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Contaminants in Europe's seas

Moving towards a clean, non-toxic marine environment

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'The most alarming of all man's assaults upon the environment is the contamination of air, earth, water and sea with dangerous and even lethal materials' (Carson, 1962).

European Environment Agency

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The report is based on the long-term work of the European Topic Centre: ETC/ICM (inland, coastal and marine waters). It is based on information reported by European Union (EU) Member States, as part of reporting under the Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD), as well as on a suite of other sources of information.

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Key messages and executive summary

For decades, European countries have shared a common vision of a marine environment with close to zero concentrations of synthetic substances and near background levels of naturally occurring substances (Table 1.1).

Efforts to achieve this vision have happened in parallel with the extremely fast discovery of new substances, followed by an ever-increasing production and consumption of chemicals. Our consumption/emission patterns have reached such a scale that scientists have become concerned about whether we are at risk of breaching a planetary boundary for 'novel entities' (Box 1.1; Figure 2.1).

As a result, the question of whether or not we are on track to achieve this dual policy vision of a marine environment with a low concentration of contaminants remains as important as ever.

This assessment represents a first attempt to map contamination 'problem areas' and 'non-problem areas' at the scale of Europe's seas, while also exploring whether Europe has broken some of the trends for long-established hazardous substances.

Consequently, the overarching aims of this report are:

1) to establish a baseline for 'non-problem' and 'problem' areas for contaminants across Europe's marine waters;

2) to present temporal trends in the concentration levels of selected contaminants;

3) to provide an indicator-based methodology for assessing contaminants across Europe's seas and, in the process, for highlighting data coverage and gaps;

4) to reflect upon the findings.

The assessment is based on publicly available monitoring data, primarily collected in the context of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) (see Annex 5). It is built on existing assessment thresholds (criteria, levels, etc.) and a harmonised, regionally supported and peer-reviewed approach capable of embracing the diversity of substances monitored within and across regional seas, i.e. the CHASE+ tool (Figure 3.1).

Chapter 1 sets the scene, defines the problem and focuses on existing policies implemented to abate contamination of marine waters in Europe. The key findings are:

- Synthetic chemicals and heavy metals mobilised by human activities (i.e. contaminants) constitute a large-scale risk to our seas, our oceans and our planet.

- Policy commitments to reduce discharges, emissions and losses of hazardous substances to Europe's seas have been in place for decades.

- An advanced and comprehensive European Union (EU) regulatory framework is in place to help mitigate the documented and potential risk to human health and the environment from contaminants.

Chapter 2 describes the usage of chemicals in modern society and the sources, fate and effects of contaminants in the seas. The key findings are:

- Chemicals are essential components of modern society and highly influential for our well-being.

- Chemical production and consumption have been increasing fast over recent decades with approximately 150 000 substances in commercial use.

- Contaminants continue to find their way into the seas through multiple pathways.

- Contaminants have potential and documented negative effects on marine life, our well-being and our health.

Chapter 3 focuses on identifying current 'problem areas' and 'non-problem areas' with respect to the contamination status of Europe's regional seas. The key findings are (Table ES.1):

- The contamination status of Europe's seas has been mapped in 1 541 assessment units.
- The mapping of 'problem areas' and 'non-problem areas' is carried out using a well-documented, regionally supported, multi-metric indicator-based tool named 'CHASE+'.
- Most areas (85 % of the assessment units) are classified as being 'problem areas', indicating that many of the marine areas in Europe are impaired as result of contaminants (Map 3.5).

Chapter 4 describes the results of long-term monitoring of specific contaminants and the temporal trends in their concentrations. The key findings are:

- Trends in the concentration levels of selected substances seem to be improving for some substances.
- The monitoring of a wider variety of substances can provide earlier warnings.
- The monitoring of a predefined subset of substances could ease preparation of regional and European assessments and ensure consistent, solid policy support on progress.

Chapter 5 contains region-specific summaries of the report's findings, a crosscutting synthesis and prospects for the future. This chapter also discusses the effectiveness of existing policies and measures as well as the potential need for additional actions andabatement measures.

The key findings are:

- The contamination of Europe's regional seas continues to be a large-scale challenge, though progress has been observed.
- The concentrations of some well-known contaminants appear to be declining, though not all of them meet the agreed thresholds.
- Positive effects, as a result of the significant efforts to reduce input into the marine environment, are observed for some ecosystem features.
- Key politically agreed targets related to contamination in the marine environment remain unlikely to be met on time, e.g. the Generation Target and the descriptor on contaminants that is part of the Marine Strategy Framework Directive's goal of achieving good environmental status in Europe's regional seas.
- Persistent substances remain in marine ecosystems, so avoiding upstream use of persistent and hazardous substances is essential for reaching long-term policy commitments.
- To reach the policy vision of achieving clean, non-toxic European seas, a profound transition is needed in how we address marine pollution.

This publication is number one in a series of European Environment Agency (EEA) marine thematic reports covering a broad range of topics: (1) contaminants, (2) eutrophication, (3) marine biodiversity, (4) potential cumulative effects of multiple human pressures, (5) sustainable use, and (6) marine protected areas (MPAs). The seventh publication will be the second edition of the EEA Marine Messages report. Preparing these thematic assessments provided the marine input to The European environment – State and Outlook 2020, by the EEA.

Table ES.1 Summary of status of contaminants in Europe's seas, 2018

	Baltic Sea	Black Sea	Mediterranean Sea	North-East Atlantic Ocean
Classification status (percentage of area assessed as 'problem areas')	96.3 %	90.8 %	87.3 %	75.0 %
Information coverage (1 000 km^2)	C: 62 out of 215	C: 12 out of 111	C: 80 out of 611	C: 172 out of 649
	O: 139 out of 187	O: 116 out of 365	O: 14 out of 1 920	O: 888 out of 6 209
Dominating trends (based on available information)	Positive	Positive	Negative	Positive

Achievement of agreed policy targets for contaminants in the marine environment by 2020-2021		
Policy commitment	Objective	Achievement of policy targets by 2020-2021
United Nations (UN) Sustainable Development Goal (SDG) 14 'Life below water'	Prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities (by 2025)	
Baltic Sea Action Plan 2007	A Baltic Sea undisturbed by hazardous substances (by 2021)	
The Esbjerg Declaration 1995	Continuously reducing discharges, emissions and losses of hazardous substances moving towards the target of their cessation within one generation (by 2020)	
Bergen Statement 2010 (OSPAR)	'... ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances.'	
Hazardous Waste Protocol 2011 (Barcelona Convention)	Minimise the risk of pollution of harmful or noxious substances and materials	
Directive 2000/60/EC	Achieve good chemical status in coastal and territorial waters	
Directive 2008/56/EC	Achieve good environmental status in the marine environment by 2020	

Legend: Indicative assessment of:

Status and trends of contaminants		Information availability and quality	
(red)	Majority of assessment units classified as 'problem areas'/deteriorating trends dominate	(red)	Limited information
(blue)	Majority of assessment units classified as 'non-problem areas'/improving trends dominate	(blue)	Good information

Notes: The status assessment builds on the information analysed with CHASE+ in Chapter 3. The trends are as presented in Chapter 4.

C, coastal waters; O, offshore.

1 Contaminants — agents of change

- Synthetic chemicals and heavy metals mobilised by human activities (i.e. contaminants) constitute a large-scale risk to our seas, our oceans and our planet.
- Policy commitments to continuously reduce discharges, emissions and losses of contaminants to Europe's seas have been in place for decades.
- An advanced and comprehensive European Union (EU) regulatory framework is in place to help mitigate the documented and potential risk to both human health and the environment from contaminants.

Box 1.1 The planetary boundaries framework

The planetary boundaries framework set out to define a safe operating space for human society to develop and thrive. It builds upon our growing understanding of the functioning of the Earth's system. It has defined nine evolving planetary boundaries.

Five of these boundaries involve chemical substances. These include ocean acidification, climate change, stratospheric ozone depletion and biogeochemical flows. This report focuses on 'novel entities', which include synthetic chemicals, heavy metals, nanomaterials, radioactive materials and plastics.

Source: Steffen et al. (2015).

Throughout history, the natural capital of Europe's seas has played a crucial role in our very existence. We depend on marine natural capital for transport, energy, food, income and, even less obviously, life-support functions, such as the air we breathe and climate regulation. As we exploit terrestrial, coastal and marine natural capital, multiple pressures arise, leading to cumulative impacts on marine ecosystems and their biodiversity. Collectively we continue to undermine the self-renewal and resilience of these ecosystems, and thus jeopardise the ecosystem services they can supply and upon which we depend.

This publication explores whether or not contaminants are a concern in acheiving clean, non-toxic European seas.

1.1 Staying within planetary boundaries

The extent of cumulative impacts from human activities across ecosystems has, over the last century, accelerated and shifted from the degradation of the local and regional environment towards the potential degradation of the Earth's system. A growing awareness of such a global impact led to the development of the planetary boundaries concept at the beginning of the century (Steffen et al., 2004). A total of nine boundaries were defined to act as limits for human growth (Rockström et al., 2009; Steffen et al., 2015) (Box 1.1).

One of these boundaries concerns 'novel entities' defined as 'new or modified existing substances, and modified life forms that have the potential for unwanted geophysical and/or biological effects' (Steffen et al., 2015). This includes naturally occurring heavy metals mobilised by human activities (e.g. mercury) and potentially harmful synthetic chemical substances. The sheer volume of known commercial substances (> 150 000) and the unfathomable complexity of their interactions with each other and with their surrounding environment have made it very difficult to identify the best metric to measure as well as a boundary value (Steffen et al., 2015). 'Novel entities' are recognised as one of the attributes of the Anthropocene, the modern geological era (Waters et al., 2016).

Nevertheless, the threat from synthetic chemical substances and heavy metals (i.e. contaminants) to marine ecosystems and our seafood is real and well documented (MOE, 2002; HELCOM, 2010, 2017; OSPAR, 2010). It is beyond the scope of this publication to provide an answer to the complex scientific challenges involved in defining the planetary boundary for 'novel entities' as well as the influence contaminants have on other boundaries. However, this publication can provide an overview of whether or not our long-term policy vision of having clean, non-toxic seas is within reach.

The planetary boundaries concept is recognised by United Nations (UN) commitments. It is at the core of the UN Sustainable Development Goals (SDGs) for 2030 as a way to guide humankind towards a sustainable future. It is also recognised by ongoing EU policy, namely the EU Seventh Environment Action Programme (7th EAP) and its 2050 vision of living well within the planets ecological limits (EC, 2013).

The simple solution for addressing these complex, intertwined scientific and policy challenges may be to focus on precautionary and preventive actions. A key step towards informing such actions regarding contaminants in Europe's seas is to understand the extent of the challenge we face across our marine regions.

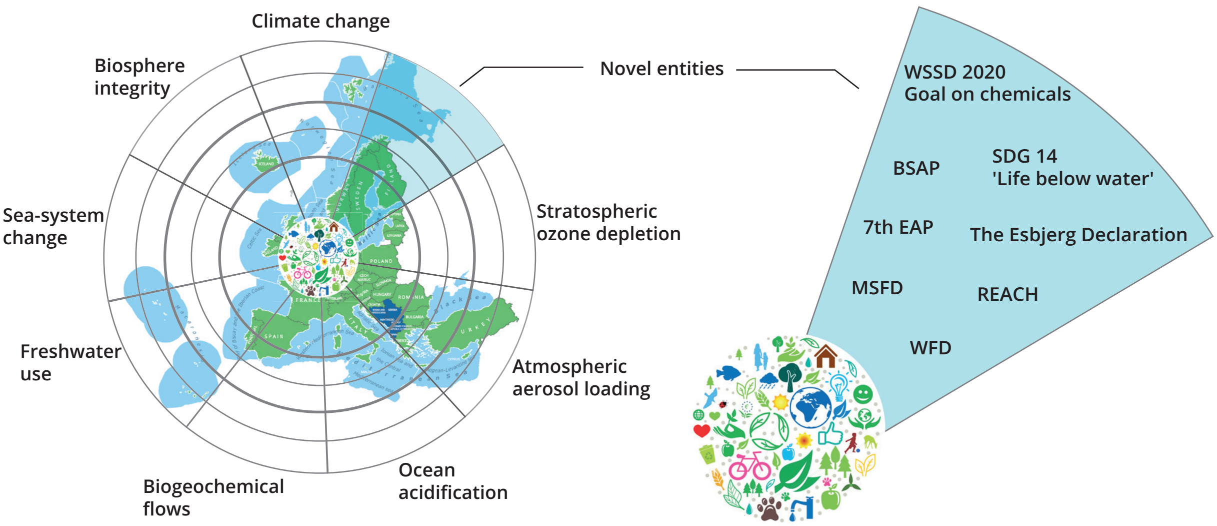
Therefore, this publication aims to further increase our understanding of whether or not contaminants in Europe's seas are a matter for concern, as well as to further the alignment of ongoing policy efforts, by:

- establishing a harmonised baseline for potential 'non-problem areas' and 'problem areas' for contaminants across Europe's marine waters;
- presenting temporal trends in the concentration levels of selected contaminants;
- providing an indicator-based methodology for assessing contaminants across Europe's seas and, in the process, illustrating data coverage and gaps;
- reflecting upon the findings.

While this thematic publication is a stand-alone product in its own right, it is also part of a series of EEA products covering a broad range of marine topics. These include climate change, biodiversity, eutrophication, acidification and cumulative effects in Europe's seas. These products will inform an integrated assessment of the health of Europe's seas — Marine Messages II.

Marine Messages II will be set in the context of living well within ecological limits of the seas, linking across themes, planetary boundaries and policies. It will provide a relevant marine contribution to *The European Environment – State and Outlook 2020* (SOER), and thus a timely and relevant thematic input to policy processes under the UN SDGs, the EU Biodiversity Strategy to 2020, the 7th EAP and the Marine Strategy Framework Directive (MSFD) (Figure 1.1).

Figure 1.1 Living within planetary limits — bridging the gap between science and policy



Notes: Novel entities, including contaminants, constitute a planetary boundary. Numerous UN, regional and EU policies address the potential risks of transgressing this boundary. This publication focuses on contaminants in Europe's seas. WSSD, World Summit on Sustainable Development; REACH, Registration, Evaluation, Authorisation and Restriction of Chemicals.

Source: EEA 2019, though inspired by Steffen et al. (2015).

Unfortunately, it has not been possible to include the potential new information reported under the MSFD in late 2018. Even if all EU Member States had reported on time, it would not have been possible to handle the data before the deadline of the SOER 2020. Any new information will be included in an update in 2021-2022.

All the aforementioned EEA products will help to inform the long-term policy goals for mitigating the risks jeopardising the health of our seas and oceans.

1.2 Growing awareness led to shared resolve to regulate contaminants

The late 1950s and early 1960s represent a turning point for humanity's understanding of ecology and our adverse influence on the environment. In 1956, an outbreak of a 'neurological disorder' occurred in Minimata, Japan, causing a range of severe neurological symptoms and in some instances leading to death. The 'Minimata disease' was caused by the ingestion of seafood that was contaminated with mercury compounds released from a local fertiliser factory (MOE, 2002). Further focus on contaminants came with the landmark publication *Silent Spring* in 1962, when Rachel Carson documented the effects of indiscriminate use of pesticides upon the environment (Carson, 1962).

For Europe's seas, the event that triggered an enhanced cooperation to combat marine pollution was the Torrey Canyon disaster in 1967. This disaster saw 117 000 tonnes of oil spilled into the sea when a 'super tanker' hit an offshore reef near Land's End in Cornwall (OSPAR, 2018c).

Such acute, visible and, at times, deadly incidents, combined with increased scientific knowledge, changed public sentiment and caused governments on both sides of the North Atlantic Ocean (and elsewhere) to enhance protection of the environment (EPA, 1992; ETC/ICM, 2018). It made us realise that the seas know no boundaries, thus promoting the need for international cooperation.

1.3 Policy commitments to safeguard our seas from contaminants

In the 1970s, this led to the establishment of significant international cooperation, e.g. the Oslo Convention in 1974, the Paris Convention in 1978, the 1974 Helsinki Convention and the Barcelona Convention in 1976. This early cooperation evolved throughout the 1990s into what is now known as the Regional Sea Conventions (RSCs). It was through this Convention that the countries sharing the Black Sea also established the Bucharest Convention in 1992 (OSPAR, 2018b; HELCOM, 1993; DG Environment, 2016).

During the 1980s, far-reaching politically based commitments were made for almost all European seas, focused on reducing pollution by utilising the precautionary principle (Table 1.1).

