there were few reliable data on sediment toxicity for either Australian or New Zealand samples from which independent sediment quality guidelines might be derived. Therefore, the option selected for the sediment quality guidelines was to use the best available overseas data and refine these based on knowledge of existing baseline concentrations, as well as by using local effects data as they become available. The recommended guideline values were tabulated as interim sediment quality guideline (ISQG) values and the low and high values corresponded to the ERL and ERM used in the NOAA listing (Long et al., 1995). Since 2000, it became more evident the high international variability of guideline value derivations for organic toxicants in sediments. The ERL values of Long et al. (1995) are considered to be less reliable than the threshold effects level (TEL) values of MacDonald et al. (2000) that were adopted in Canada (CCME, 2002).

The Water Quality Guidelines have adopted the values from McDonald et al. (2000) for many organic toxicants, as in Simpson et al. (2013), revised the DGVs for PAHs and TBT, and reported a new value for total petroleum hydrocarbons (TPHs). The GV-high represents the median value of the effects ranking. As such, GV-high could be considered as more likely to be associated with biological effects than the DGV but the extent of that impact is not necessarily known.

5 Analysis of potential inconsistencies between different frameworks

All threshold values or assessment criteria derived under the different frameworks are based on the toxic effects of individual (or group of) toxicants and the identification of the non-significant adverse effect on the exposed organisms. However, each framework follows its own derivation principles, which are described in the corresponding guidelines. A comprehensive comparison among frameworks is not performed in this work, but some key differences are highlighted below.

5.1 Minimum dataset

While the requirements regarding the type and quality of data (i.e. data relevance and reliability) are quite similar among frameworks, the minimum data requirements for the derivation of thresholds are quite different, e.g., limited under the EU WFD EQS to highly extended under the Canadian frameworks. In particular, the availability of marine data to derive marine thresholds can be mandatory (e.g., Australian/New Zealand) or not (e.g., EU WFD EQS).

5.2 Protection targets and threshold value conversion

Thresholds derived under the different frameworks are set to protect the aquatic organisms including pelagic, wildlife (i.e. predators) and benthic organisms from direct and indirect (secondary poisoning) exposure to pollutants. A value is derived specifically to address each protection target. One exception is the EU WFD EQS (also adopted under HELCOM), which also considers the protection of human health via the consumption of fishery products and allows to convert thresholds in biota into water concentrations. However, since specific effects on humans are considered (e.g., carcinogenicity without threshold), it may lead to very low values that are not comparable with those derived under other frameworks (e.g., the AA-EQS for fluoranthene is 0.0063 µg/l while the Australian/New Zealand DGV is 1 µg/l and the AA-EQS and for heptachlor and heptachlor epoxide is 0.00000001 µg/l while the Canadian CCC is 0.0036 µg/l). Yet, a very low value is not a reason *per se* to reject a value. As discussed below, the issue here would be whether TVs should be based on human toxicological considerations (WFD approach) or on occurrence/technical achievability (food limits approach, used for MSFD D9).

Furthermore, there is uncertainty linked to the conversion between the biota and water medium that can decrease the reliability of an AA-EQS based on an EQS_{biota} as well as uncertainty in biota monitoring linked to differences in trophic level, spatial-temporal variations, analytical considerations etc. (see also section 7 on issues related to the applicability of biota standards).

5.3 Relation between WFD $EQS_{biota, hh}$ and EU Food standards

Maximum levels in fish and seafood laid down in EC Regulation 1881/2006 are applied in the EU with the aim to protect public health by excluding the most contaminated food from the market. They are set according to the ALARA ("as low as reasonably achievable") principle, i.e. the lowest contaminant levels that can reasonably be achieved following good agricultural, fisheries or manufacturing practices at all stages. These limits take into account information beyond the toxicological factors, such as the basis of the diet of the 'average' European consumer (i.e. dietary standards), the health concerns of the human population including sensitive populations, typical levels of contaminants in different foodstuff, and trade issues. In other words, the European food limits reflect the prevalence of contaminants in foodstuff and may progressively be lowered when monitoring data show that lower limits are achievable. Therefore, the limits themselves do not include toxicological information, but toxicological information and exposure calculations could be a reason to lower the limits. New monitoring data could also lead to increased limits. This is not the same approach as for toxicologically-based maximum concentrations in fish, as calculated under the WFD. Although the starting point for the $QS_{biota, hh}$ under the WFD can be similar to the EC food standards, the derivation of a toxicologically-based $QS_{biota, hh}$ is based on health-based guidance values and realistic worst-case defaults for fish consumption and allocation, and doesn't take into account trade issues. In consequence, equivalence between foodstuff contaminant limits and $QS_{biota, hh}$ cannot be expected (see also section 7 on issues related to the protection goal).

5.4 Groups of substances

There are substances which, due to the analytical methodology, can be measured as group parameter (such as short chained chloroalkanes, nonylphenols, etc.), while others are grouped for reporting, as specified in the WFD (e.g., PBDE or cyclodiene pesticides), with their concentrations being reported as the sum of the single substances. According to the MSFD GES Decision, contaminants refer to single substances or groups of substances and for consistency in reporting, the grouping of substances shall be agreed at EU level. In the last MSFD reporting cycle, it has been seen that sometimes the substances within a group (reported as sum of concentrations) to assess GES are not the same as defined under the WFD to assess compliance against the EQS (Tornero et al., 2021). It would be desirable to have compatible approaches for such substance group across EU and compatible with other assessment frameworks.

Furthermore, mixtures are considered differently among the different frameworks and can refer to different groups of substances, isomers and congeners, and some environmental assessment criteria (e.g., OSPAR EAC) do not include combination toxicology.

5.5 Sediment thresholds

The procedure by which ERL are derived is very different from the general approach used to derive EU or Canadian thresholds in sediment, so precise equivalence should not be expected. Moreover, as discussed below, there are also concerns regarding the application of normalisation procedures to contaminant concentrations in sediment.

Multiple case studies have been conducted to compare different sediment quality guidelines and their ability to predict sediment toxicity. Vidal and Bay (2005) showed that the ERL/ERM performed better than the equilibrium partitioning method at predicting a non-toxic sediment concentration, but suggested that other methods could prove more protective in cases where mixtures of organics are present. They suggested using multiple sediment quality guidelines, and gave guidance on selecting the best method based on site characteristics and the contaminants of immediate concern.

6 Specificities for the marine environment

Under the EU WFD, freshwater and marine aquatic toxicity datasets were pooled for most substances because there was no evidence of a higher sensitivity of marine species and the most sensitive species were often freshwater species. However, an additional AF is often used to account for a general under-representation in the experimental dataset of specific marine key taxa and possibly a greater species diversity.

As mentioned before, marine data are mandatory under certain regulatory framework to set TVs for the marine water and/ or sediment. However, the same threshold in biota is always derived for both fresh and marine water even if, in theory, a higher trophic level should be considered for the marine predators leading to a lower EQS_{biota} (water –BCF→ aquatic organisms –BMF1→ fish –BMF2→ fish-eating predator → top predator).

As far as to our knowledge, the relevance of using freshwater bioaccumulation data (BCF, BAF, BMF, TMF) for marine organisms have not been comprehensively assessed due to the scarcity of available data. Therefore, it might be important to have reliable bioaccumulation data in marine organisms and specially biomagnification data at the highest level of the food chain (e.g., BMF2), which are relevant for the derivation of an EQS_{biota} for saltwater to protect the top predators from secondary poisoning. More research in this regard would be then needed.

It should be also noted that under the WFD, the only tested aquatic birds to assess the secondary poisoning of top predators of the marine ecosystem (coastal area) was the Mallard duck, all other test organisms were terrestrial mammals and birds.

7 Main hindrances in threshold derivation/implementation

7.1 Toxicological data availability

The main hindrance for threshold derivation is related to the availability of sufficient relevant and reliable data. It is specially the case for oral toxicity data on birds to protect them from secondary poisoning and toxicity data on benthic organisms to derive thresholds in sediment. Bioaccumulation data (BCF, BAF, BMF, TMF) are also often missing.

7.2 Protection goal: the relevance of human health

The EU EQS approach, which integrates the protection of human health from environmental contamination, is in line with the EU chemical legislation where the environmental risk assessment considers the risks to humans via the environment. The recent "One health" concept promoted at EU level states that animal health, human health and the health of the shared environment are part of a deeply interconnected system. However, it might be considered that the risks to human health of environmental contaminants in fishery products are covered by drinking water and food standards. This is only partially true because the regulated contaminants in that legislation are not the same (e.g., the lists of contaminants in the Drinking Water directive 98/83/EC ([24]) and Food standards under Reg. 1881/2006 are less exhaustive than the WFD PS list) and the integration of human health protection in environmental quality management can be considered as an upstream mechanism to preserve our drinking water and food resources from contamination. However, legislation acting at consumption level can be considered only as a downstream mechanism protecting food quality on the market but without considering long-term effect on contamination. Therefore, the choice of the protection goal is clearly a policy decision that must consider the regulatory framework as a whole.

7.3 Applicability of EQS_{biota}

There is also concern related to the applicability of the defined threshold values in biota to assess that status of the monitored water bodies. Guidance on the implementation of biota EQS dictates a number of conditions that biota data should fulfil in order to meet biota compliance requirements of the WFD (EC, 2014). This includes a stipulation that monitoring data should be converted to a trophic level of four (five for marine in theory) corresponding to the EQS_{biota}. Most contaminant data for environmental fish monitoring will be for species of a lower trophic level, therefore trophic magnification factors would need to be applied to account for the extra magnification step in the marine environment, which in most cases would give a higher concentration. However, relevant TMF are currently not available for all substances and might be site specific and the information on the trophic level is not always reported, which increases the complexity of the conversion and the applicability of the biota thresholds.

7.4 Normalisation

Under the various regulatory frameworks, biota thresholds are also normalised to the lipid content of organisms for those substances that accumulate through hydrophobic partitioning (e.g., standard lipid content of 5% in fish and 1% in bivalves are used for WFD EQS_{biota}; typical % dry weight and % lipid weight for each fish species and tissue are used in OSPAR ([25])) or against another parameter, such as dry weight for metals (e.g., dry weight contents of 26% in fish and 8.3% in bivalves are proposed for EQS_{biota}; typical species and tissue dry weight for bivalves are used in OSPAR ([20])). Biota thresholds can be defined for the whole fish or the liver.

Thresholds in sediment can also be normalised to a standard organic content (OC) for organic substances (e.g., 5% OC under HELCOM, 2.5% OC for most of the OSPAR area and 1% OC for DVG in Australian/New Zealand) and to aluminium content for metals. In OSPAR, for instance, when ERL are used as thresholds, the normalized data are directly compared to non-normalised ERL (except for Spain where only no-normalised data are used). Both biota and sediment thresholds are mostly expressed in dry weight but they can sometimes be expressed in wet weight. Overall, these different normalisation rules without providing the relevant information to make an appropriate conversion account also for the variability of the threshold values among frameworks and the difficulties to compare them.

([24]) Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption.
([25]) https://dome.ices.dk/ohat/trDocuments/2022/help_ac_basis_conversion.html.

8 Potential approaches to fill data gaps to support marine threshold derivation

8.1 Non-experimental data (Quantitative structure–activity relationships (QSARs) models)

Although the implementation of the chemical legislation, especially REACH, is increasing the availability of relevant and reliable data, the derivation of threshold values is still a long and slow process. Performing animal toxicological tests to fill data gaps might be an option, but this would entail an enormous cost and time as well as an ethical problem due the need to sacrifice many animals (mostly vertebrates). Under REACH, however, in-silico methods (e.g., QSAR and read-across methods) are accepted as alternatives to experimental data provided that they are validated according to a rigorous and well-defined protocol (ECHA, 2020). A similar approach has been adopted under other EU Regulations such as the Biocidal Products Regulation (BPR, (EU) 528/2012) ([26]), the Plant Protection Products Regulation (PPPR, (EC) 1107/2009) ([27]) and, for impurities, the human medicines directive (2001/83/EC) ([28]) Therefore, as long as there is sufficient reliability, it might be appropriate to promote the implementation of a similar approach for the derivation of toxicologically-based marine thresholds in future.

8.2 NORMAN network ([29])

The quality targets module under the NORMAN network aims to compile existing Environmental Quality Standards (EQS) or Predicted No-Effect Concentrations (PNEC) for the aquatic environment mentioned in the chapters above, which are sometimes available from different EU MS or chemical regulations (e.g., PPPR, BPR or REACH). The NORMAN Ecotoxicology Database contains all substances listed in the NORMAN Suspect List Exchange together with a lowest PNEC value, which was agreed by NORMAN experts primarily for substance prioritisation purposes. These PNECs were either calculated based on experimental data (currently 812 substances) or predicted by QSAR models for three trophic levels (more than 60000 substances).

Most of the PNECs were derived for the freshwater matrix, based on ecotoxicological data (PNECfw) and, unless there was an experimental value for other matrices, the following calculations were used for the derivation of PNECs in other matrices:

Marine water – Lowest PNECfw/10

Sediments – Lowest PNECfw*2.6*(0.615+0.019*Koc)

Biota – PNECfw*BCF

It should be noted that the equilibrium partitioning calculation has been used to calculate the PNECs sediment and the PNECs biota calculation uses the BCF (instead of the BAF as indicated in the EU TGD-EQS) and doesn't consider the protection of human health via consumptions of fishery products. In case the PNECs from the NORMAN database were used to derive TVs, a quality control in the NORMAN database in line with that followed for broad environmental assessments such as MSFD or RSC would be required.

8.3 Thresholds in biota based on critical body burden

The Federal Environmental Quality Guidelines include Fish Tissue Guidelines (FFTGs) for some substances (e.g., PBDEs) that intend to protect fish from direct adverse effects. FFTGs supplement water quality guidelines in that they provide a different metric to assess potential adverse effects. FFTGs apply to both freshwater and marine fish species, and specify the concentration of substance found in whole body fish tissue (wet weight) not expected to result in adverse effects to the fish themselves. In the absence of direct toxicity data based on fish tissue burdens, FFTGs were based on fish tissue burdens estimated from concentrations in water and the degree to which fish are known to accumulate the substance from water i.e. bioaccumulation factor or BAF. The

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([26]) Regulation (EU) No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products.