For the Baltic Sea, for example, the Contracting Parties to the Helsinki Commission were committed to achieving 'a substantive reduction [~50 %] of the substances most harmful to the Baltic Sea, especially of heavy metals and toxic or persistent organic substances ...' no later than 1995 (HELCOM, 1988). In the Baltic Sea Action Plan from 2007, the goal was updated to 'a Baltic Sea undisturbed by hazardous substances' by 2021 (HELCOM, 2007).

For the North Sea, a number of ministerial conferences in the 1980s set out to address concerns regarding various harmful substances entering the North Sea as well as other environmental challenges (OSPAR, 2018a). Among other achievements, an ambitious target known as the 'Generation Target' was agreed in 1995, though there were reservations from some Contracting Parties (Box 1.2).

For the Mediterranean Sea, the Contracting Parties to the Barcelona Convention in 1976 also agreed to minimise the risk of pollution from harmful or noxious substances and materials. Concrete targets for the depollution of the Mediterranean Sea were set as late as 2006 by the Horizon 2020 initiative. The political

Box 1.2 The 1995 generation target

'The Ministers AGREE that the objective is to ensure a sustainable, sound and healthy North Sea ecosystem. The guiding principle for achieving this objective is the precautionary principle. This implies the prevention of the pollution of the North Sea by continuously reducing discharges, emissions and losses of hazardous substances thereby moving towards the target of their cessation within one generation (25 years) with the ultimate aim of concentrations in the environment near background values for naturally occurring substances and close to zero concentrations for man-made synthetic substances'.

Source: Anon. (1995).

Table 1.1 Timeline for selected, non-exhaustive policy objectives and targets for achieving clean, non-toxic European seas

Objectives	Sources	Deadline for implementation												
		xxxx	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2025	2030
Clean, non-toxic oceans — UN														
Chemicals are used and produced in ways that lead to the minimisation of significant adverse effects on human health and the environment	WSSD 2020 goal on chemicals	2002												
Improve water quality by reducing pollution, minimising the release of hazardous chemicals and materials	SDG 6 'Clean water and sanitation'													
Prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities	SDG 14 'Life below water'													
Clean, non-toxic regional seas — RSCs														
50 % reduction of substances most harmful to the Baltic Sea, especially of heavy metals and toxic or persistent organic substances	Declaration on the Protection of the Baltic Sea 1988	1988 to 1995												
A Baltic Sea undisturbed by hazardous substances	Baltic Sea Action Plan 2007	2007												
Continuously reducing discharges, emissions and losses of hazardous substances moving towards the target of their cessation within one generation	The Esbjerg Declaration 1995	1995												
Ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances	Bergen Ministerial Statement 2010 (OSPAR)												No target year	
Minimise the risk of pollution from harmful or noxious substances and materials	Hazardous Waste Protocol 2011 (the Mediterranean Sea)												No target year	
Clean, non-toxic European seas — EU														
Improve the protection of human health and the environment from the adverse effects of contaminants.	REACH	2007							Fully phased in by 2018					→
Develop a strategy for a non-toxic environment	7th EAP													
Achieve good chemical status in coastal and territorial waters	Directive 2000/60/EC (WFD)					→						→		
Achieve good surface water chemical status in accordance with the Water Framework Directive (WFD)	Directive 2008/105/EC (EQSD)					→						→		
Achieve good environmental status in the marine environment	Directive 2008/56/EC (MSFD)										→			
Keep concentrations of contaminants at levels that do not give rise to pollution effects	Directive 2008/56/EC (MSFD)										→			
Contaminants in fish and other seafood for human consumption is not exceeding levels established by EU legislation or other relevant standards	Directive 2008/56/EC (MSFD)										→			

Table 1.1 Timeline for selected, non-exhaustive policy objectives and targets for achieving clean, non-toxic European seas (cont.)

Objectives	Sources	Deadline for implementation												
		xxxx	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2025	2030
Marine knowledge														
Coastal states and the European Economic Community (EEC) must not wait for proof of harmful effects before taking action	The Bremen Declaration 1984	1984 (blue)	blue											
Must adopt a precautionary approach and not wait for full and undisputed scientific proof of harmful effects before taking action	Declaration on the Protection of the Baltic Sea 1988	1988 (blue)	blue											
Reduce uncertainty in knowledge of the seas and provide sounder basis for marine management	Marine Knowledge 2020	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue		
Share data sets and services between public authorities for the purposes of public tasks (INSPIRE+PSI)	Directive 2007/2/EC Directive 2013/37/EU	red	red	red	red	red	red	red	red	red	red			
Analysis of marine waters for assessment of environmental status	Directive 2008/56/EC (6-year cycle)	red	red	red → 12		red	red	red	red	red → 18		red	red	red → 24 and 30

Notes: Red: legally binding obligations; blue: policy commitments; →: continuous target.

commitment was to depollute the Mediterranean Sea by 2020.

For the Black Sea, the basis for cooperation regarding the prevention of pollution and protection is the Bucharest Convention addressing marine- and land-based sources. The Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea was adopted in 2009 and includes 65 management targets. These targets are expected to improve the environmental status of the Black Sea, but the deadline for reaching good status is not defined.

A large achievement of such regional cooperation is, inter alia, the contribution to the comprehensive regulatory framework of chemical substances in the EU and the associated international policy commitments (Milieu Ltd et al., 2017) (Table 1.1).

More recently, some of these EU policy initiatives have been linked to global policy commitments established in the context of the UN. For example, at the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002, the participants committed to the sound management of chemicals throughout their entire life cycle by 2020 (Box 1.3) (UN Environment, 2002).

In 2007, such commitments were formalised in the EU by a flagship regulation on chemical substances: the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

REACH is the cornerstone of the EU's regulation of chemicals and it aims to improve the protection of both human health and the environment from the adverse effects of contaminants. In theory, it encompasses all industries and the entire supply chain, making use of the 'producer pays' principle, i.e. making companies responsible for the substances they place on the market.

REACH has contributed to significant progress in closing data gaps on the potential hazardous properties of more than 100 000 substances in EU markets (Milieu Ltd et al., 2017). Recently, it has been shown that data challenges still persist for many chemical substances, despite the ambition to fully phase in REACH provisions by 2018 (EC, 2016; Hodgson, 2018). Unfortunately, there are no environmental monitoring requirements under REACH. In 2017, all EU chemical legislation was evaluated and current instruments were assessed to be fit for purpose (Milieu Ltd et al., 2017).

In 2012, UN initiatives included the SDGs. With regard to contaminants in aquatic environments, SDG 6, 'Clean water and sanitation', aims to address contaminants in water and includes a sub-target to 'improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated waste water and substantially increasing recycling and safe reuse globally' by 2030 (United Nations, 2015).

More specifically for marine areas, SDG 14, 'Life below water', has a target to 'prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution' by 2025 (United Nations, 2015). While both targets are open to interpretation, they provide a solid direction for humanity's vision of our seas and oceans.

Both the WSSD's goal on chemicals and the SDGs link directly to the 7th EAP, which came into force in 2014. The 7th EAP is guiding EU environmental policy until 2020, though it is operating with a long-term vision for the EU for 2050. As part of achieving EU policy goals and visions, it has set three priority objectives as well as a number of more specific targets for chemicals, e.g. the preparation of a strategy for a non-toxic environment (EC, 2013; Milieu Ltd et al., 2017).

However, with the entry into force of the Water Framework Directive (WFD) in 2000, Europe had already marked a new era in water protection policy (EU, 2000). The central objective of the WFD is to achieve 'good ecological status' in all waterbodies. This includes achieving 'good chemical status' in coastal waters by 2015, though Member States may deviate from this deadline under certain circumstances. The basic concept underlying a 'good status' is that surface waters may be impaired or changed by human use but only insofar as this does not significantly damage the ecological functions of the waterbody and its typical biota (ETC/ICM, 2018).

To support the achievement of 'good chemical status of surface waters', the Directive on Environmental Quality Standards (EQSD) from 2008 sets out environmental quality standards for 33 priority substances and eight other pollutants (EU, 2008b, p. 105). In 2013, an additional 15 substances and groups of substances were added to the list.

The most recent driver of clean seas in Europe is the MSFD from 2008 (EU, 2008a, p. 56). The MSFD aims to protect the natural capital on which maritime-related economic and social activities depend by achieving 'good environmental status' of Europe's seas by 2020. Its geographical coverage goes further offshore than, for example, the WFD to encompass all of the European marine territory. The MSFD embraces an ecosystem-based approach to the management of human activities in the marine environment (ecosystem-based management (EBM)); see the EEA's *Hazardous substances in marine organisms* (2015) for details.

The MSFD aims to (1) protect and preserve the marine environment and (2) prevent and reduce inputs and pollution in the marine environment, to ensure that no significant impacts on or risks to marine biodiversity and human health persist. Therefore, the overall objective is to ensure that collective pressure from human activities does not jeopardise the marine ecosystem's capacity to respond to human-induced changes.

In addition to addressing the cumulative pressures and impacts, the MSFD has specific components that focus on contaminants. Descriptor 8 aims to keep concentrations of contaminants at levels that do not give rise to pollution effects. Descriptor 9 focuses on making sure contaminants in fish and other seafood for human consumption do not exceed levels established by EU legislation or other relevant standards (EU, 2017).

Under these policy initiatives, each EU Member State has reported and implemented a number of actions and measures to reduce discharges and emissions of substances. A summary of reported measures can be accessed at the Central Data Repository EIONET, 2018 or MSFD measures at EIONET, 2018 or through the websites of the RSCs. It is beyond the scope of this report to analyse these significant efforts to reduce contaminants in Europe's seas.

In summary, it could be argued that the EU has one of the most advanced legislative frameworks for

Box 1.3 UN WSSD 2020 goal on chemicals

'Participants aim to achieve, by 2020, that chemicals are used and produced in ways that lead to the minimisation of significant adverse effects on human health and the environment.'

Source: UN Environment (2002).

controlling chemicals and their potential hazardous effects on human health and the environment in the world (Milieu Ltd et al., 2017). As policies were inspired by acute and, at times, very visible incidents, Europe has, to some extent, managed to curb or minimise some of these risks (e.g. oil spills observed in the Baltic Sea are at an all-time low) (HELCOM, 2016). As a result, many Europeans believe the risk from contaminants is lower today than a couple of decades ago (EEA, 2018a).

With many long-term policy commitments coming to fruition between 2018 and 2021, now is the time to reflect on the extent to which we have managed to mitigate the risks and reach our long-term policy goals of a clean, non-toxic marine environment.

For example, based on the 2018 assessment of the river basin management plans, around 40 % of surface waters (rivers, lakes, and transitional and coastal waters) are in good ecological status or good ecological potential according to the WFD and only 38 % are in good chemical status (EEA, 2018b).

The following chapters will explore whether or not contaminants remain a challenge for both Europe's seas and our health at this point in time (Chapter 3) and what the future situation may be (Chapter 4), despite these long-term, far-reaching policy visions and the comprehensive regulatory framework put in place to achieve our dual ambition of clean, non-toxic seas.

2 Origin of contaminants in our seas

- Chemicals are essential components of modern society and highly influential on our well-being.
- Chemical production is increasing fast and contaminants continue to find their way into the marine environment through multiple pathways.
- Contaminants have potential and documented negative effects on marine life, our well-being and our health.

2.1 Modern society and its dependency on chemical substances

The chemical industry is an essential pillar of economic activities shaping modern-age society. By transforming raw materials into uncountable applications for every other industry, it serves all branches of our economy. This includes not only chemical products such as pharmaceuticals or antifouling hull paints, but also more or less all materials, i.e. metals, plastics, detergents, etc., applied across all sectors from our homes to aquaculture, fisheries, maritime transport, offshore energy, cables and pipelines (Milieu Ltd et al., 2017).

In fact, the prominence of 'chemical substances' in our society can be illustrated by the substantial growth in the registration/discovery of chemical substances. Over a single decade (2005-2015), the number of substances added to the CAS Registry (a division of the American Chemical Society) has grown from approximately 25 million to > 100 million substances or, in other words, the equivalent of one new substance added every 2.5 minutes for the last 50 years (CAS, 2015).

Similarly, the global production of chemicals seems to be ever growing. From 1950 to 2000, it increased 57-fold and is expected to double every 25 years, or by a 3 % increase per year, outpacing global population growth estimated at 0.77 % (Milieu Ltd et al., 2017; Wilson et al., 2008; Wilson and Schwarzman, 2009) (Figure 2.1). A recent study showed how 'the diversity and quantity of synthetic chemicals created, distributed, and released into ecosystems have been increasing at rates greatly surpassing those of other drivers of global environmental change' (Bernhardt et al., 2017).

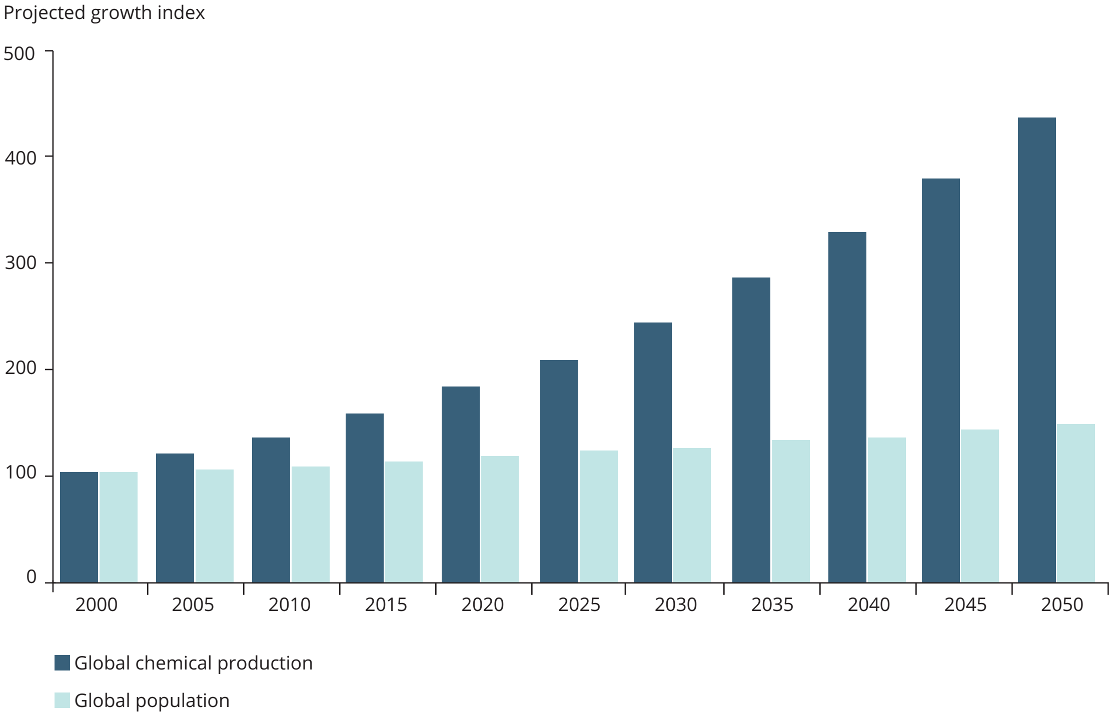
Globally, it is estimated that more 150 000 substances are in commercial use with potentially several thousand added every year (EEA, 2018a).

Some substances that have been in widespread commercial use generate particular concern as a result of their toxicity and persistent capacity. These include organotins (e.g. tributyltin (TBT)) and polybrominated diphenyl ethers (PBDEs). Organotins have been used in biocides, e.g. antifouling paints. PBDEs have been mainly used as flame retardants in textiles, plastics, electronic products and construction materials (OSPAR, 2018d). The use of these chemicals has been heavily restricted but, owing to persistence in the environment, they continue to present challenges to environmental quality.

Heavy metals are also used in numerous applications and occur naturally in the environment. Cadmium, for example, has been used in batteries and can end up in the aquatic environment as a by-product of mining of other metals or as a contaminant of phosphate fertilisers. Mercury has been used in the paper industry, occurs as a by-product of coal-based power plants leading to atmospheric deposition far from its source, and has been used for medical equipment, e.g. thermometers. Mercury can also be released by natural processes, e.g. volcanic activity. Other substances such as polycyclic aromatic hydrocarbons (PAHs) are natural components of fossil fuels (i.e. coal and oil) and can also end up in the aquatic environment through natural processes including forest fires (OSPAR, 2018b).

In Europe alone, the chemical manufacturing industry accounts for 7 % of the EU's industrial production. In

Figure 2.1 Growth in global chemical production outpaces global population growth



Source: Wilson et al. (2008).

Box 2.1 Contaminants and hazardous substances

'Contaminants' are hazardous substances (pesticides, heavy metals, pharmaceuticals or persistent organic pollutants (POPs)) that cause harmful effects to the ecosystem when they end up in the marine environment.

'Hazardous substances' are substances or groups of substances that are toxic, persistent and liable to bioaccumulation and other substances or groups of substances that give rise to an equivalent level of concern (EU, 2000). Hazardous substances are either naturally occurring substances, such as heavy metals, or intentionally or unintentionally formed anthropogenic compounds.

Source: HELCOM (2010) .

term of sales, Europe is the second largest producer, representing 17 % of the global market, coming in behind China, which directly provides approximately 1.2 million jobs with an additional 3.6 million indirect jobs (Milieu Ltd et al., 2017). In 2015, Europe consumed 350 million tonnes of chemicals. Of these, 36 % were classified as hazardous to the environment and 63 % were classified as hazardous to human health (EEA, 2018a).

This sheer volume of substances makes risk assessment of all substances from all sources and media impossible in regard to both the environment and human health (EEA, 2018a). However, toxic and persistent chemicals and/or heavy metals typically cause high risk to both the environment and human health. Persistency potentially leads to high concentration levels in the marine environment and/or accumulation in the food web.

For better or worse, 'chemical substances' remain at the very core of our society and are central to our well-being. If emissions are not controlled, they will eventually enter our ecosystems through one pathway or another (Figure 2.2).

Figure 2.2 Sources of contaminants in the marine environment

Notes: Contaminants are discharged into, lost to or deposited into the sea from numerous land- and sea-based sources. An additional source is long-range transport from neighbouring seas.

Source: EEA.

2.2 Pathways for contaminants entering the sea

Thousands of chemical substances are classified as potential contaminants, the majority of which occur in Europe's seas (Box 2.1) (Tornero and Hanke, 2017). Regarding contamination of the marine environment, groups of substances of particular concern include (1) heavy metals, (2) PAHs, (3) organotins and harmful synthetic substances (including polychlorinated biphenyls (PCBs) and TBT), and (4) PBDEs. These substances are all toxic, persistent and are able to accumulate in the food web. Europe's seas receive contaminants from a wide range of sources and pathways (Figure 2.3):

- inputs and losses from sea-based point sources;
- inputs from land-based sources (e.g. diffuse sources along shorelines and via rivers);
- atmospheric deposition from both land- and sea-based sources;
- inputs from adjacent sea areas.

Inputs from sea-based sources include human activities such as the cultivation of living resources, i.e. aquaculture and exploitation of non-renewable energy sources, e.g. oil and gas production (mercury or PAHs). They can also include antifouling substances (e.g. organotin compounds), discharges of oil products from ships and even the dumping of dredged material from ports in areas outside the port.

Inputs from land-based sources include waste water treatment plants and run-off from land areas such as roads, and urban and agricultural areas. All of these are point sources from which the substances reach the marine environment through streams and rivers or simply areas in close proximity to the coast.

Atmospheric deposition from sea-based sources can come from infrastructures, e.g. oil platforms, or from the combustion of fuel from ships. With regard to land-based sources, it can come from diffuse emissions of, for example, combustion from vehicles or industries (Dahllöf and Andersen, 2009). Atmospheric deposition can reach all, even very remote, marine areas of the globe, such as the Arctic Ocean (Box 2.2).

2.3 Fate and effects of contaminants

As soon as contaminants find their way into the marine environment, they start interacting with it. Some adsorb to particles and organic matter, while other substances can be dissolved directly in the water. Once present in the water column, they may be directly taken up by organisms eating the particles and/or through passive diffusion of dissolved substances. Some contaminants change into different substances, further interacting with the environment through an ever-expanding web of physical, chemical and/or biochemical processes (Figure 2.3). In the Black Sea, a single sediment sample showed the presence of 145 substances.

Eventually, contaminants will sink to the sea floor. Here they can accumulate in the sediment. Under certain conditions, e.g. during hypoxic events or other events (i.e. physical disturbance from human activities, weather events, etc.), they may re-enter the water column. The increased concentrations in seabed sediments put bottom-dwelling organisms at a higher risk of exposure to contaminants.

Some animals, such as mussels, actively filter high volumes of water every day, leading to potentially high levels of contaminants in their tissue. When fish, e.g. cod, or birds, e.g. eider ducks, feed on these organisms, there is the potential for bioaccumulation of contaminants in the food web, concentrating some persistent substances in the top predators. This includes fish species with high oil content, such as sardines, herring and salmon (Fernandes et al., 2015), and especially marine mammals (Box 2.2).

Where contaminants accumulate in the food chain, they may become highly relevant for humans if the predators used as our food present potential health concerns (e.g. mercury in fish).

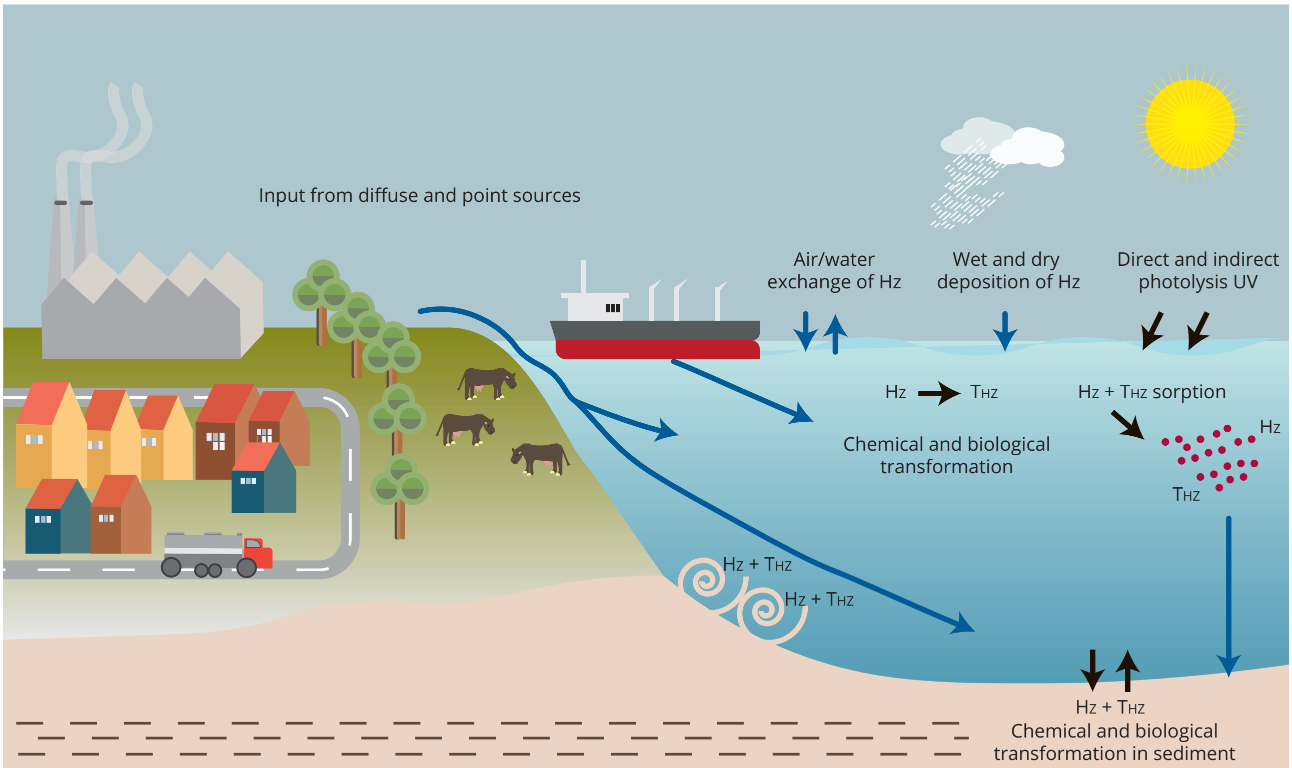
The effects of high concentrations of heavy metals include reduced cognitive ability (lead, mercury), damage to the central nervous system (mercury) and reduced skeletal strength (cadmium) or even death (MOE, 2002) (Table 2.1).

PAHs can also have long-term effects on human health, e.g. they can cause kidney and liver damage as well as cancer. Like heavy metals, they are also highly persistent and difficult to address once released into the environment.

Organotins and related substances (e.g. TBT) are synthetic chemicals with no natural occurrence. Such substances can have endocrine-disrupting qualities and long-term effects can include reduced cognitive ability, reduced weight in infants and reproductive disorders (HELCOM, 2018a).

This can be illustrated by dioxin, which originates from emissions. It also occurs as an impurity in some chlorinated chemicals, e.g. PCBs. Elevated

Figure 2.3 Fate of contaminants and transformation products



Notes: Fate of contaminants and transformation products (THz) of contaminants in the marine environment. Blue arrows indicate transportation, while black arrows indicate transformation processes.

Source: Modified from Dahllöf and Andersen (2009).

concentrations of dioxin in seafood can influence early pregnancies, leading to numerous disorders including cancer (Colborn et al., 1993; Jacobson, 2016). As a result, in some Arctic and Nordic regions, pregnant women are advised to eat less local produce (Box 2.4). Dioxin in fish can also have an indirect impact on another aspect of our well-being. For example, sales of Baltic herring and salmon have previously been restricted in EU Member States due to detected concentration levels of dioxin, with economic consequences for the industry and the communities involved.

PBDEs and POPs are toxic, are not easily degradable in the environment, bioaccumulate in the food chain and undergo long-range transport. They can cause cancer and also liver (Andersen et al., 2016b), kidney or reproductive toxicity (EPA, 2014). They can influence learning and behaviour in mammals and cause reduced reproductive success in birds (OSPAR, 2018b).

As new synthetic chemicals are developed, it is inevitable that more and more contaminants will find their way into the marine environment with unknown or unforeseen consequences for the marine environment. It is estimated that 60 % by volume of the chemicals on the EU market are hazardous to the environment or human health (Milieu Ltd et al., 2017). The Stockholm Convention for protecting human health and the environment from POPs has described some organic chemical substances that are of particular concern (Box 2.3).

Of the 150 000 substances in commercial use, it is estimated that less than 1 000 are regularly monitored. In a comprehensive study published by the Arctic Monitoring and Assessment Programme (AMAP) in 2017, approximately 1 200 substances were estimated to have long-range dispersal capacity — of these, AMAP was able to address 20 substances (2017).

Box 2.2 Toxic chemical substances can have a significant impact on marine species

PCBs have been banned since the 1980s because of their toxicity, persistence and ability to bioaccumulate in the environment. They have been shown to jeopardise reproduction, increase the chances of cancer and disrupt immune systems in vertebrates (Letcher et al., 2010). For these reasons, both in Europe and globally, actions have been taken to significantly reduce their release (OSPAR, 2017).

However, four decades after they were banned they are still present in the marine environment, jeopardising iconic top predators, such as the killer whale (*Orcinus orca*). Killer whales are especially vulnerable in marine areas where they feed on marine mammals or large predatory fish, such as tuna, as PCBs tend to be stored in fatty tissue. Populations feeding on smaller fish, such as herring and mackerel, are less likely to experience adverse effects (Desforges et al., 2018).

A recent study shows that current PCB levels could lead to the disappearance of half of the world's population of killer whales in the most contaminated areas within 30-50 years (Desforges et al., 2018). In Europe, this includes areas such as the Strait of Gibraltar and the waters surrounding both the Canary Islands and the UK. Populations around the Iceland, Faroe Islands and Norway have lower concentrations in their tissues and seem to be at less risk (Desforges et al., 2018).

Despite having spent four decades phasing out PCBs, killer whales still have high concentrations in their bodies. One of the scientists behind the research, Paul D. Jepson, Institute of Zoology, Zoological Society of London, England, concludes the following:

'This suggests that the efforts have not been effective enough to avoid the accumulation of PCBs in high trophic level species that live as long as the killer whale does. There is therefore an urgent need for further initiatives than those under the Stockholm Convention' (Bondo, 2018).

However, as shown for the Baltic white-tailed eagle (Figure 5.1), and here for the killer whale, it can take decades, if not longer, for our measures to take the necessary effect. While this is discouraging, the white-tailed eagle teaches us that it is possible to achieve positive results if we maintain our political visions and efforts to reduce the release of substances into the marine environment. Efforts are needed if we are to ultimately avoid the cascading effects on marine food webs and marine ecosystems and their capacity to deliver the services on which we all depend.

Box 2.3 Persistent organic pollutants (POPs)

POPs are carbon-based chemical substances with particular properties that, when released into the environment, (1) remain intact for exceptionally long periods of time; (2) become widely distributed throughout the environment as a result of natural processes involving soil, water and, most notably, air; (3) accumulate in the fatty tissue of living organisms, including humans, and are found at higher concentrations higher up the food chain; and (4) are toxic to both humans and wildlife.

Source: UNEP (2018).

Therefore, it will be increasingly important to be able to manage the threat and reduce the risks related to contaminants. A key step will be to prevent harmful substances, in particular those with persistent, toxic and bioaccumulative properties, from reaching the aquatic environment.

Another step is to be able to identify and describe the geographical extent of both 'non-problem areas' and 'problem areas' for contaminants in a harmonised, consistent manner across Europe's seas to better inform whether established preventive measures are effective.

Table 2.1 Groups of main contaminants found in Europe's seas

Class	Description	Potential effects of 'high' concentrations
Metals i.e. mercury (Hg), cadmium (Ca), copper (Cu), lead (Pb), etc.	Metals have a wide industrial use from batteries and fertilisers to paint and ships. Metals can exist naturally, and some can be widely distributed from active volcanoes, for example. Their mobility often depends on other elements, such as oxygen and chlorine.	Heavy metals, e.g. mercury, can bioaccumulate in the food web. High concentrations have a variety of impacts on humans, including reducing bone strength and causing damage to the nervous system.
Organobromines (including PBDEs)	Organobromines are listed as POPs. Organobromines can be used in leaded petrol or for pest control. PBDEs are used as flame retardants in different materials or products, such as plastics, textiles and electronics. They can spread through air and water.	PBDEs can bioaccumulate in food chains and some can biomagnify. They can affect the immune and reproductive systems and can influence the nervous system.
PCBs	Some PCBs are listed as POPs. They have been in commercial use since 1929, but European production stopped in the 1980s. They were used for insulation, cooling fluids or as plasticisers in paints. They are persistent in sediments and can be remobilised if the sediment is disturbed.	They are toxic and, since they are hydrophobic, bioaccumulate in fatty tissues. They can adversely affect reproduction and may affect the immune system, making disease epidemics worse. Those in the higher levels of the food web, especially salmon or fish-eating birds and marine mammals, can be affected (OSPAR, 2018).
PAHs	A group of organic chemicals with two or more fused benzene rings and napthalenes also listed as POPs. There are multiple sources but many originate from the incomplete combustion of wood and fossil fuels.	They are toxic and can bioaccumulate in, for example, marine invertebrates. Some are carcinogenic.
Organotins	Imposex is a physiological response in some marine molluscs to the exposure to certain marine contaminants such as TBT.	The exposure to high concentrations of certain contaminants can cause gastropods (sea snails), e.g. dog whelks, to develop male sex organs.
Organochlorines (except PCBs)	Some organochlorines are listed as POPs. They can be transported for long distances by air and can be dissolved in water.	Organochlorines are very persistent and can bioaccumulate in the food web, e.g. dioxin in fatty fish such as salmon. They can cause cancer and may influence reproduction.

Sources: AMAP (2016b, 2017); OSPAR (2017).

Box 2.4 Contaminants are a transboundary challenge influencing even the remote Arctic Ocean

The northern part of Europe is situated in the Arctic region. Compared with continental Europe, the Arctic region is sparsely populated. Despite a low population density and a low level of economic activity, the Arctic is not free from contamination and pollution. Contaminants are found across the marine ecosystem and are a concern, as the health of local residents can be affected. Indigenous people in particular are at risk, as their traditions, cultures and livelihoods are often closely interconnected with the sea and local food sources. The accumulation of contaminants has now reached such levels in marine mammals that pregnant women in the Arctic are advised to limit or avoid such food items if their diet is primarily derived from local marine sources.