([27]) Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC.

([28]) Directive 2001/83/EC of the European Parliament and of the Council of 6 November 2001 on the Community code relating to medicinal products for human use.

([29]) https://www.norman-network.net/.

BAFs were calculated from field sampling data on water concentration and aquatic biota levels, representing steady state bioaccumulation due to environmentally relevant levels.

The Arctic Monitoring and Assessment Programme (AMAP) report on Arctic wildlife and fish (AMAP, 2018) describes a methodology to assess the risk of exposure to persistent contaminants (e.g., PCBs and Hg) based on body residues in marine and terrestrial mammals and birds. This approach was used because actual oral exposure was often hard to estimate while tissue residues and blood concentrations were measured within the AMAP monitoring programs. The risk quotient (RQ) for a particular effect in a particular species (e.g., polar bear) is estimated by comparison of the measured body residue with a critical body residue effect thresholds (typically in adipose tissue), which is calculated from critical daily doses (e.g., for reproductive or immunotoxic effects) determined by laboratory rat studies using physiologically-based pharmacokinetic (PBPK):

RQ = Body Residue (μg/g) /Critical Body Residue (μg/g) with values ≥1 representing a risk.

8.4 Effect-Based Methods (EBM)

As explained before, the WFD follows a classical single-chemical risk-assessment approach for the management of chemical pollution of water bodies, which has some limitations (e.g., the impossibility to analyse all potential substances present in the environment as well as the effects caused by the mixtures of substances). Effect-based methods (EBMs) are based on the establishment of EQS for several critical groups of substances, each group characterised by a specific mode of action (or effect type). The use of EBM for monitoring and assessment has been proposed in the context of the WFD as a new holistic way to address the effects of known and unknown compounds in the environment, although the way to implement it is still under discussion (WFD WG Chemicals EBM Subgroup, 2021). It is necessary to bear in mind that this approach only addresses direct effects and presents difficulties to establish impacts such as secondary poisoning.

9 Conclusions

9.1 Availability of marine Threshold Values

Threshold Values for contaminants relevant for the marine environment and in the appropriate matrix are needed. TVs are currently only available for a rather limited number of contaminants and not for all environmental matrices. Although other thresholds may exist, for instance, at the national level, the TVs compiled in this report have been set for 138 contaminants in water (Annex I), 35 in biota (Annex II) and 30 in sediments (Annex III), while the number of relevant contaminants can be much higher (for instance, Tornero and Hanke (2017) provided a list of more than 2700 potential marine contaminants). While, thanks to upcoming technologies, such as mass spectrometric techniques (e.g., Time-of-flight mass spectrometry, TOF, Ion-trap mass spectrometry), a large number of contaminants can now be monitored and (semi-)quantified in environmental matrices, there is still a lack of TVs to assess if the monitored contaminant concentrations can potentially be harmful.

The availability of TVs should be further improved through the inclusion of certain substances and sampling matrix types (biota, sediment or suspended matter) within existing WFD EQS review and prioritisation processes. From the last MSFD reporting (2018), it is clear that biota and sediments are widely used for marine monitoring and reporting, but the lack of EU-agreed thresholds for those matrices often leads to the use of different TVs within and between marine (sub)regions or no assessment at all. Besides the WFD EQS development process, it is needed to understand how to develop and agree on TVs for substances which are relevant for the EEZ.

Marine threshold derivation should be based on marine ecotoxicological data, in different marine organisms, preferably the known most sensitive ones, and consider the specificities of the marine environment (e.g., in the context of persistent, bioaccumulative and toxic (PBT) substances and the sea as their final sink). Toxicological tests are often focusing on freshwater species and there is a significant gap for bioaccumulation data in marine species, thus there remains some uncertainty on potential effects on marine species. This should be amended in future to ensure that measures are based on current scientific knowledge that is harmonised across Europe. One way forward could be to consider an additional AF on freshwater QS, as proposed in the WFD TGD-EQS. Furthermore, existing sediment QS are often a result of recalculated water values, but should preferably be based on toxicity data for benthic organisms.

The technical possibilities for developing TVs and assessing chemical contamination are changing and include modelling approaches, e.g., Quantitative Structure Activity Relationship calculations, and other new methodologies, which should be considered for the way forward. For example, the NORMAN ecotoxicology database contains Predicted No-Effect Concentrations (PNEC) TVs for more than 60.000 compounds, covering both marine biota and sediment TVs. These TVs might be used for a first screening and developed further with experts in case of potential risks, until EU and RSC TVs have been agreed.

The needs for toxicological and non-toxicological (e.g., bioaccumulation) data to fill gaps on detected contaminants in marine matrices along with a strong commitment towards structured programmes at EU level to generate them should be discussed in the context of the EU Chemicals Policy, the WFD, the MSFD and related research efforts.

There is also need for an evaluation methodology of the combined effects of chemical mixtures (currently, there is only one approach developed for PFAS). TVs could be developed for substance groups like e.g., pyrethroids rather than for individual substances. The groups to be considered need to be identified and agreed between the different networks. The role of bioassays for mode of action in mixture toxicity assessments could be explored.

9.2 Implementation of marine Threshold Values

A joint EU-wide strategical approach to ensure cost-effective monitoring and compliance checking by implementing TVs in European Marine Areas, in close collaboration with RSCs, resulting in large scale harmonised and comparable assessments of contaminants in the marine environment, should be developed.

There are currently divergent approaches for assessing some chemical pollutants (e.g., PBDEs, PAHs and mercury) between MSFD-WFD-RSC. While the MSFD GES Decision states that MS should apply the WFD EQS over other thresholds, MS experts have expressed their concerns regarding their applicability to the marine environment, and instead other assessment criteria agreed regionally or set at national level are sometimes applied. This can lead to conflicting assessment goals for some parameters across the EU. Conflicting assessments between frameworks are mainly related to the use of $EQS_{biota,\ hh}$ for environmental assessments.

Safe thresholds for human health are based on mean food intake estimations, which are very much different between humans and marine mammals. Furthermore, it would be desirable to look at substances where the EQS is based on the protection of human health (e.g., dioxins), to ensure that similar principles are used and an equal protection level is reached. The assessment methodology for the application of EQS_{biota} is also challenging. Trophic level 4 is not relevant for shellfish and biomagnification data are scarcely available. TL and TMF data adjustments are not carried out by MS for their MSFD assessments.

While it can be assumed that a large amount of marine data has been generated through MS and RSCs, nowadays it is still difficult to determine what (and for which contaminants) data are available, insufficient or missing. The accessibility of all marine contaminant concentration data in different matrices through a single portal is crucial to understand data availability and highlight where further efforts are needed. EMODnet (European Marine Observation and Data Network) ([30]) would be an option for such a data collection platform and enhanced efforts should be made to make datasets accessible through it.

Coordination and collaboration between WFD/MSFD/RSC as well as with relevant regulatory agencies implementing chemical regulations (e.g., ECHA and EFSA) are essential to ensure consistency in chemical assessments across Europe and progress towards the “one substance, one assessment” principle set in the Chemical Strategy for Sustainability ([31]). Research efforts should consider the needs of supporting information in order to develop scientifically sound approaches under consideration of upcoming technologies.

Alternative assessment approaches e.g., by using temporal trends that show a degradation of the environment or by comparing the chemical concentrations to reference locations, could also be discussed and explored.

Threshold Values are thus a crucial element in environmental assessments that need to be implemented in a strategic set-up that considers spatial sampling distribution across coastal, open and deep-sea environments, species selection for biota sampling, biological effect monitoring and other approaches providing the necessary information for selection of measures to protect the Ocean.

([30]) https://emodnet.ec.europa.eu/en.
([31]) https://environment.ec.europa.eu/strategy/chemicals-strategy_en.

Main messages and recommendations

Based on the previous conclusions, the following messages and recommendations can be drawn:

- For the marine environment, sediment and biota are relevant matrices and should be more taken into account when EQSs are determined for Priority Substances under EU legislation.
- EQS are needed for additional contaminants that are relevant for the marine environment.
- The WFD WG Chemicals, which is the forum for discussion and derivation of EQS, could be the framework where EQS also relevant for the MSFD are developed, ensuring that marine expertise, including RSC experience and knowledge, are considered in the process.
- When marine EQS are set according to the European Technical Guidance for Deriving Environmental Quality Standards, priority should be given to reducing uncertainty factors in order to ensure the most reliable assessments for the marine ecosystem. This can be achieved by getting better knowledge on ecotoxicological effects from contaminants in the marine ecosystem.
- For MSFD D8 purposes, derivation of EQSbiota should focus on the protection of marine top predators rather than on human health.
- The application of generic bioaccumulation and biomagnification factors should be avoided.
- Where relevant, TVs should be developed for groups of contaminants rather than for single contaminants. The groups to be considered need to be identified and agreed between the different frameworks.
- In order to expand our understanding of the potential threats to the marine environment, modelled-derived PNECs (e.g., QSAR) for additional contaminants (other than WFD PS) could be used as a preliminary indication of TVs and to support further substance prioritization and monitoring activities. These PNECs should not be regarded as EQS and their applicability for assessing GES has to be further discussed.
- Harmonisation of the TVs used must be sought. Therefore, different TVs for the same substance/matrix should be avoided.
- Toxicity data from different chemical legislation (REACH, biocides, plant protection products, pharmaceuticals) should be held in one central database, to enable “one-substance-one-assessment”.

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List of abbreviations and definitions

BAC	Background assessment concentration
BC	Background concentration
BMF	Biomagnification factor
CCME	Canadian Environmental Quality Guidelines
EAC	Environmental assessment criteria
ECHA	European chemicals agency
EFSA	European food safety authority
EQS	Environmental quality standard
ERL	Effects Range-Low level
FEQGs	Canadian Federal Environmental Quality Guidelines
FWiDG	Federal Wildlife Dietary Guideline
MSFD	Marine Strategy Framework Directive
PAHs	Polycyclic Aromatic Hydrocarbons
PBDE	Polibrominated diphenylethers
PCB	Polychlorinated Biphenyl
PHS	Priority Hazardous Substance
PNEC	Predicted No-Effect Concentration
PS	Priority Substance
QS	Quality standard
QSR	Quality Status Report
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RSC	Regional Sea Convention
TOC	Total Organic Carbon
TRQG	Tissue residue quality guidelines
UNEP	United Nations Environmental Program
USEPA	United States Environmental Protection Agency
WFD	Water Framework Directive

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Annexes

Annex 1. Compilation of marine waters thresholds (n.a.: Not applicable)

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (µg/l)	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater (1) (µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
Aclonifen (CAS 74070-46-5)	MAC-EQS (2)= 0.012 AA-EQS= 0.012									
Alachlor (CAS 15972-60-8)	MAC-EQS= 0.7 AA-EQS= 0.3									
Aldicarb (CAS 116-06-3)					Long-term= 0.15	From 1993.				
Aldrin (3) (CAS 309-00-2)	MAC-EQS= n.a. AA-EQS (4)= 0.005		Priority Pollutant CMC (acute)= 1.3	Based on the 1980's criteria, which used different Minimum Data Requirements and derivation procedures from the 1985 Guidelines. If evaluation is to be done using an averaging period, the acute criteria values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.			0.003	From 2000. Reliability: Unknown		
Anthracene (CAS 120-12-7)	MAC-EQS= 0.1 AA-EQS= 0.1						0.01	From 2000. Reliability: Unknown		
Antimony (CAS 7440-36-0)									EQS AA≤ 20 (5)	Origin AA-EQS: Human health
Arsenic (CAS 7440-38-2)			CMC (acute)= 69 CCC (chronic)= 36	From 1995. Values derived from data for arsenic (III), but is applied here to total arsenic.	Long-term= 12.5	From 1997.			EQS AA≤ 10	Origin AA-EQS: Human health

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (µg/l)	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater** ([1]) **(µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
				Saltwater criteria for metals are expressed in terms of the dissolved metal in the water column.						
Atrazine (CAS 1912-24-9)	MAC-EQS= 2.0 AA-EQS= 0.6									
Benzene (CAS 71-43-2)	MAC-EQS= 50 AA-EQS= 8				Long-term= 110	From 1999.	500	From 2000. Moderate reliability	EQS AA≤ 10	Origin AA-EQS: Human health
Bifenox (CAS 42576-02-3)	MAC-EQS= 0.004 AA-EQS= 0.0012									
Bisphenol A (BPA) (CAS 80-05-7)					FWQG= 3.5	From 2018. Developed for freshwater and may be applied to marine waters unless it can be demonstrated that the toxicity differs significantly between these two environments (e.g., due to ionization).				
Brominated diphenylethers (PBDEs)	MAC-EQS ([6]) = 0.014				TriBDE (all congener) FWQG= 46 TetraBDE (all congener) FWQG= 24 PentaBDE (all congener) FWQG= 0.2 PentaBDE (BDE-99) FWQG= 4 PentaBDE (BDE-100) FWQG= 0.2 HexaBDE (all congener) FWQG= 120 HeptaBDE (all congener) FWQG= 17 OctaBDE (all congener)	From 2013. FWQGs apply to both freshwater and marine environments unless it can be demonstrated that the toxicity differs significantly between these two environments).				