Increased economic activity in the region, in the form of both land-based developments and offshore developments, have contributed to the amount of contaminants found in the marine environment. In addition to local sources, the Arctic is affected by long-range pollution whereby chemicals are transported into the region through ocean currents, river outlets and atmospheric deposition. Some of this pollution comes from European sources in the form of chemicals, marine litter and plastics, pesticides, pharmaceuticals, detergents, solvents/lubricants, radioactive substances or POPs/PCBs (AMAP, 2009, 2011a, 2011b, 2015, 2016a, 2016b, 2017). Furthermore, Europe indirectly influences the pollution loads in the Arctic by importing oil, gas, minerals, fish and other natural resources from the Arctic region.

Climate change has also increased levels of pollution in Arctic marine ecosystems, as the increasing summer melt of snow, ice and permafrost has brought about large releases of substances captured in the cryosphere during the winter period or through historic deposition in older ice layers (AMAP, 2017). This has led to harmful pathogens emerging from historical depositions in thawing permafrost, including anthrax in the Russian Arctic in 2016.

Increasingly, marine litter, including microplastics, is brought into the Arctic by ocean currents and rivers. There is evidence to suggest that microplastics share characteristics with traditional POPs, including their environmental persistence and potential to accumulate and cause adverse effects in fauna that ingest them (AMAP, 2017). Microplastics are not evaluated by the current approaches used by international conventions, although efforts under the UN and OSPAR are now targeting the issue of marine litter. Marine litter and microplastics are now addressed by the EU in the European strategy for plastic in a circular economy (EC, 2018).

While concentrations of certain contaminants have declined in some parts of the Arctic, others are influenced by multiple factors and do not show clear trends. In general, long-range transported pollutants, such as the legacy POPs that have been regulated or banned, e.g. by strengthening the Convention on Long-Range Transboundary Air Pollution (LRTAP) and by the Stockholm Convention, have declined and are therefore of less risk to human and ecosystem health (AMAP, 2009, 2017). It is less clear if replacement substances are safer and are similarly brought into Arctic waters. However, more newly regulated POPs, such as brominated flame retardants and fluorinated compounds, are still found in the Arctic environment.

Mercury is similarly posing a health problem in the Arctic and, despite efforts to reduce emissions in North America and Europe (except Russia), long-range transport from sources far from the Arctic, including coal burning in Asia, and artisanal and small-scale gold mining in developing parts of the world, mean that overall levels in the Arctic remain a concern. Assessments have demonstrated that levels of mercury among the Greenlandic population, as well as among wildlife, are still high (AMAP, 2011a, 2015). The EU and the Arctic States have played a role in setting up the global, legally binding instrument on regulating mercury (the Minimata Convention adopted in 2013), which hopefully in time will lead to less mercury being found in the Arctic.

A recent assessment on chemicals (AMAP, 2017) shows that enhanced cooperation on global regulations is necessary and that additional regulation may be required to reduce the increasing amounts of emerging chemicals of concern found in the Arctic. Combating pollution in the marine environment is a challenge that the Arctic States cannot solve alone, given the transboundary nature of the distribution and that many drivers require an international response. In addition, increased national and local efforts are needed, as local unsustainable waste disposal practices, diffuse pollution loads through river run-off and discharges from contaminated sites all contribute to an increasing pollution load in the Arctic Ocean.

3 Contamination in Europe's seas — a persistent large-scale problem

- The contamination status of Europe's seas has been mapped in 1 541 assessment units.
- The mapping of 'problem areas' and 'non-problem areas' is carried out using a well-documented, multi-metric indicator-based tool named 'CHASE+'.
- Most areas — 85 % of the assessment units — are classified as being 'problem areas', indicating that many of the marine areas in Europe are impaired with respect to contaminants and agreed thresholds.
- Persistent substances remain in marine ecosystems, and avoiding upstream use of persistent and hazardous substances is essential to achieving policy commitments in the long term.

The consistent and uniform mapping of 'problem areas' and 'non-problem areas' with respect to contaminants is a key challenge faced by environmental managers across Europe's seas, whether in the context of the RSCs or EU legislation.

To illustrate the challenge faced, the EU's Joint Research Centre recently prepared a list to better inform the discussions leading to the 2018 reporting under the MSFD (Tornero and Hanke, 2017). Here, more than 2 700 substances (or groups of substances) of potential relevance for the marine environment were identified. The substances originated from all the lists of contaminants compiled by relevant EU legislation, the RSCs, global conventions and other international organisations. Individual substances might not be of concern for the marine environment in general or in a given regional sea.

This list shows the vast number of substances and/or combinations of substances that need consideration when identifying 'problem areas' and 'non-problem areas' with respect to contaminants. It also illustrates the need to apply a uniform and consistent approach to the mapping of 'problem areas' and 'non-problem areas' with respect to contaminants. Such an approach has some prerequisites, including:

1. access to monitoring data for the assessment (2009-2016 period);
2. information on substance- and matrix-specific assessment criteria, i.e. threshold values;
3. the application of a well-documented (i.e. peer-reviewed) and widely accepted (i.e. used by several countries and/or the RSCs) multi-metric indicator-based assessment tool, such as CHASE+.

This chapter provides a potential solution for how to face the challenge of identifying 'problem areas' and 'non-problem areas' in a consistent manner across Europe's seas by using publicly available data and thresholds within a peer-reviewed and widely accepted multi-metric indicator-based assessment tool, i.e. CHASE+. Chapter 4 will support this snapshot and look beyond the current state. It will look into whether or not the trends in the concentrations of selected contaminants have been broken to better show the effects of ongoing reduction efforts, i.e. whether or not we are on track to reduce the concentration of specific substances even though 'problem areas' persist.

3.1 Data sources

This assessment is based on data on contaminants monitored in transitional, coastal and marine waters in the context of the WFD and the MSFD. The part of reported data from water, sediment and biota, as well as the information about biological effects, are derived from the DOME data portal of the International Council for the Exploration of the Sea (ICES). Other key data sources are data reported under the European Environment Information and Observation Network

(Eionet), EMODnet Chemistry (the Baltic Sea and the Black Sea) and the EMBLAS project (Black Sea). In addition, France and Portugal have made new data sets available (for details on data sources, see Annex 5).

For the temporal trend assessment, all sources of long-term trends of contaminants were sought within European research and monitoring literature published since 2010 using targeted searches within the ISI Web of Science or the Google search engine. The search focused on biota for assessing recent trends and identified many reports and peer-reviewed articles; however, a closer examination yielded only a few relevant trend data, some of which are discussed below. Other important data sets may exist but were not located during this effort. Overall, the best long-term data sets on monitoring of biota appear to be already available to the EEA through contributions to Eionet.

In addition to monitoring data, the analyses require information about the substance- and matrix-specific threshold levels, i.e. the concentrations or effects that are used to decide if the levels are above or below what is regarded acceptable. Threshold values can be defined in different ways and those used here include Environmental Quality Standards (EQS), Environmental Assessment Criteria (EAC), Background Assessment Criteria (BAC) and Ecological Quality Objectives (EcoQOs). A list of the substance- and matrix-specific threshold values used are found in Annex 3.

3.2 Classification methodology

The tool used for the classification of 'non-problem areas' and 'problem areas' with respect to contaminants is named CHASE+ and is based on earlier versions of the 'Chemical Status Assessment Tool' (CHASE) developed for HELCOM holistic assessments and during the Harmony project (Annexes 2 and 4) (Andersen et al., 2016b; HELCOM, 2010, 2017). This report characterises areas as a) 'Problem areas' if there is evidence of an undesirable disturbance to the marine ecosystem due to inputs of contaminants, and b) 'Non-problem areas' if there are no grounds for concern that inputs of contaminants have disturbed or may in the future disturb the marine ecosystem. The terminology originates from the OSPAR Common procedure (OSPAR, 2019).

For this analysis, Europe's seas were divided into grid cells of 20x20 km^2 in coastal waters and 100x100 km^2 in offshore areas, based on the EEA's reference grid (Annex 1). The CHASE methodology is a simple five-step procedure (Figure 3.1) applied in every assessment unit. The five steps are:

- Step 1: substances/indicators are grouped into four categories (C1: water; C2: sediment; C3: biota, C4: biological effects).
- Step 2: for each individual substance/indicator, a contaminant ratio (CR = $C_{status}/C_{threshold}$) is calculated.
- Step 3: for categories C1-3, a contamination score (CS) is calculated:

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

- For category C4, the average CR is calculated.
- Step 4: each category is subdivided into five status classes with class boundaries: 0.0-0.5 (NPA_{high}), 0.5-1.0 (NPA_{good}), 1.0-5.0 ($PA_{moderate}$), 5.0-10.0 (PA_{poor}) and > 10.0 (PA_{bad}).
- Step 5: category-specific classifications are subsequently combined for each assessment unit into an integrated classification of 'non-problem area' (NPA) or 'problem area' (PA) by using the worst classification — the 'one-out, all-out' principle.

The analysis also determined which group of substances triggered the 'problem area' status. As a result, it identified the individual substance that contributed most to the high (= bad) contamination score in an assessment unit and then determined which group of substances it belonged to. Similar attempts to identify 'problem areas' and 'non-problem areas', including classifications of chemical status, have been made for the Baltic Sea (HELCOM, 2010, 2017), the North Sea (Andersen et al., 2016a) and Danish marine waters (Andersen et al., 2016a).

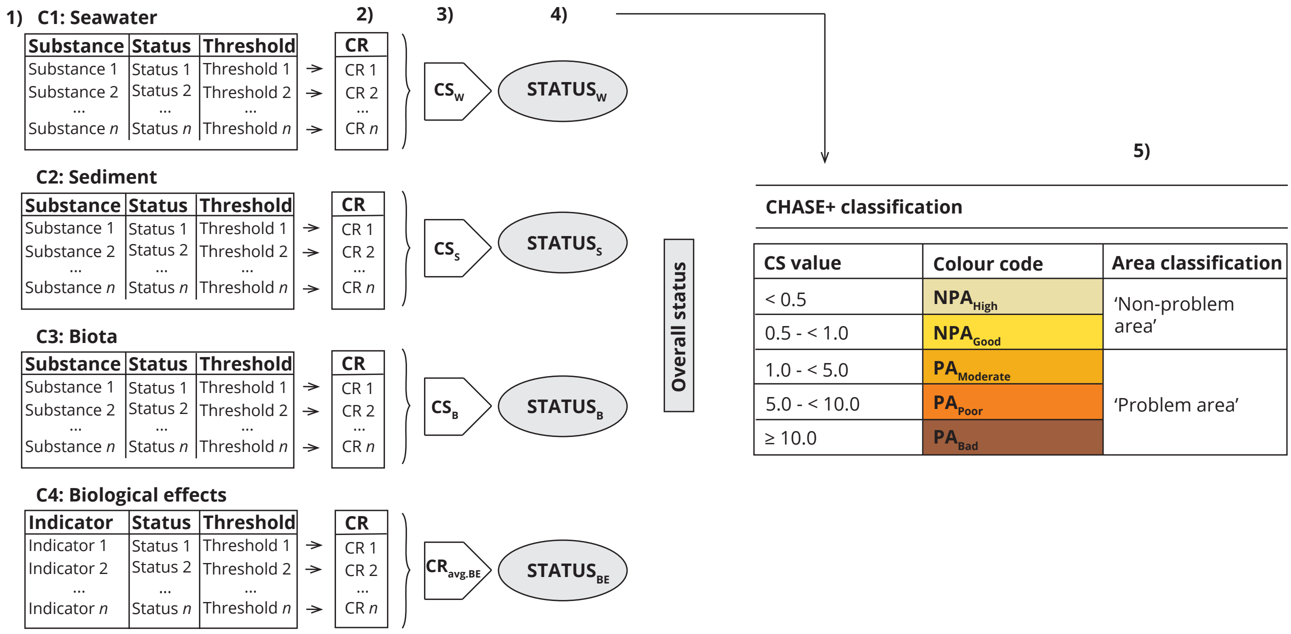
3.3 Seawater

Contaminants discharged or deposited into marine waters can contribute to elevated concentrations in seawater. Elevated concentrations can also be caused by long-range transport from neighbouring waters.

Data coverage for coastal waters is reasonably good for the Black Sea, the Mediterranean Sea, the North-East Atlantic Ocean and the southern Baltic Sea.

Poor coverage is found in some northern parts of the Baltic Sea, the Norwegian Sea and the Barents Sea and also in western parts of the Mediterranean Sea. Data coverage for offshore waters is good in the North Sea and in western parts of the Black Sea.

Figure 3.1 Concept of the Chemical Status Assessment Tool (CHASE+)



Notes: Illustration of the CHASE+ tool. The categories are (1) water, (2) sediment, (3) biota and (4) biological effects. A 'one-out, all-out' principle is applied between the compartments.

CR, contaminant ratio; CS, chemical status.

Source: Based on Andersen et al., 2016b.

Some countries, for example Denmark, Estonia, Finland, France, Latvia and Sweden, do not appear to include monitoring of matrix 'seawater'. Instead, they focus on the monitoring of sediments (Section 2.2) and biota (mussels and fish; Section 2.3). Based on the available data for matrix 'seawater', classifications have been made for a total of 641 assessment units (Table 3.2 and Map 3.1).

In the Baltic Sea, concentrations of contaminants in seawater are only monitored in the southern parts along the coasts of Germany, Lithuania and Poland. Of the areas assessed, 6.4 % are classified as 'non-problem areas' (4 out of 63 areas assessed; Table 3.2).

For the western parts of the Black Sea, 12 assessment units are classified as 'non-problem areas' (21.4 %), while 44 are classified as 'problem areas' (78.6 %). In the Mediterranean Sea, most of the assessment units are coastal. The Italian data set is particularly comprehensive, whereas only one offshore area is assessed south of Cyprus. Two per cent (5 out of 247 assessment units) are classified as 'non-problem areas'.

For the North-East Atlantic Ocean, and especially the North Sea, data coverage is better than for any other region. The total number of assessment units for the matrix 'seawater' is 275. Most parts of the North Sea are classified as 'problem areas', while 'non-problem areas' (*n* = 14 or 5.1 %) can be found in southern parts of the Norwegian Sea, western parts of the Channel and in northern parts of the Bay of Biscay.

As explained in Section 3.2, the CR gives a measure of by how much the concentration exceeds its threshold value. When focusing on the problem areas (*n* = 606), the 'worst' or 'triggering' individual substance for the matrix 'seawater' can be identified (i.e. those that have the greatest CR values) as well as the group of substances to which it belongs: metals, PCBs, other organohalogens and PAHs (Table 3.1).

Table 3.1 'Problem areas' and 'seawater': the triggering substances

Category	Number of assessment units
Metals	334
Other organohalogens	110
PCBs	85
PAHs	75
Organochlorines	1
Organotins	1

Notes: Ranking of the substances triggering the classification of the matrix 'seawater'.