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (µg/l)	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater** (1) **(µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
					FWQG= 17					
BX 1100X (CAS 39403-84-4)							25	From 2000. Reliability: Unknown		
Cadmium and its compounds (CAS 7440-43-9)	MAC-EQS (7, 8) ≤ 0.45 (Class 1) 0.45 (Class 2) 0.6 (Class 3) 0.9 (Class 4) 1.5 (Class 5) AA-EQS[9]= 0.2	0.2 (as the WFD AA-EQS) (filtered or unfiltered)	Priority Pollutant CMC (acute)= 33 CCC (chronic)= 7.9	From 2016. Saltwater criteria for metals expressed as dissolved metal in the water column.	Long-term= 0.12	From 2014.	0.7	From 2000. Very high reliability	EQS AA≤ 10	Origin AA-EQS: Human health
Carbaryl (CAS 63-25-2)			CMC (acute)= 1.3	From 2012.	Short-term= 5.7 Long-term= 0.29	From 2009.				
Carbon tetrachloride (3) (CAS 56-23-5)	MAC-EQS= n.a. AA-EQS= 12						240	From 2000. Reliability: Unknown	EQS AA≤ 2	Origin AA-EQS: Human health
Chlordane (CAS 57-74-9)			Priority Pollutant CMC (acute)= 0.09 CCC (chronic)= 0.004	Based on the 1980 criteria, which used different Minimum Data Requirements and derivation procedures from the 1985 Guidelines. If evaluation is to be done using an averaging period, the acute criteria values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.			0.001	From 2000. Reliability: Unknown		
Chlorine (CAS 7782-50-5)			CMC (acute)= 13 CCC (chronic)= 7.5	From 1986.						
C10-13 Chloroalkanes (9) (CAS 85535-84-8)	MAC-EQS= 1.4 AA-EQS= 0.4				FWQG= 2.4 (C_{10-13}) FWQG= 2.4 (C_{14-17}) FWQG= 2.4 ($C_{\geq 18}$)	From 2010.				

	EU WFD	**HELCOM**	**US EPA**		**Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)**		**Australian and New Zealand Water Quality Guidelines**		**Japan Environmental Quality Standards for water pollution (µg/l)**	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater** ([1]) **(µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
Chlorothalonil (CAS 1897-45-6)					Long-term= 0.36	From 1994.			EQS AA≤ 50 ([5])	EQS AA≤ 50
Chlorfenvinphos (CAS 470-90-6)	MAC-EQS= 0.3 AA-EQS= 0.1									
Chloroethylene (CAS 75-01-4)							100	From 2000. Reliability unknown		
Chlorpyrifos (Chlorpyrifos-ethyl) (CAS 2921-88-2)	MAC-EQS= 0.1 AA-EQS= 0.03		CMC (acute)= 0.011 CCC (chronic)= 0.0056	From 1986.	Long-term= 0.002	From 2008.				
Chromium (III) (CAS 7440-47-3)					Long-term= 56	From 1997.	2.7	From 2000. Low reliability		
Chromium (VI) (CAS 18540-29-9) (CAS 7440-47-3)			Priority Pollutant CMC (acute)= 1.1 CCC (chronic)= 50	From 1995. Saltwater criteria for metals expressed as dissolved metal in the water column.	Long-term= 1.5	From 1997.	4.4	From 2000. Very high reliability	EQS AA≤ 50	Origin AA-EQS: Human health
Cobalt (CAS 7440-48-4)							1	From 2000. High reliability		
Copper (CAS 7440-50-8)			Priority Pollutant CMC (acute)= 4.8 CCC (chronic)= 3.1	From 2007. Saltwater criteria for metals expressed as dissolved metal in the water column.			1.3	From 2000. Very high reliability	Oxine copper (organocopper) EQS AA≤ 40 ([5])	Origin AA-EQS: Human health
Corexit 7664 (CAS 12774-30-0)							1	From 2000. Reliability: Unknown		
Corexit 9527 (CAS 60617-06-3)							1000	From 2000. Moderate reliability		
Corexit 9550 (CAS 101550-82-7)							140	From 2000. Reliability: Unknown		
Cumene (Isopropylbenzene) (CAS 98-82-8)							30	From 2000. Reliability: Unknown		

	EU WFD	**HELCOM**	**US EPA**		**Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)**		**Australian and New Zealand Water Quality Guidelines**		**Japan Environmental Quality Standards for water pollution (µg/l)**	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater ([1]) (µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
Cyanide (CAS 57-12-5)			Priority Pollutant CMC (acute)= 4.8 CCC (chronic)= 3.1	From 1985. Expressed as µg free cyanide (CN/l).			4	From 2000. Very low reliability	EQS AA= not detectable ([10])	Origin AA-EQS: Human health
Cybutryne (CAS 28159-98-0)	MAC-EQS= 0.016 AA-EQS= 0.0025									
Cypermethrin ([11]) (CAS 52315-07-8)	MAC-EQS= 0.00006 AA-EQS= 0.000008									
DDT total ([3,12])	MAC-EQS= n.a. AA-EQS= 0.025									
para-para- DDT ([3]) (CAS 50-29-3)	MAC-EQS= n.a. AA-EQS= 0.01		Priority Pollutant CMC (acute)= 0.13 CCC (chronic)= 0.001	From 1980.			0.0004	From 2000. Reliability: Unknown		
Diazinon (CAS 333-41-5)									EQS AA≤ 5 ([5])	Origin AA-EQS: Human health
1,2-Dichlorobenzene (CAS 95-50-1)					Long-term= 42	From 1997.				
1,4-Dichlorobenzene (CAS 106-46-7)									EQS AA≤ 200 ([5])	Origin AA-EQS: Human health
1,1-Dichloroethene (CAS 75-35-4)							700	From 2000. Reliability: Unknown	EQS AA≤ 20	Origin AA-EQS: Human health
Cis 1,2-Dichloroethylene (CAS 156-59-2)									EQS AA≤ 40	Origin AA-EQS: Human health
Trans 1,2-Dichloroethylene (CAS 156-60-5)									EQS AA≤ 40 ([5])	Origin AA-EQS: Human health
Dichloromethane (CAS 75-09-2)	MAC-EQS= n.a. AA-EQS= 20						4000	From 2000. Reliability: Unknown	EQS AA≤ 20	Origin AA-EQS: Human health
1,1-Dichloropropane (CAS 78-99-9)							500	From 2000. Reliability: Unknown		
1,2-Dichloropropane (CAS 78-87-5)							900	From 2000. Reliability: Unknown	EQS AA≤ 60 ([5])	Origin AA-EQS: Human health
1,3-Dichloropropane (CAS 142-28-9)							1100			
1,3-Dichloropropene									EQS AA≤ 2	Origin AA-EQS:

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (µg/l)	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater** (1) **(µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
(CAS 542-75-6)										Human health
Dichlorvos (CAS 62-73-7)	MAC-EQS= 0.00007 AA-EQS= 0.00006								EQS AA≤ 8 (5)	Origin AA-EQS: Human health
1,2-Dichloroethane (CAS 107-06-2)	MAC-EQS= n.a. AA-EQS= 10						1900	From 2000. Reliability: Unknown	EQS AA≤ 4	Origin AA-EQS: Human health
Demeton (CAS 8065-48-3)			CCC (chronic)= 0.1	From 1985.						
Diazinon (CAS 333-41-5)			CMC (acute)= 0.82 CCC (chronic)= 0.82	From 2005.						
Diclofenac (CAS 15307-86-5)		Proposed value= 0.005 (as the AA-EQS in the WFD dossier)								
Dicofol (CAS 115-32-2)	MAC-EQS= n.a. (13) AA-EQS= 0.000032									
Dieldrin (3) (CAS 60-57-1)	MAC-EQS= n.a. AA-EQS[d]= 0.005		Priority Pollutant CMC (acute)= 0.71 CCC (chronic)= 0.019	From 1995. Based on the 1980 criteria, which used different Minimum Data Requirements and derivation procedures from the 1985 Guidelines. If evaluation is to be done using an averaging period, the acute criteria values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.						
Di(2-ethylhexyl)-phthalate (DEHP)	MAC-EQS= n.a. AA-EQS= 1.3								EQS AA≤ 60 (5)	Origin AA-EQS: Human health

Substance	EU WFD EQS (µg/l)	HELCOM Threshold value (µg/l)	US EPA Recommended Water Quality Criteria Saltwater (1) (µg/L)	US EPA Comments	Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG) Water Quality Guidelines or FWQGs (µg/l)	CCME/FEQG Comments	Australian and New Zealand Water Quality Guidelines Default Guideline Values (DGV) (µg/l)	ANZ Comments	Japan Environmental Quality Standards for water pollution (µg/l)	Japan Comments
(CAS 117-81-7)										
1,4-Dioxane (CAS 123-91-1)									EQS AA≤ 50 (5)	Origin AA-EQS: Human health
Diuron (CAS 330-54-1)	MAC-EQS= 1.8 AA-EQS= 0.2									
Endosulfan (CAS 115-29-7)	MAC-EQS= 0.004 (14) AA-EQS= 0.0005 (14)		Priority Pollutant CMC (acute)= 0.034 (15) CCC (chronic)= 0.0087 (15)	Based on the 1980 criteria, which used different Minimum Data Requirements and derivation procedures from the 1985 Guidelines. If evaluation is to be done using an averaging period, the acute criteria values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.	Short-term=0.09 Long-term= 0.002		0.005	From 2000. Moderate reliability		
Endrin (3) (CAS 72-20-8)	MAC-EQS= n.a. AA-EQS (4)= 0.005		Priority Pollutant CMC (acute)= 0.037 CCC (chronic)= 0.0023	From 1995. The derivation of the CCC for this pollutant did not consider exposure through the diet, which is probably important for aquatic life occupying upper trophic levels.						
Epichlorohydrin (CAS 106-89-8)									EQS AA≤ 0.4 (5)	Origin AA-EQS: Human health
EPN (CAS 2104-64-5)									EQS AA≤ 6 (5)	EQS AA≤ 50
Ethylbenzene (CAS 100-41-4)					Long-term= 25	From 1996.	80	From 2000. Reliability: unknown		

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (µg/l)	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater** [1] **(µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
Fenitrothion (122-14-5)									EQS AA≤ 3 [5]	Origin AA-EQS: Human health
Fenobucarb (BPMC) (CAAS 3766-81-2)									EQS AA≤ 30 [5]	Origin AA-EQS: Human health
Fluoranthene (CAS 206-44-0)	MAC-EQS= 0.12 AA-EQS= 0.0063						1	From 2000. Reliability: unknown		
Guthion (Azinphos-methyl) (CAS 86-50-0)			CCC (chronic)= 3.1	From 1986.						
Heptachlor and heptachlor epoxide (CAS 76-44- 8/1024-57-3)	MAC-EQS= 0.00003 AA-EQS= 0.00000001		Priority Pollutant CMC (acute)= 0.053 CCC (chronic)= 0.0036	From 1980/1981. Based on the 1980 criteria, which used different Minimum Data Requirements and derivation procedures from the 1985 Guidelines. If evaluation is to be done using an averaging period, the acute criteria values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines. This value was derived from data for heptachlor and there was insufficient data to determine relative toxicities of heptachlor and heptachlor epoxide.						
Hexabromocyclododecane (HBCDD) [16]	MAC-EQS= 0.05 AA-EQS= 0.0008				FWQG= 0.56	From 2016. FWQG applies to both freshwater and marine waters unless it can be				

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (µg/l)	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater** (1) **(µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
						demonstrated that the toxicity differs significantly between these two environments (e.g., due to ionization).				
Hexachlorobenzene (HCB) (CAS 118-74-1)	MAC-EQS= 0.05									
Hexachlorobutadiene (HCBD) (CAS 87-68-3)	MAC-EQS= 0.6									
Hexachlorocyclohexane (HCH) (CAS 608-73-1)	MAC-EQS= 0.02 (17) AA-EQS= 0.002 (17)		Priority Pollutant (P) (18) CMC (acute)= 0.16	From 1995. Based on the 1980 criteria, which used different Minimum Data Requirements and derivation procedures from the 1985 Guidelines. If evaluation is to be done using an averaging period, the acute criteria values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.						
Hydrazine (CAS 302-01-2) or Hydrazine hydrate (CAS 7803-57-8 and CAS 10217-52-4)					FWQG= 0.2	From 2013. Origin: protection of marine pelagic organisms for infinite exposure periods.				
Iprobenfos (CAS 26087-47-8)									EQS AA≤ 8 (5)	Origin AA-EQS: Human health
Isodrin (3)	MAC-EQS= n.a. AA-EQS (4)= 0.005									

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (µg/l)	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater** (1) **(µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
Isophorone (CAS 78-59-1)							130	From 2000. Reliability: unknown		
Isoprothiolane (CAS 50512-35-1)									EQS AA≤ 40 (5)	Origin AA-EQS: Human health
Isoproturon (CAS 34123-59-6)	MAC-EQS= 1.0 AA-EQS= 0.3									
Isoxathion (CAS 18854-01-8)									EQS AA≤ 8 (5)	Origin AA-EQS: Human health
Lead and its compounds (CAS 7439-92-1)	MAC-EQS= 14 AA-EQS= 1.3	1.3 (as the WFD AA-EQS) (filtered or unfiltered)	Priority Pollutant CMC (acute)= 140 CCC (chronic)= 5.6	From 1984. Saltwater criteria for metals expressed as dissolved metal in the water column.			4.4	From 2000. Low reliability	EQS AA≤ 10	
Linear alkylbenzene sulfonates (LAS) (CAS 85536-14-7)							0.1	From 2000. Reliability: unknown		
Malathion (CAS 121755)			CCC (chronic)= 0.1	From 1986.						
Manganese (CAS 7439-96-5)							80	From 2000. Reliability: unknown	Total manganese EQS AA≤ 200 (5)	Origin AA-EQS: Human health
Mercury and its compounds (CAS 7439-97-6) Methylmercury (CAS 22967-92-6)	MAC-EQS (8) = 0.07		Priority Pollutant CMC (acute)= 1.8 CCC (chronic)= 0.94	From 1995. Saltwater criteria for metals expressed as dissolved metal in the water column.	Long-term= 0.016	From 2003.	DGV (inorganic) = 0.1	From 2000. Very high reliability:	EQS AA (total)≤ 0.5 EQS AA (alkyl)= not detectable (10)	Origin AA-EQS: Human health
Methoxychlor (CAS 72-43-5)			CCC (chronic)= 0.03	From 1986.						
Methyl tert-butyl ether (MTBE) (CAS 1634-04-4)					Long-term= 5.0	From 2003.				
2-Methyl-4-chlorophenoxyacetic acid (MCPA) (CAS 94-74-6)					Long-term= 4.2	From 1995.				
Mirex			CCC (chronic)= 0.001	From 1986.						

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (μg/l)	
Substance	**EQS (μg/l)**	**Threshold value (μg/l)**	**Recommended Water Quality Criteria Saltwater** (1) **(μg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (μg/l)**	**Comments**	**Default Guideline Values (DGV) (μg/l)**	**Comments**		**Comments**
(CAS 2385-85-5)										
Molybdenum (CAS 7439-97-6)							0.1	From 2000. Very high reliability	EQS AA≤ 70 (5)	Origin AA-EQS: Human health
Monochlorobenzene (CAS 108-90-7)					Long-term= 25	From 1997.				
Naphthalene (CAS 91-20-3)	MAC-EQS= 130 AA-EQS= 2				Long-term= 1.4	From 1999.	50	From 2000. Moderate reliability		
N-hexane extract (oil, etc…)									EQS AA= not detectable (10)	Origin AA-EQS: Conservation of the living environment
Nickel and its compounds (CAS 7440-02-0)	MAC-EQS= 34 AA-EQS= 8.6		Priority Pollutant CMC (acute)= 74 CCC (chronic)= 8.2	From 1995. Saltwater criteria for metals expressed as dissolved metal in the water column.			7	From 2000. Very high reliability		
Nitrate (CAS 14797-55-8)					Short-term= 1500 mg/l Long-term= 200 mg/l	From 2012.				
Nonylphenols (4-Nonylphenol) (19) (CAS 84852-15-3)	MAC-EQS = 2 AA-EQS = 0.3		CMC (acute)= 7 CCC (chronic)= 1.7	From 2005.	Long-term= 0.7	From 2002.				
Octylphenols ((4-(1,1',3,3'-tetramethylbutyl)-phenol)) (20) (CAS 140-66-9)	MAC-EQS= n.a. AA-EQS= 0.01									
Pentachlorobenzene (CAS 608-93-5)	MAC-EQS= n.a. AA-EQS= 0.0007									
Pentachloroethane (CAS 76-01-7)							80	From 2000. Reliability: unknown		
Pentachlorophenol (CAS 87-86-5)	MAC-EQS= 1 AA-EQS= 0.4		Priority Pollutant CMC (acute)= 13 CCC (chronic)= 7.9	From 1995.						
Perfluorooctane sulfonic acid and its derivatives (PFOS)	MAC-EQS= 7.2 AA-EQS= 0.00013	0.00013 (as the WFD AA-EQS)								

	EU WFD	**HELCOM**	**US EPA**		**Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)**		**Australian and New Zealand Water Quality Guidelines**		**Japan Environmental Quality Standards for water pollution (µg/l)**	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater (1) (µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
(CAS 1763-23-1)										
Permethrin (CAS 52645531)					Long-term= 0.001	From 2006.				
Phenanthrene (CAS 85-01-8)							0.6	From 2000. Reliability: unknown		
Poly(acrylonitrile-co-butadiene-co-styrene) (CAS 9003-56-9)							250	From 2000. Low reliability		
Polyaromatic hydrocarbons (PAH):										
Benzo(a)pyrene (CAS 50-32-8)	MAC-EQS= 0.027 AA-EQS (21)= 0.017						0.1	From 2000. Reliability: unknown		
Benzo(b)fluoranthene (CAS 205-99-2) and Benzo(k)fluoranthene (CAS 207-08-9)	MAC-EQS (2)= 0.017									
Benzo(g,h,i)- perylene (CAS 191-24-2)	MAC-EQS (2) = $8.2*10^{-4}$									
Polychlorinated biphenyls (PCBs)			Priority Pollutant (P) (22) CCC (chronic)= 0.03						EQS AA= not detectable (10)	Origin AA-EQS: Human health
Propyzamide (CAS 23950-58-5)									EQS AA≤ 8 (5)	EQS AA≤ 50
Quinoxyfen (CAS 124495-18-7)	MAC-EQS= 0.54 AA-EQS= 0.015									
Selenium (CAS 7782-49-2)			Priority Pollutant CMC (acute)= 290 CCC (chronic)= 71	From 1999.					EQS AA≤ 10	Origin AA-EQS: Human health
Silver (CAS 7440-22-4)			Priority Pollutant CMC (acute)= 1.9	From 1980.	Short-term= 7.5	From 2015.	1.4	From 2000. Moderate reliability		
Simazine (CAS 122-34-9)	MAC-EQS= 4 AA-EQS= 1								EQS AA≤ 3	Origin AA-EQS: Human health
Sulfide-Hydrogen Sulfide (CAS 7783-06-4)			CMC (acute)= 2.0	From 1986.						
Terbutryn (CAS 886-50-0)	MAC-EQS= 0.0034 AA-EQS= 0.0065									

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (µg/l)	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater** (1) **(µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
Tetrabromobisphenol A (TBBPA) (CAS 79-94-7)					FWQG= 3.1	From 2016. Origin: protect all forms of aquatic life for indefinite exposure periods. The FWQG applies to both freshwater and marine waters because it cannot be demonstrated that the toxicity differs significantly between these two environments (e.g., due to ionization).				
1,2,3,4-Tetrachlorobenzene (CAS 634-66-2)							2	From 2000. Reliability: unknown		
1,2,3,5-Tetrachlorobenzene (CAS 634-90-2)							3	From 2000. Reliability: unknown		
1,2,4,5-Tetrachlorobenzene (CAS 95-94-3)							3	From 2000. Reliability: unknown		
1,1,2,2-Tetrachloroethane (CAS 79-34-5)							400	From 2000. Reliability: unknown		
Tetrachloroethylene (3) (CAS 127-18-4)	MAC-EQS= n.a. AA-EQS= 10						70	From 2000. Reliability: unknown		
Thallium (CAS 7440-28-0)							1.4	From 2000. Reliability: unknown		
Thiobencarb (CAS 28249-77-6)									EQS AA≤ 20	Origin AA-EQS: Human health
Thiram (CAS 137-26-8)									EQS AA≤ 6	Origin AA-EQS: Human health
Toluene					Long-term= 215	From 1996.	180	From 2000.	EQS AA≤ 600 (5)	Origin AA-EQS:

	EU WFD	HELCOM	US EPA		Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG)		Australian and New Zealand Water Quality Guidelines		Japan Environmental Quality Standards for water pollution (µg/l)	
Substance	**EQS (µg/l)**	**Threshold value (µg/l)**	**Recommended Water Quality Criteria Saltwater** (1) **(µg/L)**	**Comments**	**Water Quality Guidelines or FWQGs (µg/l)**	**Comments**	**Default Guideline Values (DGV) (µg/l)**	**Comments**		**Comments**
(CAS 108883)								Reliability: unknown		Human health
Toxaphene (CAS 8001352)			Priority Pollutant CMC (acute)= 0.21 CCC (chronic)= 0.0002	From 1986.						
Tributyltin compounds (including TBT- cation) (CAS 36643-28-4)	MAC-EQS= 0.0015 AA-EQS= 0.0002	0.0002 (as the WFD AA-EQS) (unfiltered ideally)	CMC (acute)= 0.42 CCC (chronic)= 0.0074	From 2004.	Long-term= 0.001	From 1992.	0.006 (as µg Sn/l)	From 2000. High reliability		
Trichlorobenzenes (CAS 12002-48-1)	MAC-EQS= n.a. AA-EQS (23)= 0.4				Long term= 5.4 (24)	From 1997.	20 (24)	From 2000. Reliability: unknown		
1,1,1-Trichloroethane (CAS 71-55-6)							270	From 2000. Reliability: unknown	EQS AA≤ 1000	Origin AA-EQS: Human health
1,1,2-Trichloroethane (CAS 79-00-5)							1900	From 2000. Very low reliability	EQS AA≤ 6	Origin AA-EQS: Human health
Trichloroethylene (3) (CAS 79-01-6)	MAC-EQS= n.a. AA-EQS= 10						330	From 2000. Reliability: unknown	EQS AA≤ 30	Origin AA-EQS: Human health
Trichloromethane (CAS 67-66-3)	MAC-EQS= n.a. AA-EQS= 2.5						370	From 2000. Reliability: unknown	EQS AA≤ 60 (5)	Origin AA-EQS: Human health
Trifluralin (CAS 1582-09-8)	MAC-EQS= n.a. AA-EQS= 0.03									
Uranium (CAS 7440-61-1)									EQS AA≤ 2 (5)	Origin AA-EQS: Human health
Vanadium (CAS 7440-62-2)					FWQG= 5	From 2016. Origin: protect all forms of marine aquatic life for indefinite exposure periods.	100	From 2000. Moderate reliability		
Vinyl chloride monomer (CAS 75-01-4)									EQS AA≤ 2 (5)	Origin AA-EQS: Human health
Xylene									EQS AA≤ 400 (5)	Origin AA-EQS:

Substance	EU WFD EQS (μg/l)	HELCOM Threshold value (μg/l)	US EPA Recommended Water Quality Criteria Saltwater (1) (μg/L)	US EPA Comments	Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG) Water Quality Guidelines or FWQGs (μg/l)	Canadian Environmental Quality Guidelines (CCME) or Federal Environmental Quality Guidelines (FEQG) Comments	Australian and New Zealand Water Quality Guidelines Default Guideline Values (DGV) (μg/l)	Australian and New Zealand Water Quality Guidelines Comments	Japan Environmental Quality Standards for water pollution (μg/l)	Japan Environmental Quality Standards for water pollution Comments
(CAS 1330-20-7)										Human health
m-xylene (CAS 108-38-3)							75	From 2000. Reliability: unknown		
Zinc (CAS 7440-66-6)			Priority Pollutant CMC (acute)= 90 CCC (chronic)= 81	From 1995.			15	From 2000. Moderate reliability	Water areas inhabited by aquatic life EQS AA≤ 20 Water areas inhabited by Class A organisms, those that should be conserved as spawning/rearing areas of aquatic life EQS AA≤ 10	Origin AA-EQS: Conservation of the living environment, adaptability of the habitat status of aquatic life

(1) US EPA National Recommended Aquatic Life Criteria_Conversion Factors for Dissolved Metals:

Metal	Saltwater CMC	Saltwater CCC
Arsenic	1.000	1.000
Cadmium	0.994	0.994
Chromium VI	0.993	0.993
Copper	0.83	0.83
Lead	0.951	0.951
Mercury	0.85	0.85
Nickel	0.990	0.990
Selenium	0.998	0.998
Silver	0.85	
Zinc	0.946	0.946

(2) MAC-QS is set equal to AA-QS.

(3) This substance is not a WFD PS but one of the other pollutants for which the EQS are identical to those laid down in the legislation that applied prior to 13 January 2009.

(4) EQS is Σ cyclodiene pesticides (aldrin, dieldrin, endrin, isodrin).

(5) Monitored substances and guideline values.

(6) For the group of WFD PS covered by brominated diphenylethers, the EQS water refers to the sum of the concentrations of congener numbers 28, 47, 99, 100, 153 and 154.

(7) For Cadmium and its compounds, the EQS values vary depending on the hardness of the water as specified in five class categories (Class 1: < 40 mg CaCO 3 /l, Class 2: 40 to < 50 mg CaCO 3 /l, Class 3: 50 to < 100 mg CaCO 3 /l, Class 4: 100 to < 200 mg CaCO 3 /l and Class 5: ≥ 200 mg CaCO 3 /l).

(8) EQS correspond to Maximum Permissible Addition (MPA) to the background concentration (EQSwater = Cbackground + MPA).

(9) No indicative parameter is provided for this group of substances. The indicative parameter(s) must be defined through the analytical method.

(10) The value for total cyanide is the maximum value and 'not detectable' means that when the substance is measured by the specified method, the amount is less than the quantification limit defined by the method.

(11) The WFD EQS refer to an isomer mixture of cypermethrin, alpha-cypermethrin (CAS 67375-30-8), beta-cypermethrin (CAS 65731-84-2), theta-cypermethrin (CAS 71697-59-1) and zeta-cypermethrin (52315-07-8).

(12) DDT total comprises the sum of the isomers 1,1,1-trichloro-2,2 bis (p-chlorophenyl) ethane (CAS number 50-29-3; EU number 200-024-3); 1,1,1-trichloro-2 (o-chlorophenyl)-2-(p-chlorophenyl) ethane (CAS number 789-02-6; EU Number 212-332-5); 1,1-dichloro-2,2 bis (p-chlorophenyl) ethylene (CAS number 72-55-9; EU Number 200-784-6); and 1,1-dichloro-2,2 bis (p-chlorophenyl) ethane (CAS number 72-54-8; EU Number 200-783-0).

(13) There is insufficient information available to set a MAC-EQS for these substances.

(14) The EQSs refer to α-endosulfan (CAS 959-98-8) and β-endosulfan (CAS 33213-65-9) and endosulfan sulphate (CAS 1031-07-8).

(15) The recommended aquatic life criteria refer to α-endosulfan and β-endosulfan.

(16) The EQSs refer to 1,3,5,7,9,11-hexabromocyclododecane (CAS 25637-99-4), 1,2,5,6,9,10- hexabromocyclododecane (CAS 3194-55-6), α-hexabromocyclododecane (CAS 134237-50-6), β-hexabromocyclododecane (CAS 134237-51-7) and γ- hexabromocyclododecane (CAS 134237-52-8).

(17) Mixed isomers

(18) The recommended aquatic life criteria refers to gamma-HCH (lindane) (CAS 58-89-9).

(19) The EQSs include isomers 4-nonylphenol (CAS 104-40-5, EU 203-199-4) and 4- nonylphenol (branched) (CAS 84852-15-3, EU 284-325-5).

(20) The EQSs water include isomer 4-(1,1',3,3'-tetramethylbutyl)-phenol (CAS 140-66-9, EU 205-426-2).

(21) For the group of priority substances of polyaromatic hydrocarbons (PAH), benzo(a)pyrene (CAS 50-32-8), benzo(b)fluoranthene (CAS 205-99-2), bBenzo(k)fluoranthene (CAS 207-08-9), benzo(g,h,i)- perylene (CAS 191-24-2) and indeno(1,2,3- cd)-pyrene (CAS 193-39-5), the AA-EQS in water refer to the concentration of benzo(a)pyrene, on the toxicity of which they are based. Benzo(a)pyrene can be considered as a marker for the other PAHs, hence only benzo(a)pyrene needs to be monitored for comparison with the biota EQS or the corresponding AA- EQS in water.