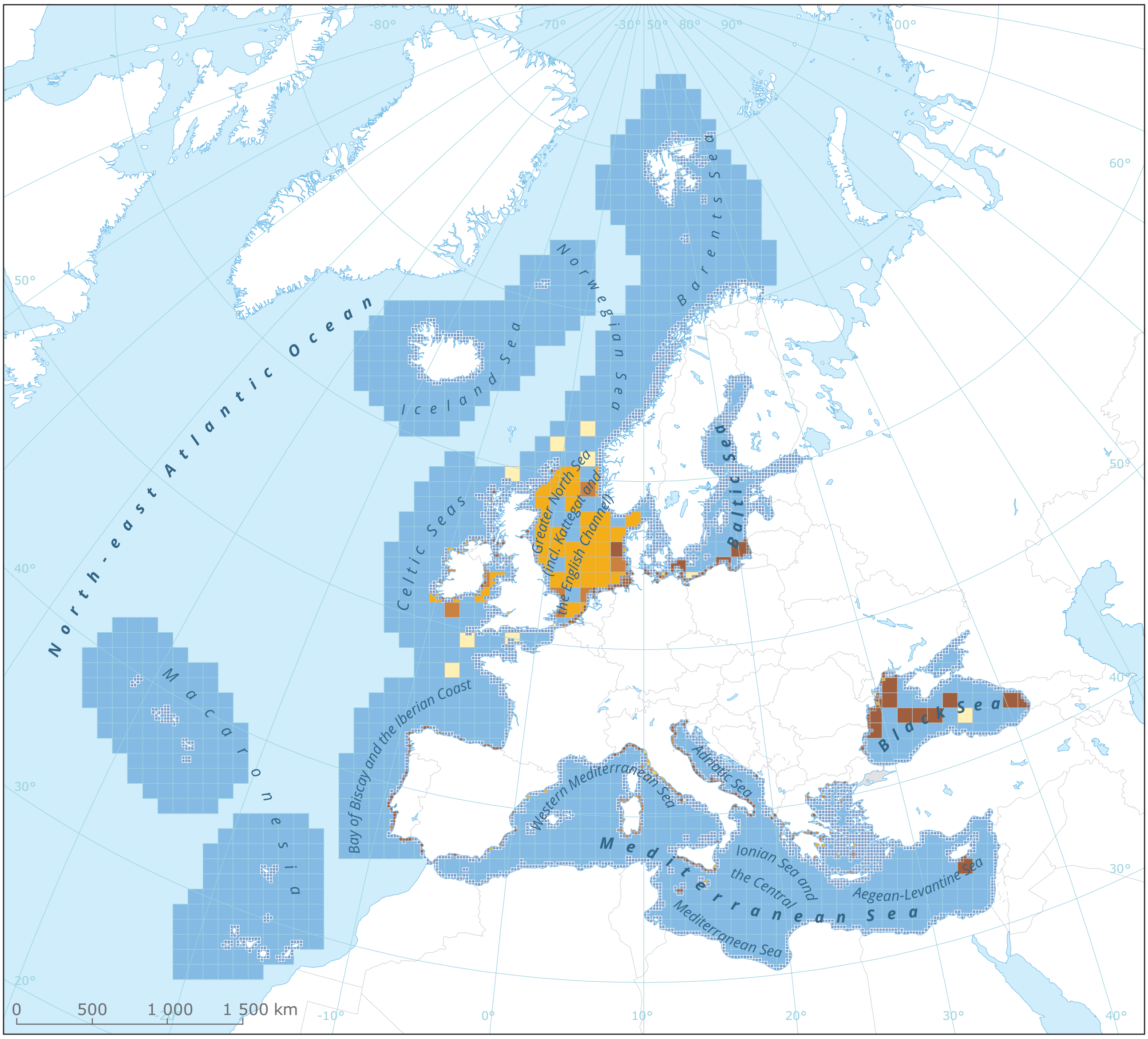
In this case, the triggering substance belonged to the group 'metals' in 334 units (more than 50 %). The other organohalogens, PCBs and PAHs groups were the worst substances in 110, 85 and 75 units, respectively. The organochlorines and organotins groups each contained the triggering substance in only one assessment unit. More than one substance or group of substances can have concentrations above thresholds in a given assessment unit.

Table 3.2 Summary of classifications of the matrix 'seawater' and identification of 'problem areas' and 'non-problem areas'

Class	Region								Total
	Baltic Sea		Black Sea		Mediterranean Sea		North-East Atlantic Ocean		
	n	%	n	%	n	%	n	%	
NPA_{high}	3	4.8	12	21.4	1	0.4	14	5.1	30
NPA_{good}	1	1.6			4	1.6			5
$PA_{moderate}$			3	5.4	22	8.9	55	20.0	80
PA_{poor}	1	1.6			87	35.2	51	18.5	139
PA_{bad}	58	92.1	41	73.2	133	53.8	155	56.4	387
Total	63		56		247		275		641

Notes: See Figure 3.1 for explanations of NPA_{high} and NPA_{good}, $PA_{moderate}$, PA_{poor} and PA_{bad}. Please note that NPA_{high} and NPA_{good} indicate 'non-problem areas', while $PA_{moderate}$, PA_{poor} and PA_{bad} indicate 'problem areas'.

Map 3.1 **CHASE+-based classifications of contaminant status of 'seawater'**



CHASE classification of contaminant status in seawater

Non-problem areas: High, Good

Problem areas: Moderate, Poor, Bad

Outside coverage

No data

100x100 km in offshore areas (> 20 km from the coastline)

20x20 km in coastal areas (≤ 20 km from the coastline)

Note:
CHASE: Chemical Status Assessment Tool

Notes: Mapping of contamination 'problem areas' and 'non-problem areas' based on measurements in the matrix 'seawater'. See Annex 4 for maps with higher resolution and regional focus as well as additional classifications, excluding specific groups of substances.

3.4 Sediments

Contaminants entering the marine environment from land, air or neighbouring waters may ultimately be deposited on the sea floor. Accumulation over years and decades can result in high concentrations of substances in surface sediments.

Most countries in Europe include marine sediments in long-term monitoring activities. Consequently, the data coverage is good, especially in southern parts of the Baltic Sea, the North Sea, the Celtic Sea, the Bay of Biscay, western parts of the Black Sea and the coastal waters of France, Italy and Portugal.

Some countries, such as Estonia, Greece, Iceland, Ireland and Latvia, do not appear to monitor contaminants in sediment on a regular basis.

Based on the sediment data available, classifications of contamination status have been made for a total of 780 assessment units (Table 3.3).

Baltic Sea sediments are mostly monitored in the Eastern Bothnian Bay, the Northern Baltic Proper, the Southern Baltic Proper, south-western parts of the Baltic Sea and the Danish Straits and the Kattegat; 77 % of assessment units (*n* = 97) are classified as 'problem areas'.

Only 19 areas are assessed in the Black Sea and 11 of them are classified as 'problem areas' (57.9 %).

In the Mediterranean Sea, the number of assessment units is 153, approximately 50 % more than in the Baltic Sea. Of these, 104 (68 %) are classified as 'non-problem areas', while 49 units are classified as 'problem areas'.

The number of assessment units monitored and classified in the North-East Atlantic Ocean is 511, which is equivalent to 66 % of the total number of sediment assessments made on a pan-European scale. The spatial coverage in this region is therefore much higher than in the Baltic Sea, the Black Sea or the Mediterranean Sea, especially for offshore waters. In this region, 290 assessment units (56.8 %) are classified as 'non-problem areas' — the remaining 221 (43.2 %) are classified as 'problem areas'.

When examining the groups of substances that are responsible for triggering the classification of 'problem areas', the results for the matrix sediments are somewhat similar to those for seawater (Table 3.4). One exception is organotins, which cause more problems in the North-East Atlantic Ocean.

Of 356 assessment units classified as 'problem areas', substances in the group 'metals' triggered the classification in 177 (49.7 %). Mercury is widely distributed, highly persistent and likely to be present in most localities. However, concentrations are declining (Figure 4.2), so it may be valid to investigate if other substances may be of concern. When excluding mercury from the classification, other metals still triggered the classification in 142 assessment units (43 %). PCBs triggered the classification in 67 assessment units (18.8 %) and in 72 when excluding mercury from the classifications.

Table 3.3 'Problem areas' and sediments: the triggering substances

Category	Number of assessment units (+Hg)	Number of assessment units (-Hg)
Metals	177	142
PCBs	67	72
PAHs	48	52
Organotins	38	38
Other organohalogens	25	25
Organochlorines	1	1

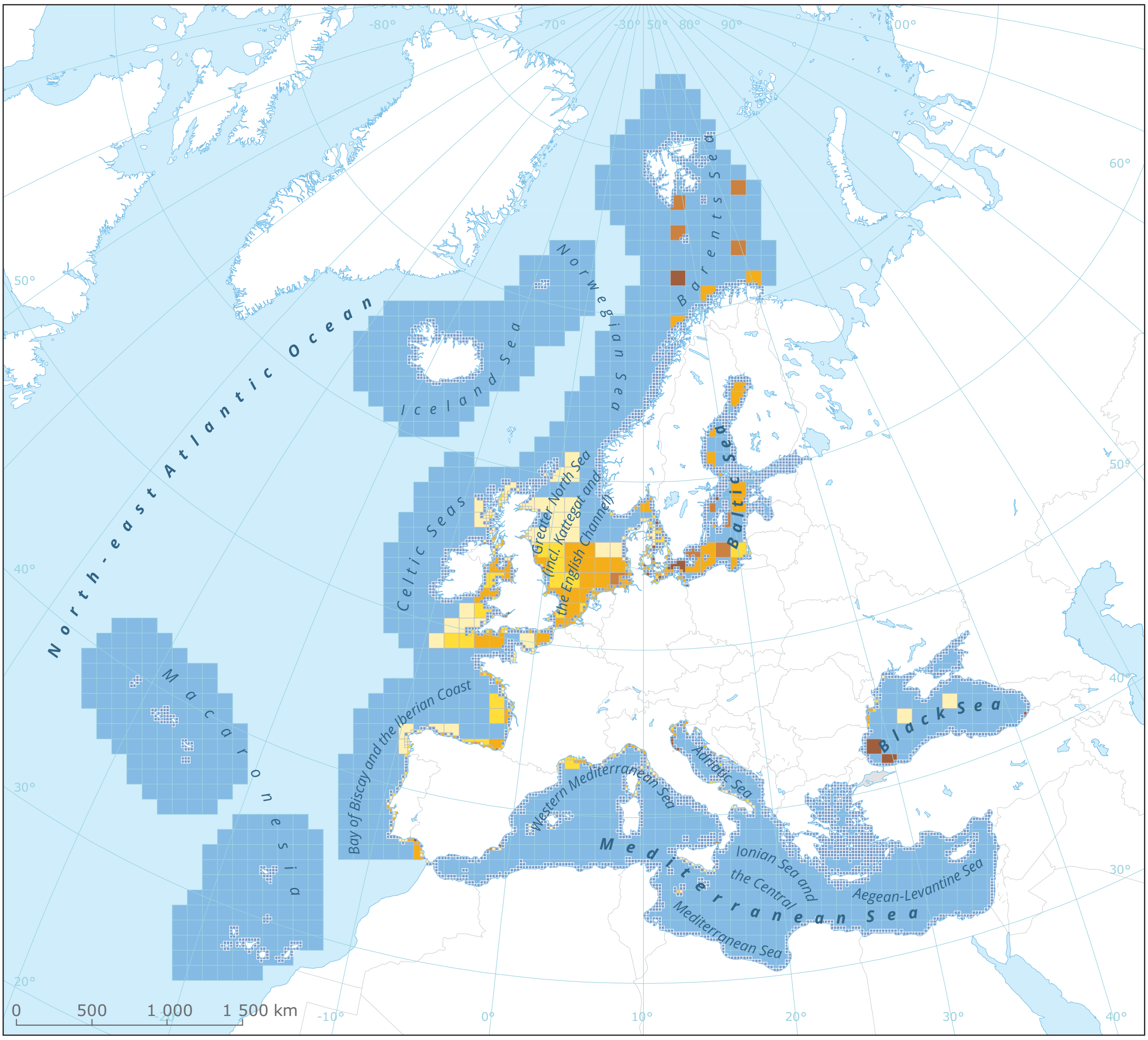
Notes: Ranking of substances triggering the classification of the matrix 'sediment'. +Hg, including mercury; -Hg, excluding mercury.

Table 3.4 Summary of classifications of the matrix 'sediment' and identification of 'problem areas' and 'non-problem areas'

Class	Region								Total
	Baltic Sea		Black Sea		Mediterranean Sea		North-East Atlantic Ocean		
	n	%	n	%	n	%	n	%	
NPA_{high}	13	13.4	5	26.3	74	48.4	195	38.2	287
NPA_{good}	9	9.3	3	15.8	30	19.6	95	18.6	137
$PA_{moderate}$	53	54.6	7	36.8	34	22.2	186	36.4	280
PA_{poor}	8	8.2			5	3.3	22	4.3	35
PA_{bad}	14	14.4	4	21.1	10	6.5	13	2.5	41
Total	97		19		153		511		780

Notes: See Figure 3.1 for explanations of NPA_{high} and NPA_{good}, $PA_{moderate}$, PA_{poor} and PA_{bad}. Please note that NPA_{high} and NPA_{good} indicate 'non-problem areas', while $PA_{moderate}$, PA_{poor} and PA_{bad} indicate 'problem areas'.

Map 3.2 **CHASE+-based classifications of contaminant status of 'sediments'**



CHASE classification of contaminant status in sediments

Non-problem areas: High, Good

Problem areas: Moderate, Poor, Bad

Outside coverage

No data

100x100 km in offshore areas (> 20 km from the coastline)

20x20 km in coastal areas (≤ 20 km from the coastline)

Note:
CHASE: Chemical Status Assessment Tool

Notes: Mapping of contamination 'problem areas' and 'non-problem areas' based on measurements in 'sediments'. See Annex 4 for maps with higher resolution and regional focus as well as additional classifications, excluding specific groups of substances.

3.5 Biota

Contaminants in seawater and sediment can enter the food web through both ingestion by animals and bioaccumulation in a wide range of organisms. Typically, monitored organisms include filter feeders (e.g. mussels) and fish. The matrix 'biota' is monitored in slightly more assessment units (*n* = 853;Table 3.6) than sediments (*n* = 780) and water (*n* = 641) are.

Most countries do include this matrix in their monitoring networks, especially for coastal waters. There are, however, some gaps in the networks, for example in parts of the Mediterranean Sea and the Black Sea (Map 3.3).

Monitoring and assessment for the matrix 'biota' in the Baltic Sea has been carried out for 198 assessment units, more than twice the number of units for sediments. Only 21 have been classified as 'non-problem areas', while 177 have been classified as 'problem areas'.

In the Black Sea, 12 coastal units have been assessed and none of these have been classified as a 'non-problem area'. No information from offshore assessment units is available.

In the Mediterranean Sea, a total of 161 coastal assessment units have been assessed. No information from offshore assessment units is available. 17 units (10.6 %) are classified as 'non-problem areas'; the remaining 144 are classified as 'problem areas'.

In the North-East Atlantic Ocean, a total of 482 units have been assessed. This number corresponds to 57 % of the overall number of units assessed on a European scale. Of the 482 units, only 37, or 7.7 %, have been classified as 'non-problem areas' and 445 (93.3 %) have been classified as 'problem areas'.

With regard to which group of substances is decisive when classifying the matrix 'biota', the overall picture differs from what was found for 'seawater' and 'sediments' (Table 3.5). Now 'organobromines' and 'other organohalogens' are triggering the classification in 354 and 216 cases, respectively.' 'Metals', ranked first for 'water' and 'sediments', are decisive in 188 cases.

Table 3.5 'Problem areas' and biota: the triggering substances

Category	Number of assessment units	Number of assessment units (-Hg)	Number of assessment units (-PBDEs)
Organobromines	354	359	-
Other organohalogens	216	223	429
Metals	188	109	283
PAHs	7	9	13
Organochlorines	7	7	8
PCBs	6	6	11

Notes: Ranking of the substances triggering the classification of the matrix 'biota'.
-Hg, excluding mercury; -PBDEs, excluding PBDEs.