(22) This criterion applies to total PCBs (e.g., the sum of all congener or all isomer or homolog or Aroclor analyses).

(23) The EQSs refer to 1,2,3-TCB (CAS 87-61-6); 1,2,4-TCB (CAS 120-82-1); 1,3,5-TCB (CAS 108-70-3).

(24) The water quality guidelines and DGV refer to 1,2,4 TCB (CAS 120-82-1).

Source: EU WFD EQS Directive, RSC lists of chemicals and list of chemicals of relevant frameworks beyond the EU.

Annex 2. Compilation of marine biota thresholds (sw: saltwater; ww: wet weight; dw: dry weight; sec pois: secondary poisoning; BMF: Biomagnification factor; lw: lipid weight; PHS: Priority Hazardous Substance; EAC: Environmental Assessment criteria; BAC: Background Assessment Concentration; MED: Mediterranean Sea; EC: maximum levels in EC Reg. 1881/2006; CCME: Canadian Environmental Quality Guidelines; FEQGs: Canadian Federal Environmental Quality Guidelines; TRQG: Tissue residue quality guidelines; FWiDG: Federal Wildlife Dietary Guideline; WHO-EHC: World Health Organization Environmental Health Criteria)

	EU WFD EQS		**OSPAR Assessment criteria** (3)		**HELCOM hazardous substances indicator and threshold values**		**Canadian Environmental Quality Guidelines (CCME) or FEQGs**		**UNEP MAP assessment criteria**	
Substance	**EQS biota** (1) **(µg.kg^{-1} ww)**	**Comments**	**BAC EAC EC levels** (2) **FEQGs (µg.kg^{-1})**	**Comments**	**Threshold value (µg.kg^{-1} ww)**	**Comments**	**Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg^{-1} ww)**	**Comments**	**MED BAC** (4) **EAC (EC levels)** (2) **(µg.kg^{-1} ww)**	**Comments**
Bisphenol A (BPA)							FWiDG mammalian= 660	From 2018.		

Substance	EU WFD EQS: EQS biota ([1]) (µg.kg⁻¹ ww)	EU WFD EQS: Comments	OSPAR Assessment criteria ([3]): BAC EAC EC levels ([2]) FEQGs (µg.kg⁻¹)	OSPAR Assessment criteria ([3]): Comments	HELCOM hazardous substances indicator and threshold values: Threshold value (µg.kg⁻¹ ww)	HELCOM hazardous substances indicator and threshold values: Comments	Canadian Environmental Quality Guidelines (CCME) or FEQGs: Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg⁻¹ ww)	Canadian Environmental Quality Guidelines (CCME) or FEQGs: Comments	UNEP MAP assessment criteria: MED BAC ([4]) EAC (EC levels) ([2]) (µg.kg⁻¹ ww)	UNEP MAP assessment criteria: Comments
							FWiDG avian= 110	Origin: protection of wildlife consumers (diet)		
Brominated diphenylethers (PBDEs) ([5])	0.0085	Dossier from 2011. PHS Origin: Human health Most sensitive organism: Mice (no sw data) Effect: Hyperactivity and alterations in anxiety-like behaviour	Fish and shellfish (any tissue) BAC= BDE 28, 47, 66, 85, 99, 100, 126, 153,154, 183, 209: 0.065 ug/kg lw Fish and shellfish (any tissue) FEQG= BDE 28= 2400 BDE 47= 880 BDE 99= 20 BDE 100= 20 BDE 153= 80 BDE 154= 80 ([7]) ug/kg lw	2020 Proposal. Environmental threshold FEQG are considered as EAC-proxies (to be accepted for OSPAR purposes). BDE28, 99 and 100: Fish health BDE47, 66, 153, 154: Mammalian wildlife health Human health is out of the protection scope of FEQG derivation. The FEQG are expressed on a lipid weight basis assuming the original values were derived for fish with 5% lipid.	0.0085	Threshold type: Primary Origin: EU WFD EQS (5% lipid normalisation)	TetraBDE (all congener): FWiDG= 44 PentaBDE (all congener): FWiDG mammal= 3 FWiDG birds= 13 PentaBDE (BDE-99): FWiDG= 3 HexaBDE (all congener): FWiDG= 4 HeptaBDE (all congener: FWiDG= 64 OctaBDE (all congener): FWiDG= 63 NonaBDE (all congener): FWiDG= 78 DecaBDE (all congener): FWiDG= 9	From 2013. Origin: protection of mammalian wildlife consumers (diet)		

Substance	EU WFD EQS		OSPAR Assessment criteria (3)		HELCOM hazardous substances indicator and threshold values		Canadian Environmental Quality Guidelines (CCME) or FEQGs		UNEP MAP assessment criteria	
	EQS biota (1) (μg.kg^{-1} ww)	Comments	BAC EAC EC levels (2) FEQGs (μg.kg^{-1})	Comments	Threshold value (μg.kg^{-1} ww)	Comments	Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (μg.kg^{-1} ww)	Comments	MED BAC (4) EAC (EC levels) (2) (μg.kg^{-1} ww)	Comments
			Sum PBDE = 0.0085 μg/kg ww fish muscle and bivalves	Human health threshold Origin: EU WFD EQS EQS included on a trial basis, for human health only						
Cadmium			Mussels BAC= 960 μg/kg dw Oysters BAC= 3000 μg/kg dw Fish BAC= 26 μg/kg ww fish liver EC MPC in bivalve of 1000 μg/kg ww, applied also for fish liver EC MPC in fish of 50 μg/kg ww, applied for fish muscle	 Human health threshold Origin: EC Reg. 1881/2006	Mussels and fish= 160	Threshold type: Secondary Origin: QS derived from EQS (whole fish, secondary poisoning), based upon Danish input			Mussel MED BAC= 1065 μg/kg dw Fish MED BAC= 7.8 (6) Mussel EAC= 1000 Fish EAC= 50	MED BAC: Mussel= 1.5*Background Concentration (50th median) Fish= 2* Background Concentration (50th median) Origin: EC Reg. 1881/2006
Chlorinated alkanes Short chain (SCCAs): C10-13 Medium chain (MCCAs): C14-17 Long chain (LCCAs): C≥18							FWiDG SCCAs= 18 FWiDG MCCAs= 0.54 FWiDG LCCAs $C_{\geq 20\ liquid}$= 18 FWiDG LCCAs $C_{\geq 20\ solid}$= 770	From 2016. Origin: protection of wildlife consumers (diet)		
Diclofenac					QS proposed= 1	Threshold type: Not determined Origin: WFD EQS dossier				
Dicofol	33	Dossier from 2011. PHS Origin: Top predators								

Substance	EU WFD EQS: EQS biota ([1]) (µg.kg^{-1} ww)	EU WFD EQS: Comments	OSPAR Assessment criteria ([3]): BAC EAC EC levels ([2]) FEQGs (µg.kg^{-1})	OSPAR: Comments	HELCOM hazardous substances indicator and threshold values: Threshold value (µg.kg^{-1} ww)	HELCOM: Comments	Canadian Environmental Quality Guidelines (CCME) or FEQGs: Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg^{-1} ww)	Canadian: Comments	UNEP MAP assessment criteria: MED BAC ([4]) EAC (EC levels) ([2]) (µg.kg^{-1} ww)	UNEP MAP: Comments
		Most sensitive organism: Bird (no sw data) Effect: Reproduction Additional BMF for sw organisms: No								
DDT (total)							TRQG= 14	From 1997. Origin: protection of wildlife consumers (avian)		
pp-DDE			Mussels and oysters BAC= 0.63 µg/kg dw Fish BAC= 0.10 µg/kg ww						Mussel MED BAC= 3.05 µg.kg^{-1} dw Mussel EAC= 5-50 µg.kg^{-1} dw	Origin: OSPAR Commission, CEMP 2008/2009. EAC: earlier data from the QSR2017 report
Dieldrin									Mussel EAC= 5-50 µg.kg^{-1} dw	Origin: OSPAR Commission, CEMP 2008/2009. EAC: earlier data from the QSR2017 report
Heptachlor and heptachlor epoxide	0.0067	Dossier from 2011. PHS Origin: Human health Most sensitive organism: Mice (no sw data) Effect: Carcinogenic								
Hexabromocyclododecane (HBCDD) ([7])	167	Dossier from 2011. PHS Origin: Top predators Most sensitive organism: Bird (no sw data) Effect: Survival hatched chicks	167 ug/kg ww	Environmental threshold Origin: EU WFD EQS (converted to lipid weight assuming whole fish lipid content of 5%)	167	Threshold type: Primary Origin: EU WFD EQS (5% lipid normalisation)	FWiDG mammalian= 40 (mg/kg food ww). It is the concentration of a TBBPA in aquatic biota, expressed on whole body, ww basis that could be eaten by terrestrial or semi-aquatic wildlife	From 2016. Origin: protection of mammals that consume aquatic biota		

	EU WFD EQS		OSPAR Assessment criteria (3)		HELCOM hazardous substances indicator and threshold values		Canadian Environmental Quality Guidelines (CCME) or FEQGs		UNEP MAP assessment criteria	
Substance	**EQS biota (1) (µg.kg^{-1} ww)**	**Comments**	**BAC EAC EC levels (2) FEQGs (µg.kg^{-1})**	**Comments**	**Threshold value (µg.kg^{-1} ww)**	**Comments**	**Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg^{-1} ww)**	**Comments**	**MED BAC (4) EAC (EC levels) (2) (µg.kg^{-1} ww)**	**Comments**
		Additional BMF for SW organisms: No								
Hexachlorobenzene (HCB)	10	Dossier from 2005. PHS Origin: Human health Most sensitive organism: Pig and Rat (no sw data) Effect: Neoplastic (WHO-EHC value)	Mussels and oysters BAC= 0.63 µg/kg dw Fish BAC= 0.09 µg/kg ww 16.7 µg/kg ww fish and bivalves 10 µg/kg ww	Environmental threshold Origin: QS sec pois (converted to lipid weight assuming whole fish lipid content of 5%) Human health threshold Origin: EU WFD EQS (converted to lipid basis using the typical species-muscle lipid content)						
Hexachlorobutadiene (HCBD)	55	Dossier from 2005. PHS Origin: Top predators Most sensitive organism: Mice (no sw data) Effect: Chronic toxicity Additional BMF for SW organisms: No								
α-HCH			Mussels and oysters BAC: 0.64 µg/kg dw						Mussels (µg.kg^{-1} dw) BAC= 0.75	Origin: OSPAR Commission, CEMP 2008/2009

	EU WFD EQS		OSPAR Assessment criteria (3)		HELCOM hazardous substances indicator and threshold values		Canadian Environmental Quality Guidelines (CCME) or FEQGs		UNEP MAP assessment criteria	
Substance	**EQS biota (1) (µg.kg^{-1} ww)**	**Comments**	**BAC EAC EC levels (2) FEQGs (µg.kg^{-1})**	**Comments**	**Threshold value (µg.kg^{-1} ww)**	**Comments**	**Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg^{-1} ww)**	**Comments**	**MED BAC (4) EAC (EC levels) (2) (µg.kg^{-1} ww)**	**Comments**
Lead			Mussels and oysters BAC= 1300 µg/kg dw Fish BAC= 26 µg/kg ww fish liver EC MPC in bivalve of 1500 µg/kg ww, applied also for fish liver EC MPC in fish of 300 µg/kg ww, applied for fish muscle	 Human health threshold Origin: EC Reg. 1881/2006	Fish liver= 26 Mussels= 110	Threshold type: Secondary Origin: OSPAR proxy BAC for fish liver. Mussel value based upon Danish input			Mussel MED BAC= 1650 µg/kg dw Fish MED BAC= 36.6 (6) Mussel EAC= 7500 µg/kg dw Fish EAC= 300	MED BAC: Mussel= 1.5*Background Concentration (50th median) Fish= 2* Background Concentration (50th median) Origin: EC Reg. 1881/2006
Lindane			Mussels and oysters BAC: 0.97 µg/kg dw Mussels and oysters EAC= 0.29 µg/kg ww Fish EAC= 1.1 µg/kg ww whole fish 61 µg/kg ww for fish and bivalves	 Human health threshold Origin: QS derived from EQS (human health)					Mussel EAC= 1.45 µg.kg^{-1} dw Fish EAC= 11	Origin: OSPAR EAC fish liver derived by applying a conversion factor of 10 on EAC for whole fish (OSPAR CEMP 2008/2009)
Mercury and its compounds	20 (8)	Dossier from 2005. PHS Origin: Top predators Most sensitive organism: Monkey (sw data: Mallard	Mussels BAC= 90 µg/kg dw Oster BAC= 180 µg/kg dw (not used as above the EQS)		20	Threshold type: Primary Origin: EU WFD EQS	Methylmercury TRQG= 33	From 2001. Origin: protection of wildlife consumers (avian)	Mussel MED BAC= 117 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median)

	EU WFD EQS		OSPAR Assessment criteria (3)		HELCOM hazardous substances indicator and threshold values		Canadian Environmental Quality Guidelines (CCME) or FEQGs		UNEP MAP assessment criteria	
Substance	**EQS biota (1) (µg.kg^{-1} ww)**	**Comments**	**BAC EAC EC levels (2) FEQGs (µg.kg^{-1})**	**Comments**	**Threshold value (µg.kg^{-1} ww)**	**Comments**	**Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg^{-1} ww)**	**Comments**	**MED BAC (4) EAC (EC levels) (2) (µg.kg^{-1} ww)**	**Comments**
		duck; similar sensitivity) Effect: Growth Additional BMF for SW organisms: No	Fish BAC= 35 µg/kg ww (fish muscle) (not used as above the EQS) EC MPC 500 µg/kg ww (fish muscle and bivalves) 20 µg/kg ww whole fish sec pois	 Human health threshold Origin: EC Reg. 1881/2006 Environmental threshold Origin: EU WFD EQS					Fish MED BAC= 81.2 Mussel EAC= 2500 µg/kg dw Fish EAC= 1000	Fish= 2* Background Concentration (50th median) Origin: EC Reg. 1881/2006
Perfluorooctane sulfonic acid and its derivatives (PFOS)	9.1	Dossier from 2011. PHS Origin: Human health Most sensitive organism: Monkey Sw data: Mallard duck (predators) Effect: Sub-chronic	33 µg/kg ww whole fish 9.1 ug/kg ww	Environmental threshold (QS sec pois) Human health threshold	9.1	Threshold type: Primary Origin: EU WFD EQS. Conversion from liver to muscle	FWiDG mammalian= 4.6 FWiDG avian= 8.2	From 2018. Origin: protection of wildlife consumers (diet expressed on whole body)		
Polyaromatic hydrocarbons (PAH):										
Anthracene			EAC (9)= 290 ug/kg dw						MED BAC (10)= 1.68 µg/kg dw EAC (10)= 290 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median) Origin: OSPAR
Benzo(a)anthracene			EAC (9)= 80 ug/kg dw						MED BAC (10)= 0.90 µg/kg dw	MED BAC:

Substance	EU WFD EQS		OSPAR Assessment criteria [3]		HELCOM hazardous substances indicator and threshold values		Canadian Environmental Quality Guidelines (CCME) or FEQGs		UNEP MAP assessment criteria	
	EQS biota [1] (µg.kg^{-1} ww)	**Comments**	**BAC EAC EC levels [2] FEQGs (µg.kg^{-1})**	**Comments**	**Threshold value (µg.kg^{-1} ww)**	**Comments**	**Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg^{-1} ww)**	**Comments**	**MED BAC [4] EAC (EC levels) [2] (µg.kg^{-1} ww)**	**Comments**
			BAC [9]= 2.5 ug/kg dw						EAC [10]= 80 µg/kg dw	Mussel= 1.5*Background Concentration (50th median) Origin: OSPAR
Benzo(a)pyrene	5 [11, 12]	Dossier from 2011. PHS Origin: EC Reg. 1881/2006 maximum levels given for foodstuffs (human health) (crustaceans and cephalopods). Effect: Carcinogenic	EAC [9]= 600 ug/kg dw BAC[9] = 1.4 ug/kg dw 5 µg/kg ww	Human health threshold Origin: EU WFD EQS	5	Threshold type: Primary Origin: EU WFD EQS			EAC [10]= 600 µg/kg dw	Origin: OSPAR
Benzo(b)fluoranthene									MED BAC [10]= 1.50 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median)
Benzo(g,h,i)- perylene			EAC [9]= 110 ug/kg dw BAC [9]= 2.5 ug/kg dw						MED BAC [10]= 1.50 µg/kg dw EAC [10]= 110 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median) Origin: OSPAR
Benzo(k)fluoranthene									MED BAC [10]= 1.50 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median)

	EU WFD EQS		OSPAR Assessment criteria (3)		HELCOM hazardous substances indicator and threshold values		Canadian Environmental Quality Guidelines (CCME) or FEQGs		UNEP MAP assessment criteria	
Substance	**EQS biota (1) (µg.kg^{-1} ww)**	**Comments**	**BAC EAC EC levels (2) FEQGs (µg.kg^{-1})**	**Comments**	**Threshold value (µg.kg^{-1} ww)**	**Comments**	**Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg^{-1} ww)**	**Comments**	**MED BAC (4) EAC (EC levels) (2) (µg.kg^{-1} ww)**	**Comments**
									EAC (10)= 260 µg/kg dw	Origin: OSPAR
Chrysene			BAC (9)= 8.1 ug/kg dw						MED BAC (10)= 3.81 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median)
Fluoranthene	30 (11)	Dossier from 2011. PHS Origin: Human health Most sensitive organism: Rat (no sw data) Effect: Carcinogen (without threshold)	EAC (9)= 110 ug/kg dw BAC (9)= 12. ug/kg dw 2 30 µg/kg ww	 Human health threshold Origin: EU WFD EQS	30	Threshold type: Primary Origin: EU WFD EQS			MED BAC (10)= 7.25 µg/kg dw EAC (10)= 110 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median) Origin: OSPAR
Fluorene									MED BAC (10)= 3.75 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median) Origin: OSPAR
Indeno(1,2,3- cd)-pyrene			BAC (9)= 2.4 ug/kg dw							
Naphtalene			EAC (9)= 340 ug/kg dw						MED BAC (10)= 0.84 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median)
Phenanthrene			EAC (9)= 1700 ug/kg dw BAC (9)= 11 ug/kg dw						MED BAC (10)= 8.03 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median)

Substance	EU WFD EQS		OSPAR Assessment criteria ([3])		HELCOM hazardous substances indicator and threshold values		Canadian Environmental Quality Guidelines (CCME) or FEQGs		UNEP MAP assessment criteria	
	EQS biota ([1]) **(µg.kg^{-1} ww)**	**Comments**	**BAC EAC EC levels** ([2]) **FEQGs (µg.kg^{-1})**	**Comments**	**Threshold value (µg.kg^{-1} ww)**	**Comments**	**Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg^{-1} ww)**	**Comments**	**MED BAC** ([4]) **EAC (EC levels)** ([2]) **(µg.kg^{-1} ww)**	**Comments**
									EAC ([10])= 1700 µg/kg dw	Origin: OSPAR
Pyrene			EAC ([9])= 100 ug/kg dw BAC ([9])= 9 ug/kg dw						MED BAC ([10])= 3.75 µg/kg dw EAC ([10])= 100 µg/kg dw	MED BAC: Mussel= 1.5*Background Concentration (50th median) Origin: OSPAR
Polychlorinated biphenyls (PCBs), dioxins and furans	0.0065 ([13, 14]) ($\mu g_{WHO98-TEQ}$.kg-1 ww)	Dossier from 2011. PHS Origin: EC Reg. 1881/2006 maximum levels given for foodstuffs ([15]) (human health) (content of the sum of dioxins and DL-compounds) Effect: Reproduction (rat)	Dioxin like PCBs Bivalve BAC (µg/kg dw): CB105= 0.75 CB118= 0.60 CB156= 0.60 Fish BAC (µg/kg ww): CB105: 0.08 CB118: 0.10 CB156: 0.08 EAC CB 118=25 µg/kg lw for bivalves and fish Non dioxin-like PCBs Bivalve BAC (µg/kg dw): CB28= 0.75 CB52= 0.75 CB101= 0.70 CB138= 0.60 CB153= 0.60	Only applied to fish tissues with a typical lipid content > 3% Environmental threshold	Dioxin like PCBs, dioxins and furans EQS= 0.0065 TEQ.kg-1 ww Non dioxin-like PCBs EC= 75	Threshold type: Primary Origin: EU WFD EQS and Food Reg. EU 1259/2011 (5% lipid normalisation)	PCBs TRQG mammalian = 0.79 ng TEQ·kg-1 diet ww TRQG avian=2.4 ng TEQ·kg-1 diet ww (TEQ is total dioxin toxic equivalents) Polychlorinated dibenzo-p-dioxins/ dibenzo furans (PCDD/PCFs) TRQG mammalian = 0.71 ng TEQ·kg-1 diet ww Based on TEF values for mammals (van den Berg et al., 1998). TRQG avian=2.4 ng TEQ·kg-1 diet ww Interim guideline, based on TEF values for birds (van den Berg et al., 1998)	PCBs From 1998. Origin: protection of wildlife consumers. PCDD/PCFs From 2001. Origin: protection of wildlife consumers	Bivalve MED BAC (µg/kg dw): CB28= 0.20 CB52= 0.38 CB101= 1.20 CB118= 1.23 CB138= 2.31 CB153= 3.45 CB180= 0.50 Sum 7 PCBs= 18.4 Bivalve EAC (µg/kg dw): CB28= 3.2 CB52= 5.4 CB101= 6 CB118= 1.2 CB138= 15.8 CB153= 80 CB180= 24 Fish EAC (µg/kg lipid): CB28= 64 CB52= 108	 Origin: EAC OSPAR, CEMP 2008/2009

Substance	EU WFD EQS		OSPAR Assessment criteria (3)		HELCOM hazardous substances indicator and threshold values		Canadian Environmental Quality Guidelines (CCME) or FEQGs		UNEP MAP assessment criteria	
	EQS biota (1) (µg.kg-1 ww)	Comments	BAC EAC EC levels (2) FEQGs (µg.kg-1)	Comments	Threshold value (µg.kg-1 ww)	Comments	Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg-1 ww)	Comments	MED BAC (4) EAC (EC levels) (2) (µg.kg-1 ww)	Comments
			CB180= 0.60 Fish BAC (µg/kg ww): CB28= 0.10 CB52= 0.08 CB101= 0.08 CB138= 0.09 CB153= 0.10 CB180= 0.11 EAC (µg/kg lw for bivalves and fish): CB28= 67 CB52= 108 CB101= 121 CB138= 317 CB153= 1585 CB180= 469 EC MPCs ΣICES6 PCBs: Liver: 200 µg/kg ww Muscle: 75 µg/kg ww	Only applied to fish tissues with a typical lipid content > 3% Environmental threshold Human health threshold Origin: EC Reg. 1881/2006 (decided to apply EC MPC for ΣICES6 PCBs in fish muscle to bivalves)					CB101= 120 CB118= 24 CB138= 316 CB153= 1600 CB180= 480	
TBT			Bivalve BAC= 5.0 µg/kg dw Bivalve EAC= 12.0 µg/kg dw 15.2 µg/kg ww for fish and bivalves	Environmental threshold Human health threshold						

	EU WFD EQS		OSPAR Assessment criteria (3)		HELCOM hazardous substances indicator and threshold values		Canadian Environmental Quality Guidelines (CCME) or FEQGs		UNEP MAP assessment criteria	
Substance	**EQS biota** (1) **(µg.kg-1 ww)**	**Comments**	**BAC EAC EC levels** (2) **FEQGs (µg.kg-1)**	**Comments**	**Threshold value (µg.kg-1 ww)**	**Comments**	**Tissue residue quality guidelines (TRQG) or Federal Wildlife Dietary Guideline (FWiDG) (µg.kg-1 ww)**	**Comments**	**MED BAC** (4) **EAC (EC levels)** (2) **(µg.kg-1 ww)**	**Comments**
				Origin: QS derived from EQS (human health)						
Tetrabromobisphenol A							FWiDG mammalian= 20	From 2016. Origin: protection of mammal wildlife consumers (diet expressed on whole body)		
Toxaphene							TRQG= 6.3	From 1997. Origin: protection of wildlife consumers (avian)		

(1) Unless otherwise indicated, the biota EQS relate to fish. An alternative biota taxon, or another matrix, may be monitored instead, as long as the EQS applied provides an equivalent level of protection.
(2) EC Maximum Permissible Concentration (MPC) (EC Reg. 1881/2006).
(3) A full description of the TV applied in the OSPAR 2022 CEMP Assessment can be found at https://dome.ices.dk/ohat/trDocuments/2022/help_ac_biota_contaminants.html.
(4) Proposed new updated regional assessment criteria in 2022, according to UNEP MAP (2022). Besides regional values, sub-regional ones are also available in UNEP MAP (2022), but not included in this annex.
(5) Only Tetra, Penta, Hexa and Heptabromodiphenylether (CAS -numbers 40088-47-9, 32534-81-9, 36483-60-0, 68928-80-3, respectively).
(6) UNEP MAP MED BAC: Liver matrix should be recommended in fish for Cd and Pb as within OSPAR convention.
(7) The EQS biota refers to 1,3,5,7,9,11-hexabromocyclododecane (CAS 25637-99-4), 1,2,5,6,9,10- hexabromocyclododecane (CAS 3194-55-6), α-hexabromocyclododecane (CAS 134237-50-6), β-hexabromocyclododecane (CAS 134237-51-7) and γ- hexabromocyclododecane (CAS 134237-52-8).
(8) The EQS_{biota} assessment was based on methyl mercury which is deemed more toxic than inorganic Hg.
(9) OSPAR EAC/BAC refer to fish muscle.
(10) UNEP MAP EACs and MED BACs refer to mussels.
(11) For fluoranthene and PAHs, the biota WFD EQS refers to crustaceans and molluscs. For the purpose of assessing chemical status, monitoring of fluoranthene and PAHs in fish is not appropriate.
(12) Benzo(a)pyrene can be considered as a marker for the other PAHs, hence only benzo(a)pyrene needs to be monitored for comparison with the biota EQS or the corresponding AA- EQS in water.
(13) Dioxins and dioxin-like compounds: this EQS biota refers to polychlorinated dibenzo-p-dioxins (PCDDs) 2,3,7,8-T4CDD (CAS 1746-01-6), 1,2,3,7,8-P5CDD (CAS 40321-76-4), 1,2,3,4,7,8- H6CDD (CAS 39227-28-6), 1,2,3,6,7,8-H6CDD (CAS 57653-85-7), 1,2,3,7,8,9-H6CDD (CAS 19408-74-3), 1,2,3,4,6,7,8-H7CDD (CAS 35822-46-9), 1,2,3,4,6,7,8,9-O8CDD (CAS 3268-87-9); polychlorinated dibenzofurans (PCDFs) 2,3,7,8-T4CDF (CAS 51207-31-9), 1,2,3,7,8-P5CDF (CAS 57117-41-6), 2,3,4,7,8-P5CDF (CAS 57117-31-4), 1,2,3,4,7,8-H6CDF (CAS 70648-26-9), 1,2,3,6,7,8-H6CDF (CAS 57117-44-9), 1,2,3,7,8,9-H6CDF (CAS 72918- 21-9), 2,3,4,6,7,8-H6CDF (CAS 60851-34-5), 1,2,3,4,6,7,8-H7CDF (CAS 67562-39-4), 1,2,3,4,7,8,9-H7CDF (CAS 55673-89-7), 1,2,3,4,6,7,8,9-O8CDF (CAS 39001-02-0) and dioxin-like polychlorinated biphenyls (PCB-DL) 3,3',4,4'-T4CB (PCB 77, CAS 32598-13-3), 3,3',4',5-T4CB (PCB 81, CAS 70362- 50-4), 2,3,3',4,4'-P5CB (PCB 105, CAS 32598-14-4), 2,3,4,4',5-P5CB (PCB 114, CAS 74472-37-0), 2,3',4,4',5-P5CB (PCB 118, CAS 31508-00-6), 2,3',4,4',5'-P5CB (PCB 123, CAS 65510-44-3), 3,3',4,4',5-P5CB (PCB 126, CAS 57465-28-8), 2,3,3',4,4',5-H6CB (PCB 156, CAS 38380-08-4), 2,3,3',4,4',5'-H6CB (PCB 157, CAS 69782-90-7), 2,3',4,4',5,5'-H6CB (PCB 167, CAS 52663-72-6), 3,3',4,4',5,5'-H6CB (PCB 169, CAS 32774-16-6), 2,3,3',4,4',5,5'-H7CB (PCB 189, CAS 39635-31-9).
(14) For dioxins and dioxin-like compounds, the biota WFD EQS relates to fish, crustaceans and molluscs.