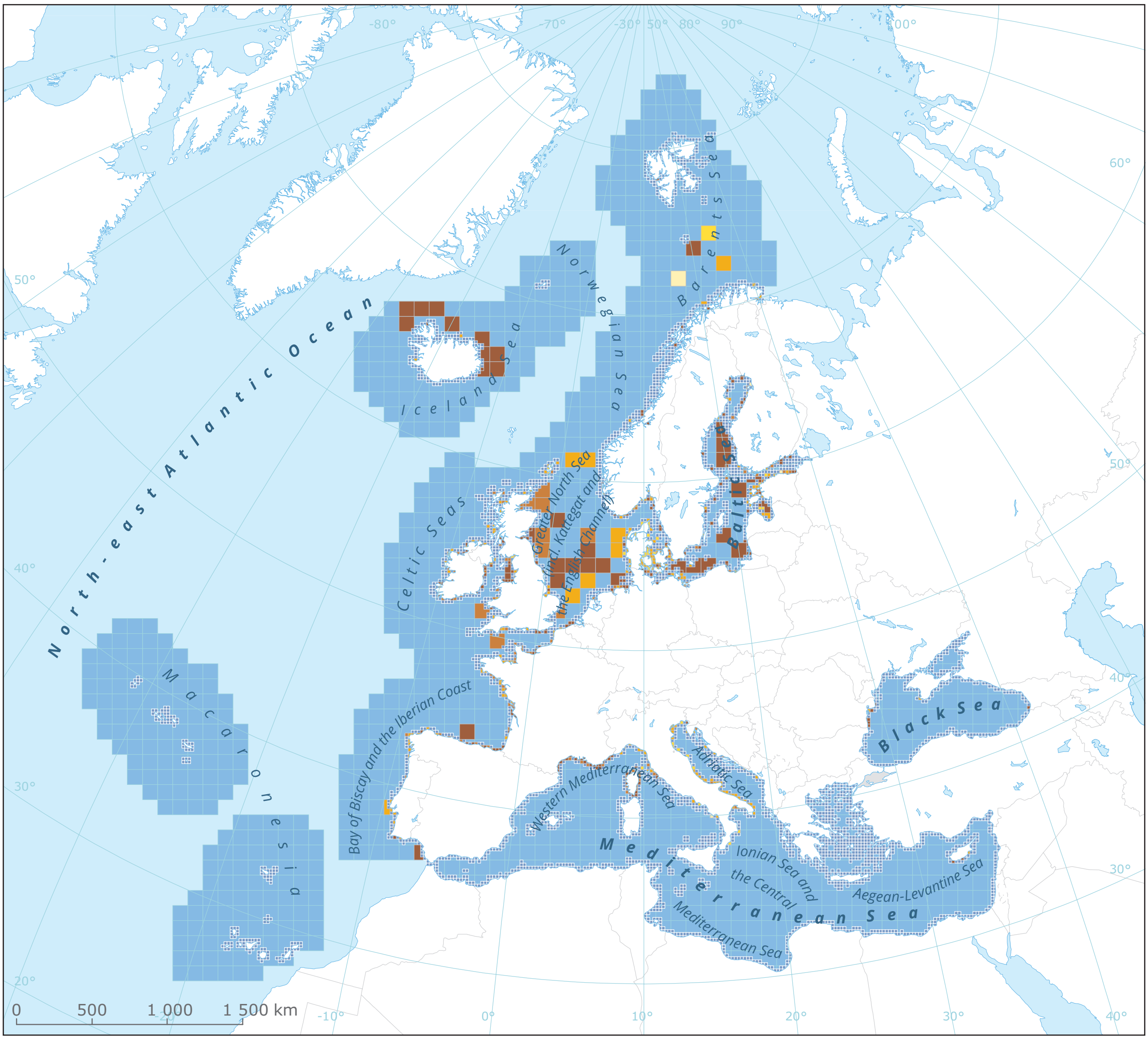
Table 3.6 Summary of classifications of the matrix 'biota' and identification of 'problem areas' and 'non-problem areas'

Class	Region								Total
	Baltic Sea		Black Sea		Mediterranean Sea		North-East Atlantic Ocean		
	n	%	n	%	n	%	N	%	
NPA_{high}	4	2.0			5	3.1	3	0.6	12
NPA_{good}	17	8.6			12	7.5	34	7.1	63
$PA_{moderate}$	75	37.9	4	33.3	64	39.8	183	38.0	326
PA_{poor}	33	16.7	1	8.3	35	21.7	116	24.1	185
PA_{bad}	69	34.8	7	58.3	45	28.0	146	30.3	267
Total	198		12		161		482		853

Notes: See Figure 3.1 for explanations of NPA_{high} and NPA_{good}, $PA_{moderate}$, PA_{poor} and PA_{bad}. Please note that NPA_{high} and NPA_{good} indicate 'non-problem areas', while $PA_{moderate}$, PA_{poor} and PA_{bad} indicate 'problem areas'.

When excluding mercury from the classifications, the group 'other organohalogens' increases slightly, while 'metals' decreases from 188 cases to 109 cases. When excluding PBDEs from the classifications, the groups 'other organohalogens', 'metals' and 'PAHs' trigger significantly more classifications, i.e. 429 (+213), 283 (+95) and 13 (+6), respectively. Therefore, the analysis could support the identification and ranking of substances that may be of concern in more specific areas of a marine region.

Map 3.3 CHASE+-based classifications of contaminant status of 'biota'



CHASE classification of contaminant status in biota

Non-problem areas: High, Good

Problem areas: Moderate, Poor, Bad

Outside coverage

No data

100x100 km in offshore areas (> 20 km from the coastline)

20x20 km in coastal areas (≤ 20 km from the coastline)

Note:
CHASE: Chemical Status Assessment Tool

Notes: Mapping of contamination 'problem areas' and 'non-problem areas' based on measurements in biota. See Annex 4 for maps with higher resolution and regional focus as well as additional classifications, excluding specific groups of substances.

3.6 Biological effects

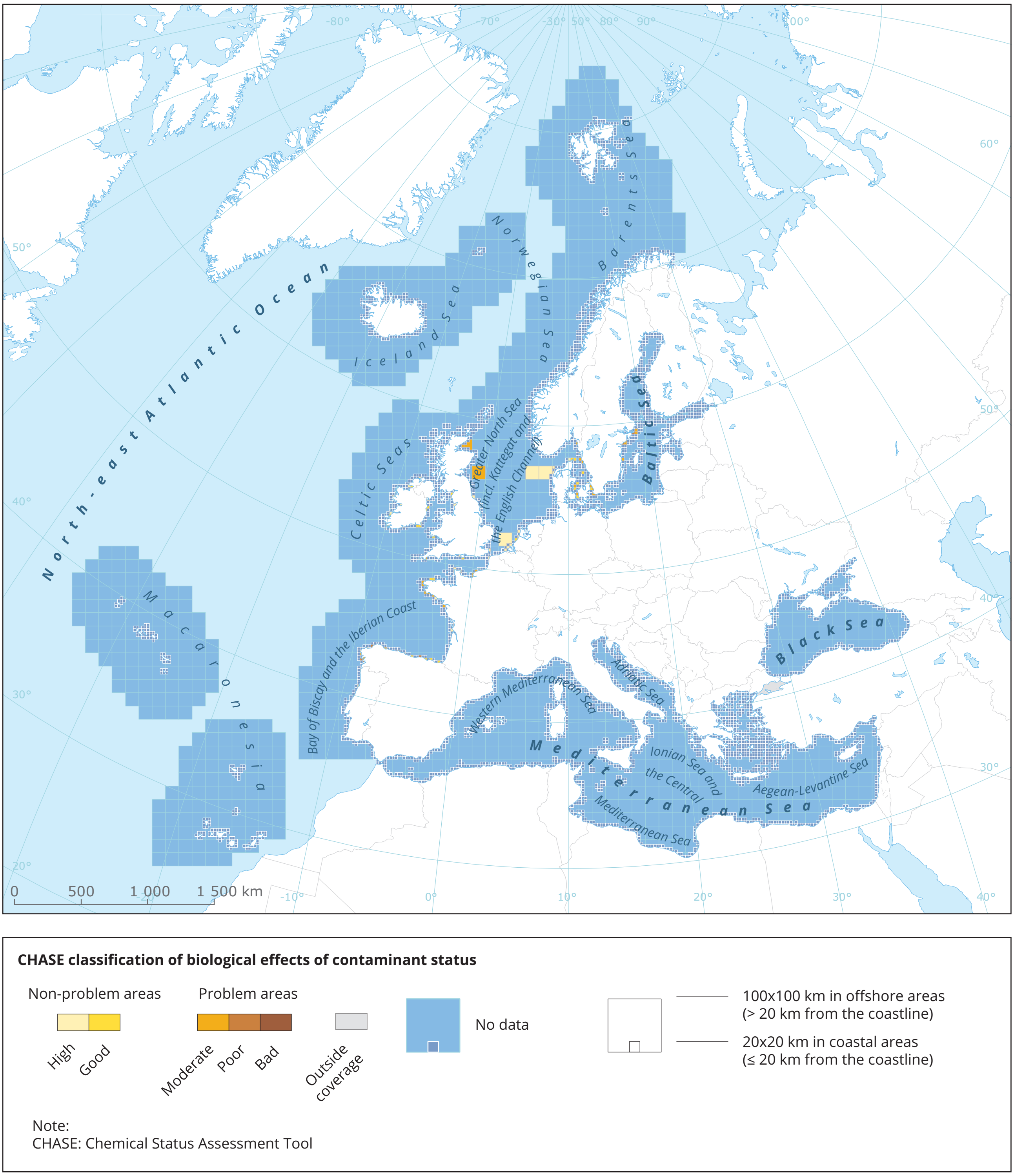
Elevated concentrations of contaminants in marine ecosystems have the potential to affect various ecosystem components. Although concentrations in water, sediments and biota may be below detection limits or assessment criteria, they can reach harmful levels if the substance bioaccumulates in an organism. In contrast, biological effects are used to study the impact on an organism, though often the exact cause of the effect may be unclear. Examples of well-known and well-documented biological effects are the deformation of sexual characteristics (imposex) in snails, lysosomal membrane stability in mussels and the deformation of fish fry in eelpouts (*Zoarces viviparus*).

Monitoring biological effects is restricted to a few indicators and data coverage is currently limited. Biological effects have thus been addressed in only 134 assessment units, mostly in the Baltic Sea, the North Sea and the North-East Atlantic Ocean. Of these, 76 units (62.7 %) have been classified as being 'non-problem areas'. Imposex has been documented as the indicator with the highest contamination ratio in 52 out of 58 'problem areas' (89.7 %; Table 3.7), while other bioeffect indicators have been identified as having the highest contamination ratio in six units (Map 3.4).

Table 3.7 'Problem areas' and biological effects triggering indicators

Category	Number of assessment units
Imposex	52
Other bioeffects	6

Map 3.4 **CHASE+-based classifications of contaminant status of indicators of biological effects**



Notes: Mapping of contamination 'problem areas' and 'non-problem areas' based on measurements of biological effects. See Annex 4 for maps with higher resolution and regional focus.

3.7 Identification of 'problem areas' and 'non-problem areas'

The CHASE+ tool, as described in Section 3.2, combines the classifications of the matrices 'water', 'sediment' and 'biota' with indicators of 'biological effects' in an integrated classification of chemical status. Chemical status is evaluated in five classes, where NPA_{high} and NPA_{good} are recognised as 'non-problem areas' and $PA_{moderate}$, PA_{poor} and PA_{bad} are recognised as 'problem areas' (Figure 3.1).

A total of 1 541 assessment units have been assessed. All regional seas are covered by this thematic assessment of contaminants in Europe's seas, some being better than others. Out of these 1 541 assessment units, 1 305 (85 %) have been classified as being 'problem areas' with respect to contamination.

Sixteen per cent of the areas assessed have a healthy status, i.e. they have been identified as 'non-problem areas'. The percentage of 'non-problem areas' in the Baltic Sea, the Black Sea, the Mediterranean Sea and the North-East Atlantic Ocean is 7 %, 19 %, 7 % and 21 %, respectively. Given the data available, the degree of contamination seems to be at the same level in the Baltic Sea, the Mediterranean Sea and the North-East Atlantic Ocean. For the Black Sea, the results seem to be related to the substances being monitored as well as to the spatial coverage.

In the Baltic Sea, 18 assessment units are classified as 'non-problem areas' and 257 as 'problem areas'. The spatial coverage seems adequate, although there are some gaps, i.e. along the west coast of Latvia, in Russian coastal waters and in some Swedish and Finnish coastal waters. For the Black Sea, access to relevant monitoring data seems to be a challenge, resulting in an assessment limited to the western parts. Only 62 areas have been assessed and 12 of these have been classified as 'non-problem areas'.

In the Mediterranean Sea, there seems to be good spatial coverage for many coastal waters. However, gaps have been identified in Spain, in eastern parts of the Adriatic Sea and in some parts of Greece, Italy and Turkey. For offshore water, the spatial coverage is poor, as only two assessment units are included, one south of Marseille, France, and one south of Cyprus. A total of 354 areas have been assessed and 24 of these have been identified as 'non-problem areas'.

For the North-East Atlantic Ocean, a total of 850 areas has been assessed as a result of good access to monitoring data in most sub-regions. Data coverage is very good for the North Sea and the Skagerrak. Good coverage is also found for north of Iceland, the Channel, around the UK and the Bay of Biscay. Data coverage is also good for the coastal waters of Portugal and Ireland. Gaps have been identified along the west coast of Norway, in the south of Iceland, in Macaronesia and in the offshore regions of the North-East Atlantic Ocean.

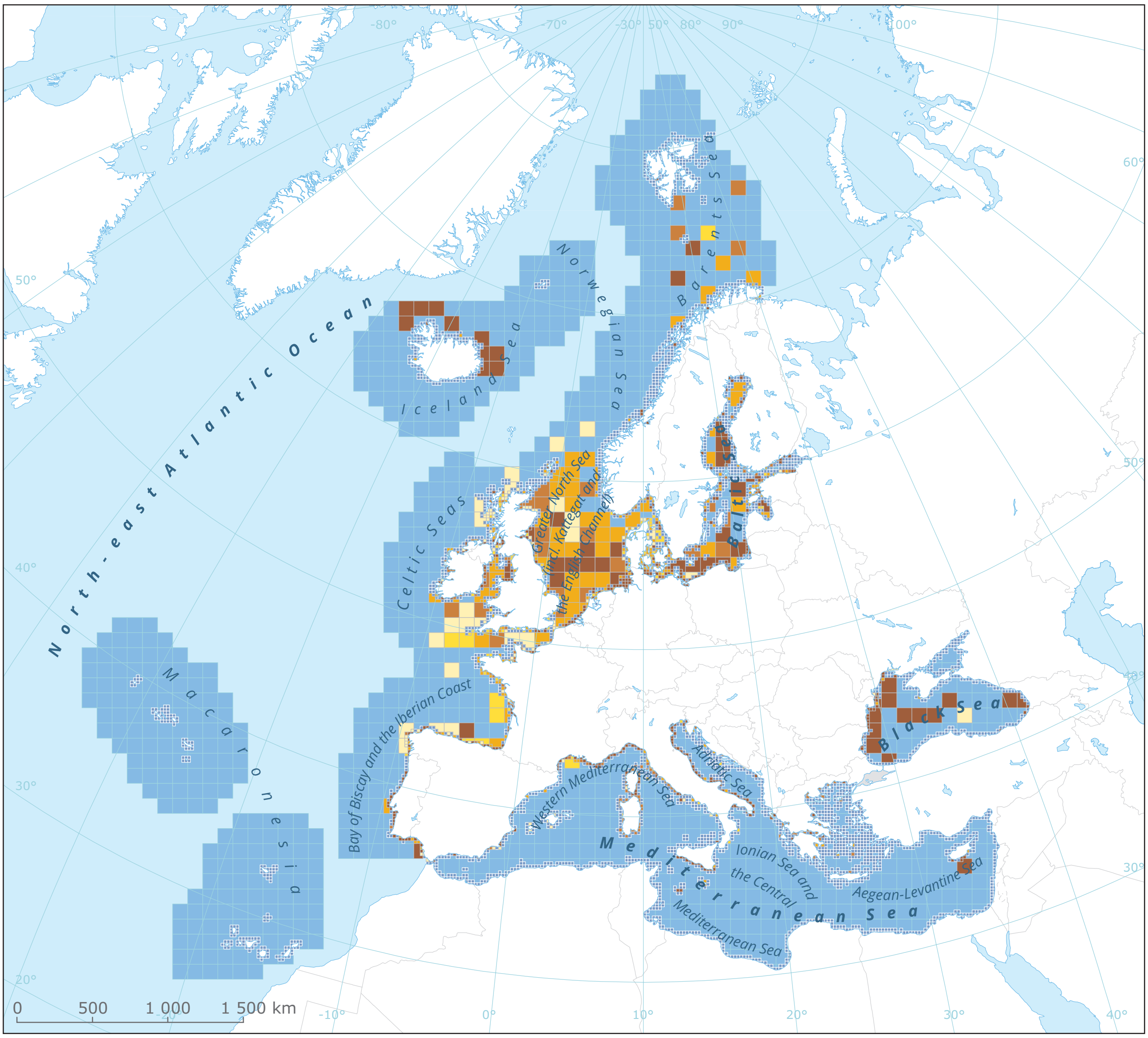
This integrated assessment of chemical status shows that it is indeed possible to identify 'problem areas' and 'non-problem areas' with respect to contamination across Europe's seas despite the large number of substances in existence and the vast diversity of substances monitored by individual monitoring programmes:

- Firstly, although data coverage is decent, there is room for improvement through further data mining and further development of the quality of the monitoring activities.
- Secondly, better threshold values are required. Some of the values used could be improved to better reflect the boundary between 'problem areas' and 'non-problem areas'.
- Thirdly, more threshold values could improve the confidence of the classifications. Some substances monitored cannot be included in the assessment because of an absence of validated threshold values.

The substances and indicators triggering the integrated classifications are summarised in Table 3.8. A 'triggering substance' is a substance or a group of substances that has the highest value above agreed threshold values in a given assessment unit.