([15]) Muscle meat of fish and fishery products and products thereof, excluding eel. The maximum level applies to crustaceans, excluding the brown meat of crab and excluding head and thorax meat of lobster and similar large crustaceans (*Nephropidae* and *Palinuridae*).

Source: EU WFD EQS Directive, RSC lists of chemicals and list of chemicals of relevant frameworks beyond the EU.

Annex 3. Compilation of marine sediment thresholds (BAC: Background Assessment Concentration; EAC: Environmental Assessment criteria; ERL: Effects Range-Low; FEQG: Federal Environmental Quality Guidelines; ERM: Effects Range-Median; ISQGs: Interim sediment quality guidelines; PELs: Probable effect levels; FSeQG: Federal Sediment Quality Guideline; DGVs: Default Guideline Values; GV-high: Additional upper guideline values; CCME: Canadian Council of Ministers of the Environment; fw: freshwater; AF: Assessment factor; MPA: Maximum Permissible Addition; TOC: total organic carbon; ww: wet weight; dw: dry weight)

	OSPAR Assessment criteria ([1])		**HELCOM hazardous substances indicator and threshold values**		**UNEP MAP assessment criteria**		**US EPA**		**Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG**		**Australian and New Zealand Sediment Quality Guidelines**	
Substance	**BAC EAC ERL FEQG (µg.kg^{-1}dw) ([2])**	**Comments**	**Threshold value (µg.kg^{-1} dw)**	**Comments**	**BAC ([3]) EAC (ERL) (µg.kg^{-1} dw)**	**Comments**	**ERL ERM (µg.kg^{-1} dw)**	**Comments**	**ISQGs PELs FSeQG (µg.kg^{-1} dw)**	**Comments**	**DGVs (GV-high) (µg.kg^{-1} dw)**	**Comments**
Antimony											DGV= 2000 GV-high= 25000	ANZECC & ARMCANZ (2000) ([4])
Arsenic	BAC= 25000 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz)						ERL= 8200 ERM= 70000	Origin: Long et al. (1995)	ISQG= 7240 PEL= 41600	From 1998. Origin: CCME	DGV= 20000 GV-high= 70 000	ANZECC & ARMCANZ (2000) ([4])
Bisphenol A									FSeQG= 25	From 2018.		
Brominated diphenylethers (PBDEs)	BAC: BDE28, BDE47, BDE66, BDE85, BDE99, BDE100, BDE153, BDE154, BDE183, BDE209= 0.05 <u>BDE28</u> FEQG ([2])= 110 <u>BDE47</u> FEQG ([2])= 97.5 <u>BDE66</u> FEQG ([2])= 97.5 <u>BDE85</u> FEQG ([2])= 1 <u>BDE99</u> FEQG ([2])= 1	Proposed in 2020. Origin: sediment-dwelling and pelagic health FEQG are considered as EAC-proxies	QS sediment= 310 (5% OC concentration normalisation)	Threshold type: Not determined Origin: EU WFD EQS dossier of 2011 (benthic community protection from PBDEs): <u>Marine dataset</u>: 1 Fish <u>Most sensitive organism</u>: Oligochete (fw) <u>Additional AF for marine water</u>: Yes (5)					<u>TriBDE</u> (all congeners) FSeQG= 44 <u>TetraBDE</u> (all congeners) FSeQG= 39 <u>PentaBDE</u> (all congeners) FSeQG= 0.4 <u>PentaBDE (BDE-99)</u> FSeQG= 0.4 <u>PentaBDE (BDE-100)</u> FSeQG= 0.4 <u>HexaBDE</u> (all congener) FSeQG= 440 <u>OctaBDE</u> (all congener) FSeQG= 5600 <u>DecaBDE</u> (all congener) FSeQG= 19 (normalised to 1% OC)	From 2013. Origin: protection of sediment dwelling animals as well as pelagic animals which bioaccumulate PBDEs from sediments		

	OSPAR Assessment criteria ([1])		HELCOM hazardous substances indicator and threshold values		UNEP MAP assessment criteria		US EPA		Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG		Australian and New Zealand Sediment Quality Guidelines	
Substance	**BAC EAC ERL FEQG (µg.kg^{-1}dw) ([2])**	**Comments**	**Threshold value (µg.kg^{-1} dw)**	**Comments**	**BAC ([3]) EAC (ERL) (µg.kg^{-1} dw)**	**Comments**	**ERL ERM (µg.kg^{-1} dw)**	**Comments**	**ISQGs PELs FSeQG (µg.kg^{-1} dw)**	**Comments**	**DGVs (GV-high) (µg.kg^{-1} dw)**	**Comments**
	<u>BDE100</u> FEQG ([2])= 1 <u>BDE153</u> FEQG ([2])= 1100 <u>BDE154</u> FEQG ([2])= 1100 <u>BDE183</u> FEQG ([2])= 14000 <u>BDE209</u> FEQG ([2])= 47.5											
Cadmium	BAC= 310 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 86 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 1200	OSPAR IA 2017. Origin: US EPA.	QS sediment= 2.3 (5% aluminium normalization)	Threshold type: Secondary Origin: EU WFD EQS dossier of 2005 (freshwater benthic community protection): QS sediment, fw = $C_{background}$ + 2.3 (MPA) <u>Marine dataset</u>: No data <u>Most sensitive organism</u>: Chironomus (fw) <u>Additional AF for marine water</u>: No QS for marine sediment was derived	MED BAC= 161 EAC= 1200 (2.5% total organic carbon normalised)	From 2016. Origin: US EPA ERL	ERL= 1200 ERM= 9600	Origin: Long et al. (1995)	ISQG= 700 PEL= 4200	From 1997. Origin: CCME	DGV= 1500 GV-high= 10000	ANZECC & ARMCANZ (2000) ([4])
Chromium	ERL= 81000	Origin: US EPA.					ERL= 81000 ERM= 370000	Origin: Long et al. (1995)	Total Cr (CAS 7440-47-3) ISQG= 52300 PEL= 160000	From 1998. Origin: CCME	DGV= 80000 GV-high= 370000	ANZECC & ARMCANZ (2000) ([4])
Chlordane									ISQG= 2.26 PEL= 4.79	From 1998. Origin: CCME	DGV= 4.5 GV-high= 9.0 (1% OC) ([5])	ANZECC & ARMCANZ (2000) ([6])

	OSPAR Assessment criteria (1)		HELCOM hazardous substances indicator and threshold values		UNEP MAP assessment criteria		US EPA		Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG		Australian and New Zealand Sediment Quality Guidelines	
Substance	**BAC EAC ERL FEQG ($\mu g.kg^{-1}$dw) (2)**	**Comments**	**Threshold value ($\mu g.kg^{-1}$ dw)**	**Comments**	**BAC (3) EAC (ERL) ($\mu g.kg^{-1}$ dw)**	**Comments**	**ERL ERM ($\mu g.kg^{-1}$ dw)**	**Comments**	**ISQGs PELs FSeQG ($\mu g.kg^{-1}$ dw)**	**Comments**	**DGVs (GV-high) ($\mu g.kg^{-1}$ dw)**	**Comments**
Chlorinated alkanes (CAs): Short chain (SCCAs): C_{10-13} Medium chain (MCCAs): C_{14-17} Long chain (LCCAs): $C_{\geq 18}$									FSeQG SCCAs= 1.8 FSeQG MCCAs= 5.4 FSeQG LCCAs $C_{18-20\ (liquid)}$= 100 (normalized to 1% OC)	From 2016. Origin: sediment dwelling animals as well as pelagic animals which bioaccumulate CAs from sediments		
Copper	BAC= 27000 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) ERL= 34000	Origin: US EPA.	30000	5% OC			ERL= 34000 ERM= 270000	Origin: Long et al. (1995)	ISQG= 18700 PEL= 108000	From 1998. Origin: CCME	DGV= 65000 GV-high= 270000	ANZECC & ARMCANZ (2000) (4)
Total DDTs							ERL= 1.58 ERM= 46.1	Origin: Long et al. (1995)	ISQG= 1.19 PEL= 4.77	From 1998. Origin: CCME	DGV= 1.2 GV-high= 5.0 (1% OC) (5)	ANZECC & ARMCANZ (2000) (6)
DDD									ISQG= 1.22 PEL= 7.81	From 1998. Origin: CCME		
o,p'- + p,p'-DDD											DGV= 3.5 GV-high= 9.0 (1% OC) (5)	ANZECC & ARMCANZ (2000) (6)
p,p'-DDE	BAC= 0.09 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz)				EAC= 2.2 (2.5% TOC normalised)	From 2016. Origin: US EPA ERL	ERL= 2.2 ERM= 27	Origin: Long et al. (1995)	ISQG= 2.07 PEL= 374	From 1998. Origin: CCME	DGV= 1.4 GV-high= 7.0 (1% OC) (5)	ANZECC & ARMCANZ (2000) (6)
Dieldrin	BAC= 0.19 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz)				EAC= 2.0 (2.5% TOC normalised)	From 2016. Origin: US EPA ERL			ISQG= 0.71 PEL= 4.3	From 1998. Origin: CCME	DGV= 2.8 GV-high= 7.0 (1% OC) (5)	ANZECC & ARMCANZ (2000) (6)
Endrin									ISQG= 2.67 PEL= 62.4	From 1998. Origin: CCME	DGV= 2.7 GV-high= 60 (1% OC) (5)	ANZECC & ARMCANZ (2000) (6)

	OSPAR Assessment criteria (1)		HELCOM hazardous substances indicator and threshold values		UNEP MAP assessment criteria		US EPA		Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG		Australian and New Zealand Sediment Quality Guidelines	
Substance	**BAC EAC ERL FEQG (µg.kg^{-1}dw) (2)**	**Comments**	**Threshold value (µg.kg^{-1} dw)**	**Comments**	**BAC (3) EAC (ERL) (µg.kg^{-1} dw)**	**Comments**	**ERL ERM (µg.kg^{-1} dw)**	**Comments**	**ISQGs PELs FSeQG (µg.kg^{-1} dw)**	**Comments**	**DGVs (GV-high) (µg.kg^{-1} dw)**	**Comments**
HBCDD			QS sediment= 170 (5% OC concentration normalization)	Threshold type: Secondary Origin: EU WFD EQS dossier of 2011 (benthic community protection): Marine dataset: 1 Fish Most sensitive organism: Oligochete (fw) Additional AF for marine water: Yes (5)					FSeQG= 1.6 Normalized to 1% OC	From 2006. Origin: CCME Origin: sediment dwelling animals as well as pelagic animals which bioaccumulate HBCDD from sediments		
HCB	BAC= 0.16 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz)				EAC= 20 (2.5% TOC normalised)	From 2016. Origin: US EPA ERL						
Heptachlor									ISQG= 0.6 PEL= 2.74	From 1998. Origin: CCME		
Lead	BAC= 38000 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 22400 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 47000	OSPAR IA 2017. Origin: US EPA	QS sediment= 120 (5% aluminium normalization)	Threshold type: Secondary Origin: EU WFD EQS dossier of 2011 (marine benthic community protection): Marine dataset: Chronic 1 Polychaete 1 Amphipod Pooling fw/sw dataset: Yes Most sensitive organism: SSD approach	MED BAC= 22500 EAC= 46700 (2.5% total organic carbon normalised)	 From 2016. Origin: US EPA ERL	ERL= 46700	Origin: Long et al. (1995)	ISQG= 30200 PEL= 112000	From 1998. Origin: CCME	DGV= 50000 GV-high= 220000	ANZECC & ARMCANZ (2000) (4)

	OSPAR Assessment criteria ([1])		HELCOM hazardous substances indicator and threshold values		UNEP MAP assessment criteria		US EPA		Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG		Australian and New Zealand Sediment Quality Guidelines	
Substance	**BAC EAC ERL FEQG (µg.kg^{-1}dw) ([2])**	**Comments**	**Threshold value (µg.kg^{-1} dw)**	**Comments**	**BAC ([3]) EAC (ERL) (µg.kg^{-1} dw)**	**Comments**	**ERL ERM (µg.kg^{-1} dw)**	**Comments**	**ISQGs PELs FSeQG (µg.kg^{-1} dw)**	**Comments**	**DGVs (GV-high) (µg.kg^{-1} dw)**	**Comments**
				Additional AF for marine water: No								
Lindane	BAC= 0.13 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz)				EAC= 3 (2.5% TOC normalised)	From 2016. Origin: US EPA ERL			ISQG= 0.32 PEL= 0.99	From 1998. Origin: CCME	DGV= 0.9 GV-high= 1.4 (1% OC) ([5])	ANZECC & ARMCANZ (2000) ([6])
Mercury and its compounds	BAC= 70 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 91 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 150	OSPAR IA 2017. Origin: US EPA			MED BAC= 75 EAC= 150 (2.5% total organic carbon normalised)	From 2016. Origin: US EPA ERL	ERL= 150 ERM= 710	Origin: Long et al. (1995)	ISQG= 130 PEL= 700	From 1997. Origin: CCME	DGV= 150 GV-high= 1000	ANZECC & ARMCANZ (2000) ([4])
Nickel	BAC= 36000 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz)						ERL= 20900 ERM= 51600	Origin: Long et al. (1995)			DGV= 21000 GV-high= 52000	ANZECC & ARMCANZ (2000) ([4])
Nonylphenol and its ethoxylates									ISQG= 1000	From 2002. Origin: CCME		

	OSPAR Assessment criteria ([1])		HELCOM hazardous substances indicator and threshold values		UNEP MAP assessment criteria		US EPA		Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG		Australian and New Zealand Sediment Quality Guidelines	
Substance	**BAC EAC ERL FEQG (µg.kg^{-1}dw) ([2])**	**Comments**	**Threshold value (µg.kg^{-1} dw)**	**Comments**	**BAC ([3]) EAC (ERL) (µg.kg^{-1} dw)**	**Comments**	**ERL ERM (µg.kg^{-1} dw)**	**Comments**	**ISQGs PELs FSeQG (µg.kg^{-1} dw)**	**Comments**	**DGVs (GV-high) (µg.kg^{-1} dw)**	**Comments**
Polyaromatic hydrocarbons (PAHs) and their metabolites	Anthracene BAC= 5 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 1.8 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 85 Benzo(a)anthracene BAC= 16 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 7.1 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 261 Benzo(a)pyrene BAC= 30 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 8.2 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 430 Benzo(g,h,i)-perylene BAC= 80 (OSPAR area excluding the MIME subregions	OSPAR IA 2017. Origin ERL: US EPA	Anthracene QS sediment= 24 (5% OC concentration normalization) Fluorathene QS sediment= 3500 (adjusted QS value as a mistake was found in the WFD EQS dossier) (5% OC concentration normalization)	Threshold type: Secondary Origin: EU WFD EQS dossier of 2011: Marine dataset: No data Most sensitive organism: Oligochete (fw) Additional AF for marine water: No.	Anthracene EAC= 85 Benzo(a)anthracene MED BAC= 5.1 EAC= 261 Benzo(a)pyrene EAC= 430 Benzo(b)fluoranthene MED BAC= 7.5 Benzo(g,h,i)-perylene EAC= 85 Benzo(kb)fluoranthene MED BAC= 6 Chrysene MED BAC= 4 EAC= 384 Fluoranthene MED BAC= 7.5 EAC= 600 Indeno(1,2,3-cd)-pyrene EAC= 240 Phenanthrene MED BAC= 4.7 EAC= 240 Pyrene MED BAC= 9.3 EAC= 660	Origin EAC US EPA ERL	Acenaphtene ERL= 16 ERM= 500 Acenaphtylene ERL= 44 ERM= 640 Anthracene ERL= 85.3 ERM= 1100 Benzo(a)anthracene ERL= 261 ERM= 1600 Benzo(a)pyrene ERL= 430 ERM= 1600 Chrysene (incl. triphenylene) ERL= 384 ERM= 2800 Dibenzo(a,h)anthracene ERL= 63.4 ERM= 260 Fluorene ERL= 19 ERM= 540 Fluoranthene ERL= 600 ERM= 5100 2-methyl naphthalene ERL= 70 ERM= 670 Naphtalene ERL= 160 ERM= 2100 Phenanthrene ERL= 240	Origin: Long et al. (1995)	Acenaphtene ISQG= 6.71 PEL= 88.9 Acenaphtylene ISQG= 5.87 PEL= 128 Anthracene ISQG= 46.9 PEL= 245 Benzo(a)anthracene ISQG= 74.8 PEL= 693 Benzo(a)pyrene ISQG= 88.8 PEL= 763 Chrysene ISQG= 108 PEL= 846 Dibenz(a,h)anthracene ISQG= 6.22 PEL= 135 Fluoranthene ISQG= 113 PEL= 1494 Fluorene ISQG= 21.2 PEL= 144 2-methylnaphtalene ISQG= 20.2 PEL= 201 Naphtalene ISQG= 34.6 PEL= 391 Phenanthrene ISQG= 86.7 PEL= 544 Pyrene ISQG= 153 PEL= 1398	From 1998. Origin: CCME	DGV ([5,6])= 10000 GV-high ([6,7])= 50000 (1% OC) ([5])	ANZECC & ARMCANZ (2000)

Substance	OSPAR Assessment criteria ([1])		HELCOM hazardous substances indicator and threshold values		UNEP MAP assessment criteria		US EPA		Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG		Australian and New Zealand Sediment Quality Guidelines	
	BAC EAC ERL FEQG ($\mu g.kg^{-1}$dw) ([2])	**Comments**	**Threshold value ($\mu g.kg^{-1}$ dw)**	**Comments**	**BAC ([3]) EAC (ERL) ($\mu g.kg^{-1}$ dw)**	**Comments**	**ERL ERM ($\mu g.kg^{-1}$ dw)**	**Comments**	**ISQGs PELs FSeQG ($\mu g.kg^{-1}$ dw)**	**Comments**	**DGVs (GV-high) ($\mu g.kg^{-1}$ dw)**	**Comments**
	Iberian Sea and Gulf of Cadiz) BAC= 6.9 (Iberian Sea and Gulf of Cadiz) (not normalised) Chrysene (incl. triphenylene) BAC= 20 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 8 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 384 Dibenzothiophene ERL= 190 Fluoranthene BAC= 39 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 14.4 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 600 Indeno(1,2,3- cd)-pyrene BAC= 103 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 8.3 (Iberian Sea and Gulf of						ERM= 1500 Pyrene ERL= 665 ERM= 2600 ΣLPAH ERL= 552 ERM= 3160 ΣHPAH ERL= 1700 ERM= 9600 Σ of total PAH ERL= 4022 ERM= 44792					

Substance	OSPAR Assessment criteria ([1]) BAC EAC ERL FEQG (µg.kg-1dw) ([2])	OSPAR Comments	HELCOM hazardous substances indicator and threshold values Threshold value (µg.kg-1 dw)	HELCOM Comments	UNEP MAP assessment criteria BAC ([3]) EAC (ERL) (µg.kg-1 dw)	UNEP MAP Comments	US EPA ERL ERM (µg.kg-1 dw)	US EPA Comments	Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG ISQGs PELs FSeQG (µg.kg-1 dw)	Canadian Comments	Australian and New Zealand Sediment Quality Guidelines DGVs (GV-high) (µg.kg-1 dw)	Australian and New Zealand Comments
	Cadiz) (not normalised) Naphthalene BAC= 8 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) ERL= 160 Phenanthrene BAC= 32 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 7.3 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 240 Pyrene BAC= 24 (OSPAR area excluding the MIME subregions Iberian Sea and Gulf of Cadiz) BAC= 11.3 (Iberian Sea and Gulf of Cadiz) (not normalised) ERL= 665											
Polychlorinated biphenyls (PCBs), doxins and furans	The BACs apply to MIME subregions apart from the Iberian Sea and Gulf of Cadiz CB28 BAC= 0.22 EAC= 1.7	From 2008. Origin: OSPAR-ICES			CB28 MED BAC= 0.10 EAC= 1.7 CB52 MED BAC= 0.07 EAC= 2.7 CB101 MED BAC= 0.10	EAC (2.5% TOC normalised) Origin EAC: OSPAR (from 2016)	Total PCBs ERL= 22.7 ERM= 180	Origin: Long et al. (1995)	PCDDs, PCDFs ISQG= 0.85 ng TEQ.kg-1dw PEL= 21.5 ng TEQ.kg-1dw PCBs ISQG= 21.5 PEL= 189 Arochlor 1254 ISQG= 63.3	From 2001. Origin: CCME	Total PCBs DGV= 34 GV-high= 280 (1% OC) ([5])	ANZECC & ARMCANZ (2000) ([6])

	OSPAR Assessment criteria (1)		HELCOM hazardous substances indicator and threshold values		UNEP MAP assessment criteria		US EPA		Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG		Australian and New Zealand Sediment Quality Guidelines	
Substance	**BAC EAC ERL FEQG ($\mu g.kg^{-1}$dw) (2)**	**Comments**	**Threshold value ($\mu g.kg^{-1}$ dw)**	**Comments**	**BAC (3) EAC (ERL) ($\mu g.kg^{-1}$ dw)**	**Comments**	**ERL ERM ($\mu g.kg^{-1}$ dw)**	**Comments**	**ISQGs PELs FSeQG ($\mu g.kg^{-1}$ dw)**	**Comments**	**DGVs (GV-high) ($\mu g.kg^{-1}$ dw)**	**Comments**
	<u>CB52</u> BAC= .12 EAC= 2.7 <u>CB101</u> BAC= 0.14 EAC= 3.0 <u>CB118</u> BAC= 0.17 EAC= 0.6 <u>CB138</u> BAC= 0.15 EAC= 7.9 <u>CB153</u> BAC= 0.19 EAC= 40 <u>CB180</u> BAC= 0.10 EAC= 12				EAC= 3.0 <u>CB118</u> MED BAC= 0.10 EAC= 0.6 <u>CB138</u> MED BAC= 0.11 EAC= 7.9 <u>CB153</u> MED BAC= 0.14 EAC= 40 <u>CB180</u> MED BAC= 0.09 EAC= 12 <u>∑7CBs ICES</u> MED BAC= 0.40 EAC= 11.5				PEL= 709			
Silver							ERL= 1000 ERM= 3700	Origin: Long et al. (1995)			DGV= 1000 GV-high= 4000	ANZECC & ARMCANZ (2000) (4)
Toxaphene									ISQG= 0.1	From 2002. Origin: CCME		
Total petroleum hydrocarbon (TPHs)											DGV= 280 GV-high= 550	ANZECC & ARMCANZ (2000) (6,8)
Tributyltin compounds (including TBT-cation)	TBSN+ QS sediment= 0.8 normalised to 2.5% organic carbon	Based on threshold of 1.6 for 5% organic carbon (see HELCOM), but hasn't been adjusted yet.	Adjusted TBT QS sediment= 1.3 (5% OC concentration normalization)	Threshold type: Primary Origin: Threshold of 1.6 was initially developed by Sweden and based on the original QS= 0.02 derived under the EU WFD EQS dossier of 2005							Tributyltin as Tin DGV= 9 GV-high= 70 (1% OC) (5)	ANZECC & ARMCANZ (2000)

	OSPAR Assessment criteria ([1])		**HELCOM hazardous substances indicator and threshold values**		**UNEP MAP assessment criteria**		**US EPA**		**Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG**		**Australian and New Zealand Sediment Quality Guidelines**	
Substance	**BAC** **EAC** **ERL** **FEQG** **(µg.kg^{-1}dw)** ([2])	**Comments**	**Threshold value (µg.kg^{-1} dw)**	**Comments**	**BAC** ([3]) **EAC (ERL)** **(µg.kg^{-1} dw)**	**Comments**	**ERL** **ERM** **(µg.kg^{-1} dw)**	**Comments**	**ISQGs** **PELs** **FSeQG** **(µg.kg^{-1} dw)**	**Comments**	**DGVs** **(GV-high)** **(µg.kg^{-1} dw)**	**Comments**
				(equilibrium partitioning approach; no benthic toxicity data). This value was adjusted to the current threshold, based on a Danish assessment where a SDS could be performed. WFD EQS dossier: <u>Marine dataset</u> (pelagic): <u>Acute:</u> 2 Algae 1 Crustacea 1 Mollusc <u>Chronic:</u> 1 Algae 2 Annelida 6 Molluscs 4 Crustacea 1 Echinoderma 2 Fish <u>Most sensitive organism</u>: Mollusc (sw) <u>Effect</u>: Imposex <u>Additional AF for marine water</u>: No								
Zinc	BAC= 122000 (OSPAR area excluding the MIME subregions Iberian						ERL= 150000 ERM= 410000	Origin: Long et al. (1995)	ISQG= 124000 PEL= 271000	From 1998. Origin: CCME	DGV= 200000 GV-high= 410000	ANZECC & ARMCANZ (2000) ([4])

Substance	OSPAR Assessment criteria ([1]) BAC EAC ERL FEQG (µg.kg^{-1}dw) ([2])	Comments	HELCOM hazardous substances indicator and threshold values: Threshold value (µg.kg^{-1} dw)	Comments	UNEP MAP assessment criteria: BAC ([3]) EAC (ERL) (µg.kg^{-1} dw)	Comments	US EPA: ERL ERM (µg.kg^{-1} dw)	Comments	Canadian Sediment quality guidelines for the protection of marine aquatic life or FEQG: ISQGs PELs FSeQG (µg.kg^{-1} dw)	Comments	Australian and New Zealand Sediment Quality Guidelines: DGVs (GV-high) (µg.kg^{-1} dw)	Comments
	Sea and Gulf of Cadiz) ERL= 150000											

([1]) A full description of the TV applied in the OSPAR 2022 CEMP Assessment can be found at https://dome.ices.dk/ohat/trDocuments/2022/help_ac_sediment_contaminants.html.

([2]) Unless otherwise stated, BAC are normalised to 2.5% TOC for organics and 5% aluminium for metals; the EAC and FEQG are normalised to 2.5% TOC; and the ERL are not normalised.

([3]) Proposed new updated regional assessment criteria in 2022, according to UNEP MAP (2022). Besides regional values, sub-regional ones are also available in UNEP MAP (2022), but not included in this annex.

([4]) Primarily adapted from the effects range low (ERL) and effects range median (ERM) values of Long et al. (1995).

([5]) Normalised to 1% OC within the limits of 0.2 to 10%. Thus if a sediment has (i) 2% OC, the '1% normalised' concentration would be the measured concentration divided by 2, (ii) 0.5% OC, then the 1% normalised value is the measured value divided by 0.5, (iii) 0.15% OC, then the 1% normalised value is the measured value divided by the lower limit of 0.2.

([6]) Primarily adapted from threshold effects level (TEL) and probable effects level (PEL) values of MacDonald et al. (2000) and CCME (2002).

([7]) The DGV and GV-high values for total PAHs (sum of PAHs) include the 18 parent PAHs: naphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[a]pyrene, perylene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[e]pyrene, benzo[ghi]perylene, dibenz[a,h]anthracene and indeno[1,2,3-cd]pyrene. Where nonionic OCs like PAHs are the dominant chemicals of potential concern (COPCs), the use of equilibrium partitioning sediment benchmarks (ESBs) is desirable, which includes a further 16 alkylated PAHs (generally listed as C1-/C2-/C3-/C4-alkylated), as described in Appendix A3 of Simpson et al. (2013).

([8]) Origin described in Appendix A5 of Simpson et al. (2013).

Source: EU WFD EQS Directive, RSC lists of chemicals and list of chemicals of relevant frameworks beyond the EU.

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