'Metals' has been identified as the group of substances that most often triggers the classification of 'problem area'. This has happened in 491 cases, indicating that the inputs of metals into Europe's marine ecosystems have probably yet to be reduced to or fall below critical levels. Inputs of organobromines (279 cases),

Map 3.5 **Mapping of 'problem areas' and 'non-problem areas' in Europe's seas (based on CHASE-based classifications)**



Mapping of 'problem areas' and 'non-problem areas' in Europe's seas, based on CHASE+ classification

Non-problem areas: High, Good

Problem areas: Moderate, Poor, Bad

Outside coverage

No data

100x100 km in offshore areas (> 20 km from the coastline)

20x20 km in coastal areas (≤ 20 km from the coastline)

Note:
CHASE: Chemical Status Assessment Tool

Notes: Identification of potential contamination 'problem areas' and 'non-problem areas' based on the first ever Europe-wide application of the CHASE+ tool and data available from MSFD, WFD, ICES, Eionet and EMODnet Chemistry.

Source: EEA 2019.

other organohalogens (271) and PCBs (114) are also apparently close to the critical levels established to meet environmental standards, i.e. the threshold values. Other substances, or groups of substances, can also trigger the classification of 'problem area'. A key message to consider is that staying within the levels stipulated by the agreed threshold values requires reductions in discharges, losses and emissions of contaminants to Europe's seas.

In summary, challenges still exist for individual substances or groups of substances across Europe's seas, as not all concentrations of substances fall below agreed threshold values. A graphical summary of the identification of 'non-problem areas' and 'problem areas' for the matrices 'water', 'sediments', 'biota' and 'biological effects' and the integrated assessments for the Baltic Sea, the Black Sea, the Mediterranean Sea and the North-East Atlantic Ocean is given in Figure 3.2.

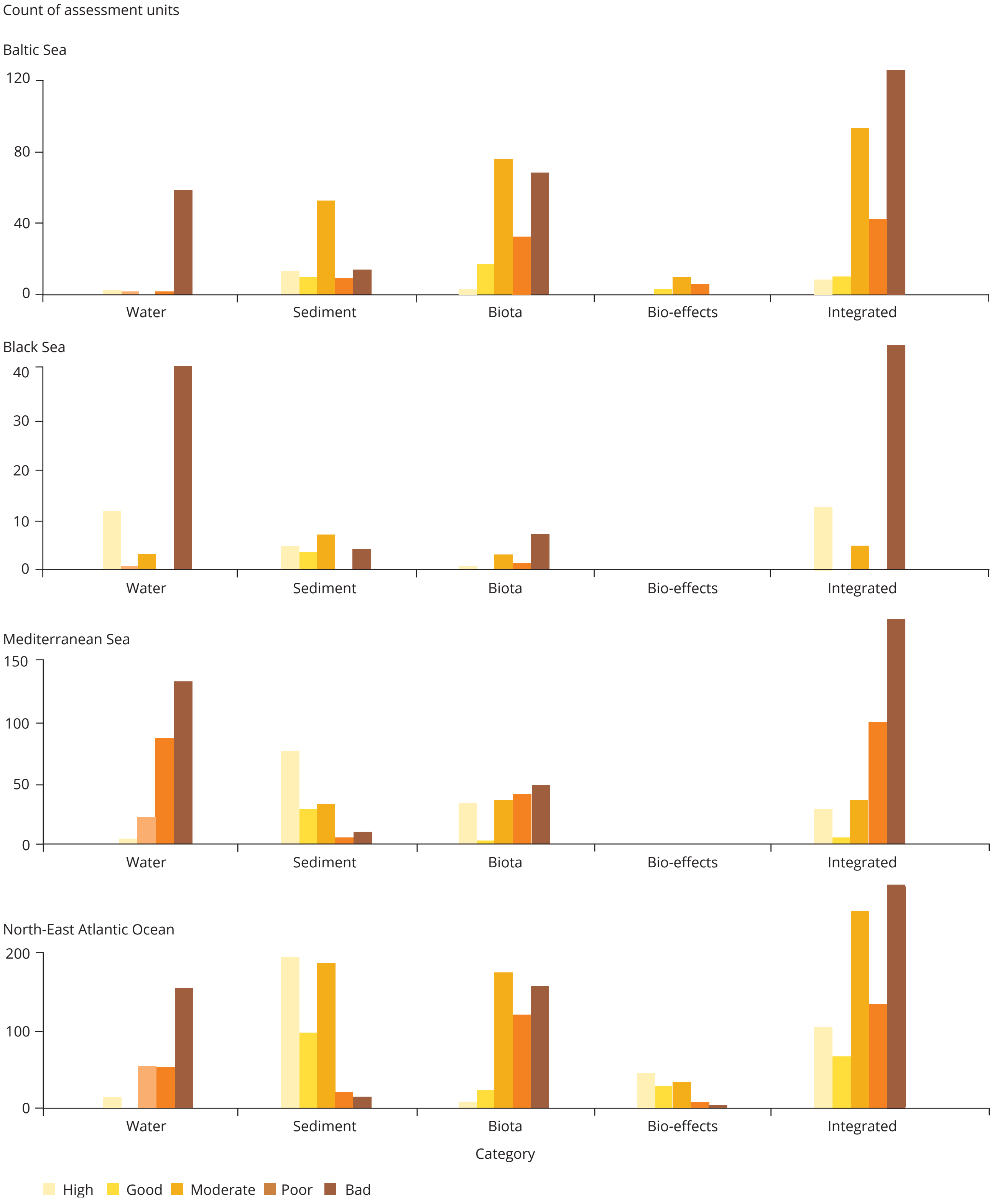
Another key finding is that differences between monitoring approaches exist among the regional seas, i.e. (1) 'biota' is a widely used matrix for monitoring in the Baltic Sea; (2) in the Black Sea, 'water' is the most used matrix for monitoring; (3) in the Mediterranean Sea, the matrices 'water' and 'sediment' are the most used matrices; (4) in the North-East Atlantic Ocean, 'water', 'sediments' and 'biota' are widely used; and (5) 'bio-effects' are only used in the Baltic Sea and the North-East Atlantic Ocean.

Table 3.8 Integrated assessment: the triggering substances and indicators

Category	Number of assessment units	Number of assessment units (-Hg)	Number of assessment units (-PBDEs)
Metals	491	418	596
Organobromines (PBDEs)	279	283	-
Other organohalogens	271	277	404
PCBs	114	115	118
PAHs	89	93	94
Organotins	30	31	34
Imposex	26	28	32
Organochlorines	5	5	6

Note: Ranking of the substances triggering the overall CHASE+ classification.
-Hg, excluding mercury; -PBDEs, excluding PBDEs.

Figure 3.2 **Results of the mapping of 'problem areas' and 'non-problem areas' based on the CHASE+-based classifications**



Notes: Number of assessment units within each region (the Baltic Sea, the Black Sea, the Mediterranean Sea, the NE Atlantic Ocean) achieving each of the five classifications (NPA_{high}, NPA_{good}, $PA_{moderate}$, PA_{poor} or PA_{bad}). Please note the differences on the y axes. Results are shown for each compartment (water, sediment, biota, bio-effects) as well as for the overall CHASE+ classifications, which combine all four compartments using a 'one-out, all-out' principle.

Source: EEA 2019.

4 Have the trends been broken?

- Concentrations of known contaminants are decreasing but concerns remain.
- Monitoring of a predefined subset of substances with a more complete geographical coverage could ensure consistent, solid policy support on progress.
- Given the toxicity, persistence and widespread occurrence of known contaminants, a precautionary approach would be to monitor a wider variety of substances to provide earlier warnings.

The need to reduce pollution from contaminants across Europe is widely accepted (see Table 1.1), but it is difficult to achieve because of the persistent nature of chemical substances and heavy metals. Therefore, contaminants still appear to be widespread and, in many areas, above the agreed threshold levels in Europe's marine environment, despite the comprehensive policy and regulative framework in place (Figure 3.2).

This chapter has benefited from the solid work done by HELCOM and OSPAR on some of the contaminants of most concern. Less information on trends has been available for the Mediterranean Sea and the Black Sea.

This chapter considers the effect of these policy and regulative frameworks in reducing discharges and emissions from land-based and sea-based sources — are we on track to have clean, non-toxic European seas?

4.1 Few Europe-wide temporal data sets are available

Despite the many contaminants present in the marine environment, there are only a few substances for which the available data sets have sufficient geographical and temporal coverage to enable a pan-European assessment. Within these restrictions, the EEA has developed the indicator 'hazardous substances in marine organisms (MAR001)' based on the individual assessment of eight substances (Figure 4.3).

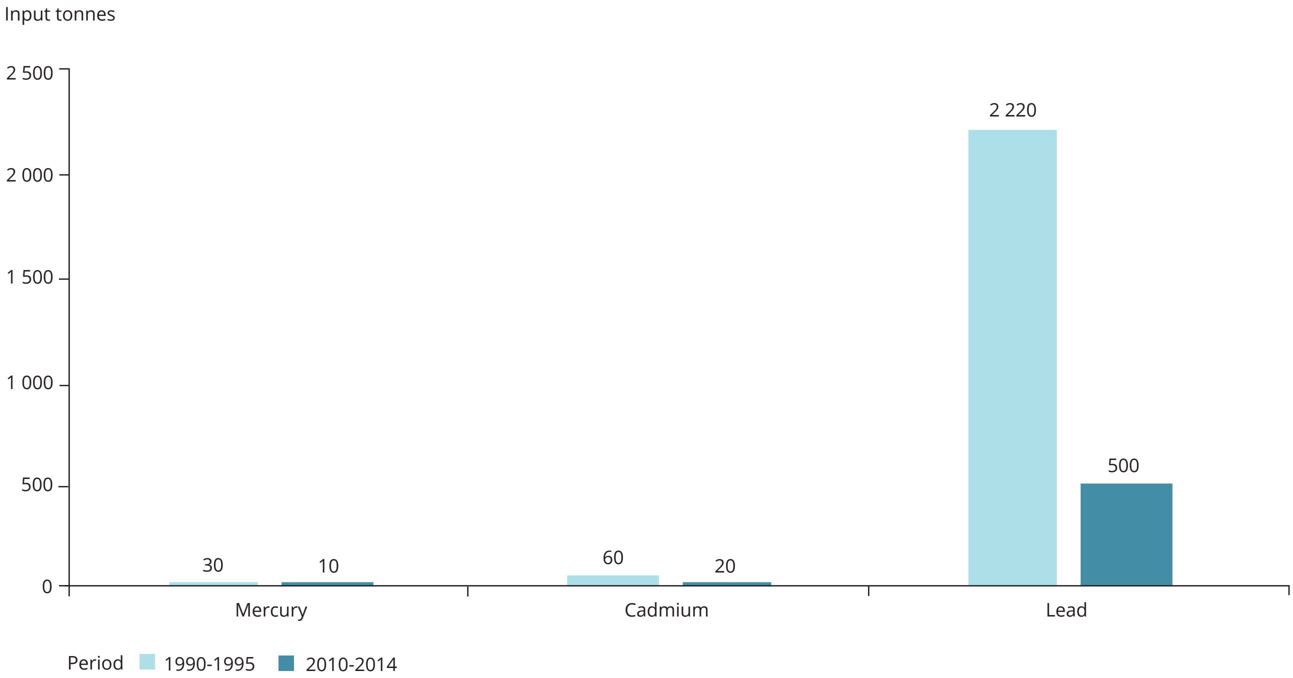
The indicator addresses concentrations and trends for a small subset of eight hazardous substances found in marine organisms: mercury, lead, cadmium, hexachlorobenzene (HCB), lindane (γ-HCH or gamma-1,2,3,4,5,6-hexachlorocyclohexane), PCBs (using a sum of seven congeners), DDT (dichlorodiphenyltrichloroethane, using the metabolite p'pDDE, as a proxy) and BAP (benzo[*a*]pyrene), a polycyclic aromatic hydrocarbon (PAH) (EEA, 2015).

The first seven substances have been banned from use, and, while the combined riverine inputs and direct discharges of these substances have declined, they are still found in the coastal and marine environment (OSPAR, 2009; EEA, 2011). Although their use has been severely restricted or banned, observations show that these persistent substances are still present in all of Europe's seas. There are still large amounts of waste containing PCB that have to be destroyed somehow. Emissions from waste are a contributing factor that ensures that levels will not decrease in spite of the ban.

4.2 Inputs of heavy metals in decline in some areas of Europe's seas

In the Greater North Sea, the estimated total inputs of mercury, cadmium and lead from rivers and the atmosphere appear to have substantially decreased since 1990 (Figure 4.1). It should be mentioned that there is low confidence in the data, as improved analytical procedures make it difficult to estimate the proportion of change that is caused by a reduction in discharges. The assessment does not cover the entire OSPAR area (OSPAR, 2017). The reduction in the input of mercury has further resulted in declining concentrations in the tissue of blue mussels. This is observed in selected stations across the North-East Atlantic Ocean (Figure 4.2).

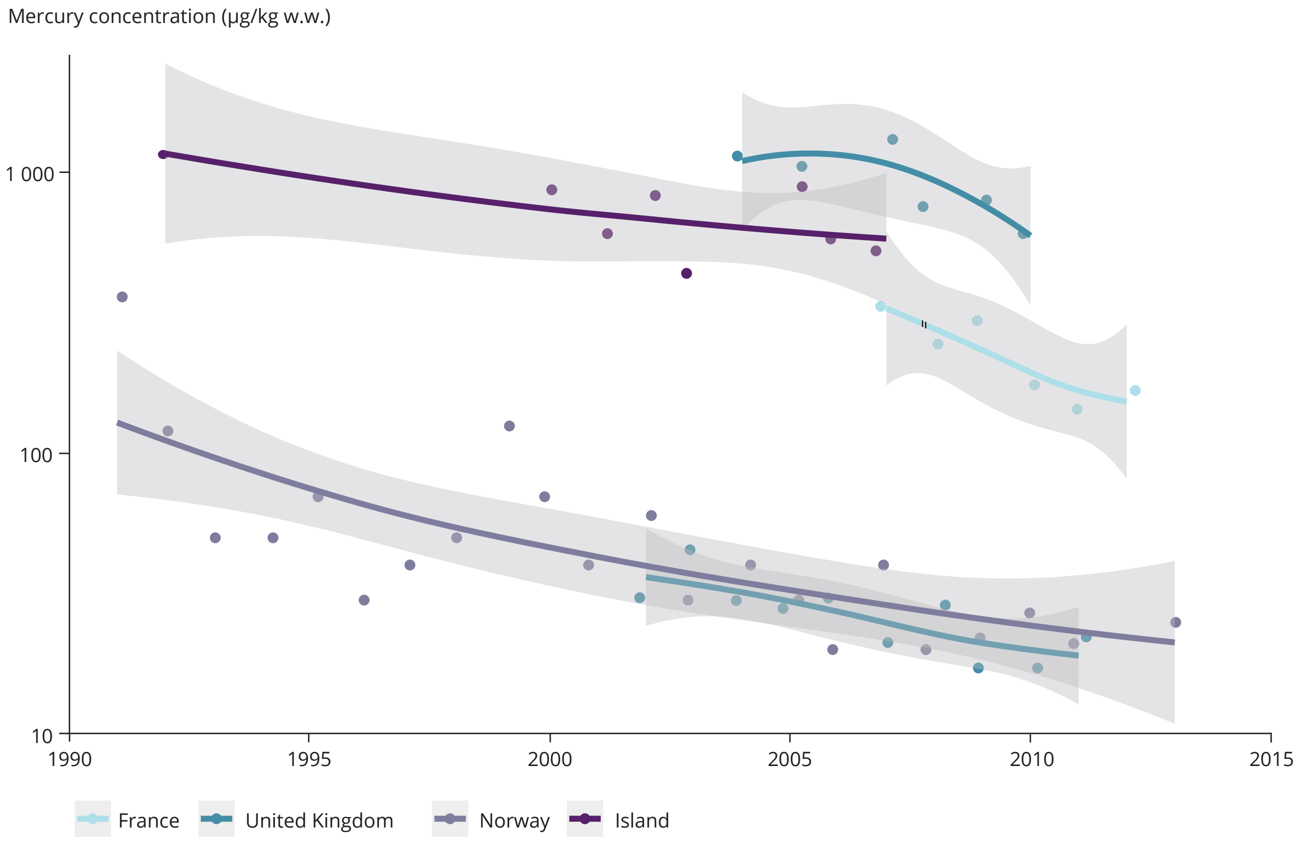
Figure 4.1 Estimated total input of mercury, cadmium and lead to the Greater North Sea



Note: Values are in tonnes rounded to the nearest 5 tonnes for cadmium and mercury and 100 tonnes for lead.

Source: OSPAR, 2017.

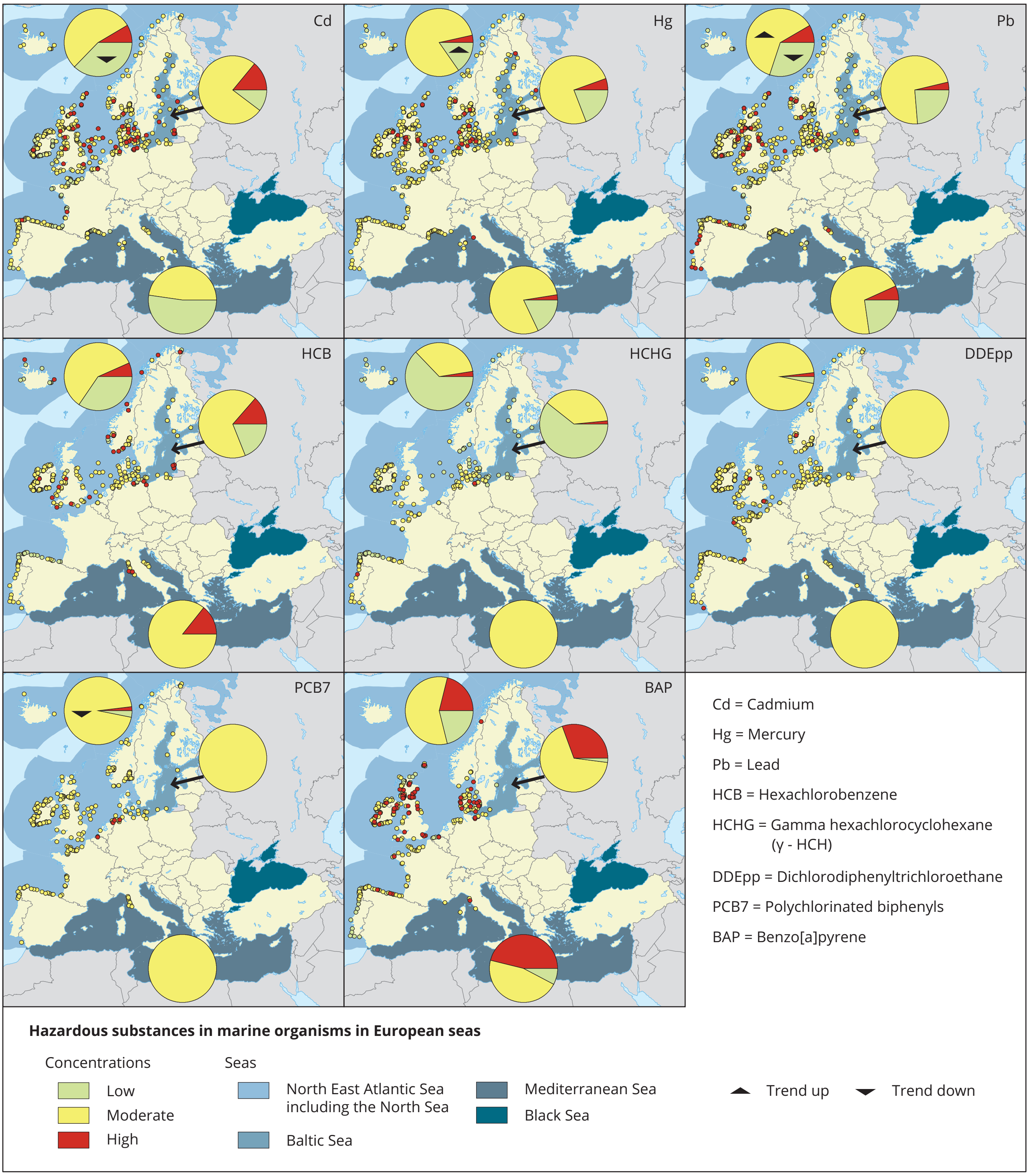
Figure 4.2 Mercury trends in blue mussels in the North-East Atlantic Ocean



Notes: Mercury trends in selected stations from the North-East Atlantic Ocean in blue mussels (*Mytilus edulis*). w.w. wet weight.

Source: EIONET, 2018c.

Figure 4.3 A pan-European overview of persistent substances



Notes: Assessment of hazardous substances in biota in the North-East Atlantic Ocean, the Baltic Sea and the Mediterranean Sea (2007-2015).

Source: EIONET, 2017.

In the Baltic Sea, all areas assessed failed to reach the agreed concentration threshold levels for mercury. Better results were achieved for cadmium and lead, though they are still a cause of concern for large parts of the Baltic Sea. It should be mentioned that assessment results are not available for all areas of the Baltic Sea (HELCOM, 2018b). However, atmospheric deposition of both cadmium and mercury are declining across the entire Baltic Sea (HELCOM, 2018b).

4.3 Concentrations of polycyclic aromatic hydrocarbons are declining where monitored

In the North-East Atlantic Ocean, concentrations of PAHs in sediments are in decline in areas such as the English Channel and the Gulf of Cadiz. On the Scottish west coast and in the Gulf of Cadiz, concentrations are at natural background levels. In all areas assessed, mean PAH concentrations are below the United States Environmental Protection Agency (US EPA) effects range low (ERL), but not below OSPAR's own standards in four areas. A key point is that adverse effects on marine organisms are 'rarely' observed at concentrations below the ERL value. While there is high confidence in the results, for some areas of the Greater North Sea, the Celtic Seas and the Bay of Biscay there is a lack of monitoring data (OSPAR, 2017). However, in all (10) assessment areas, mean PAH concentrations in shellfish are above background levels (though at levels that are unlikely to cause adverse effects). Temporal trends are either declining or stable, with no increasing trends (OSPAR, 2017).

Similarly encouraging observations have been noted in the Baltic Sea, where concentrations of BAP as a representative of PAHs has achieved the threshold value in both coastal and offshore areas. However, for large parts of the Baltic Sea, there are no monitoring data available, making an overall evaluation less certain (HELCOM, 2018b). A long-term declining trend for BAP is also observed in the Arctic (AMAP, 2017).

There are several hundred different PAHs, 16 of which were selected as priority substances in the 1970s by the US EPA. The selection was based on their toxicity, environmental occurrence at the time and the ability to be analysed. These have become a de facto global standard since then (AMAP, 2017). PAHs are also POPs (see Box 2.3).

4.4 Concentrations of banned organotins are (mostly) declining

Organotins can be very toxic to marine organisms and have documented effects on reproductive capacity, growth, etc. Well-known organotins are TBT compounds.

A 'classic' example of a source of toxicity is the use of antifouling paint that contains TBT compounds. These compounds have been widely used to prevent biological 'fouling' (a build-up of algae and animals) on ship hulls. These paints have been shown to cause imposex (the growth of male sex organs in females of sensitive snail species, e.g. dog whelks) as well as lower growth rates in oysters. TBT also accumulates in tissue and can reach high levels in top predators. Because of this, the use of paints containing TBT has gradually been phased out, and reduced concentrations of TBT in coastal waters have since been observed (OSPAR, 2017). Concentrations of TBT in marine waters are slow to decrease, in part because of continued leakage from sediments. TBT was banned in antifouling paints in 2003 by the EU, though the regulation only entered into force in 2008 (EC, 2003).

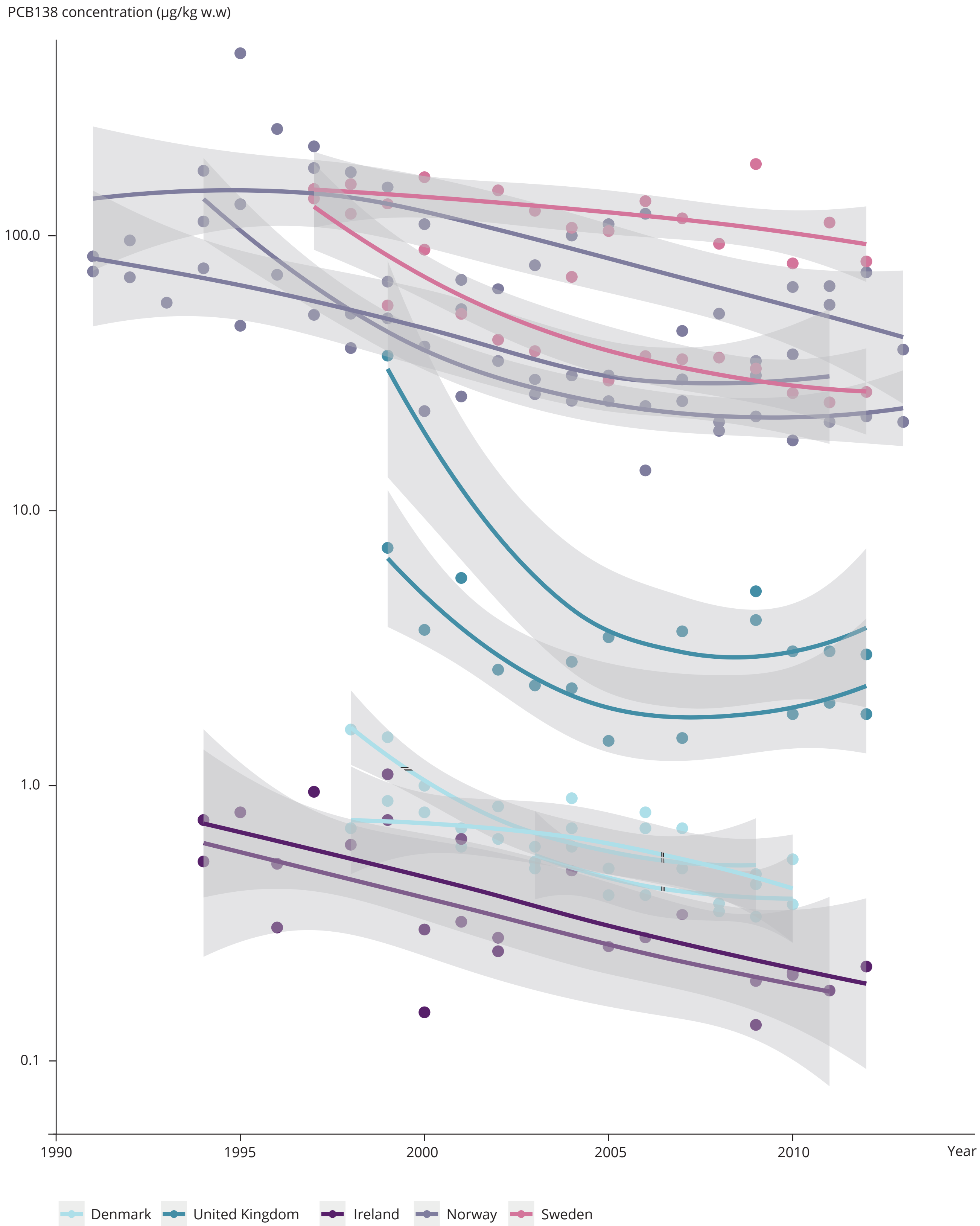
In the Baltic Sea, concentration trends of TBT are in general declining, though most assessed coastal areas are considered as having a 'not good' status'. Threshold values are still to be agreed. Where data are available, the confidence in the trends observed is high, but data availability is low for large areas (HELCOM, 2018b).

In the North-East Atlantic Ocean, improvements in imposex have been detected in 48 % of the monitored sites, with no changes observed in the rest of the sites. The most common species monitored, dog whelks, showed an improvement in 74 % of the sites (157 out of 174 sites). Of the 10 OSPAR assessment areas, nine are below the level at which adverse effects are likely to occur. In the Iberian Sea, the imposex level is more than five times higher than this target. Despite these positive trends, no areas have yet reached the agreed natural background levels (OSPAR, 2017).

4.5 Concentrations of polychlorinated biphenyls are (mostly) declining

PCBs are a group of intentionally or unintentionally manufactured compounds. They have been used as dielectric fluids or as flame retardants or they can

Figure 4.4 PCB trends in the North-East Atlantic Ocean and the Baltic Sea



Notes: PCB trends in selected stations from the North-East Atlantic Ocean and the Baltic Sea, Atlantic cod (*Gadus morhua*) (Norway, Sweden), plaice (*Pleuronectes platessa*) (United Kingdom), blue mussel (*Mytilus edulis*) (Denmark, Ireland, Sweden).
w.w. wet weight.

Source: EIONET, 2018.

be generated unintentionally as impurities during the manufacture of pigments. Some PCBs have toxic properties similar to dioxin (i.e. they are more toxic than other PCBs) and are included under the same dioxin group of substances. PCB levels in biota have been decreasing in some areas of the Baltic Sea, though most stations show stable concentrations. While the confidence in the indicator is medium, 'major data reporting problems' exist, making a Baltic-wide evaluation less certain (HELCOM, 2018b).

PCB concentrations in sediments have generally been declining throughout the North-East Atlantic Ocean for six out of seven PCB congeners from 1995 to 2015. However, in some areas of the southern North Sea, the English Channel and the Irish Sea, concentrations of the most toxic PCB monitored (CB118) are still at levels that can have adverse effects on marine organisms (OSPAR, 2017). Downward trends for PCB in biota from the North-East Atlantic Ocean and the Baltic Sea have been observed. Some examples include Atlantic cod, European plaice and blue mussel (Figure 4.4).

The time trends of PCB in surface sediments from Belgium's coastal zone indicated a two- to three-fold PCB concentration decrease during the last 20 years. However, trends in the Western Scheldt estuary were spatially heterogeneous and not significantly decreasing. These results demonstrate that international efforts to cut emissions of PCBs have been effective in reducing concentrations in open water ecosystems, such as the Belgian coastal zone, but have had little effect in the urbanised and industrialised area of the Scheldt (Everaert et al., 2014).

Despite the reductions, an increase in PCB atmospheric deposition has been registered in two high altitude locations (in Spain and Austria) since 1996. This indicates that the trends reported by OSPAR and HELCOM are not pan-European (Arellano et al., 2015). So, even though the use of PCBs was banned more than 25 years ago, because of PCB persistence, it may be decades before target levels are reached (OSPAR, 2017).

Box 4.1 Human health effects of contaminants

Humans can be affected in many different ways when exposed to chemical substances or heavy metals in our environment. This is something that is of relevance to all of us, no matter where we live.

For example, in Germany it has been documented that the reproductive health of men is at risk. It is likely that young German men only produce one third of the sperm that German men produced 30 years ago. It may mean that half of German men have a reduced reproductive capacity. It remains difficult to prove a causal link between specific contaminants and the reduction in fertility. However, results from animal experiments and human health monitoring programmes indicate that the presence of these 'endocrine' disruptors in the environment may be partially responsible for this reduction in fertility (UBA, 2018).

Some of these chemicals acting as endocrine disruptors, e.g. plasticisers such as phthalates, have widespread applications, along with other basic chemicals for plastics, and can be found in the blood of most German people regardless of their age (UBA, 2018). These substances can be used in plastics or even personal care products. A high concentration of phthalates has been found in Europe's seas from Bergen, Norway, to the German Bight, North Sea, though at much lower concentrations in the Arctic Ocean (AMAP, 2017). Phthalates are listed as priority substances under the WFD, illustrating some of the existing efforts to reduce our exposure to such substances (EU, 2000).

Besides the potential effect that contaminants have on marine species (see, for example, Box 2.2), human health can also be adversely affected by contaminants from the marine environment. For example, dioxin has been observed in especially fatty fish such as herring and salmon in the Baltic Sea. This has caused health authorities to advise restricted consumption of fish from these areas, especially by pregnant women. Dioxin can disrupt growth, cause cancer or adversely affect the immune system (Livsmedelsverket, 2018).

The positive side of these examples is that the measures taken to reduce emissions and overall concentrations in the environment are starting the work. However, because of their persistence and ability to bioaccumulate, such substances still pose a threat to the environment and to human health. They also illustrate that we are learning hard, late lessons through hindsight, which gives rise to the question of whether or not we are adequately applying the precautionary principle concerning new emerging substances.

4.6 Polybrominated diphenyl ethers

PBDEs are synthetic flame-retardant chemicals that are widely used to make consumer products difficult to burn. These products include electronic products, plastics, textiles, etc.

Consequently, these chemicals are likely to have saved many lives. Unfortunately, they are also considered to be POPs, a group of environmentally persistent, toxic chemicals. In 2009, certain PBDEs were banned from production by 180 countries. In the Baltic Sea, there is a tendency for decreased concentrations of PBDEs in herring as well as a strong decline in concentrations in kittiwake eggs, a fish-feeding bird species. However, no decline has been observed in cod, a predatory fish (Figure 4.5). Furthermore, in a recent status assessment, HELCOM found that threshold values are exceeded at every monitoring site in the Baltic Sea (HELCOM, 2018b).

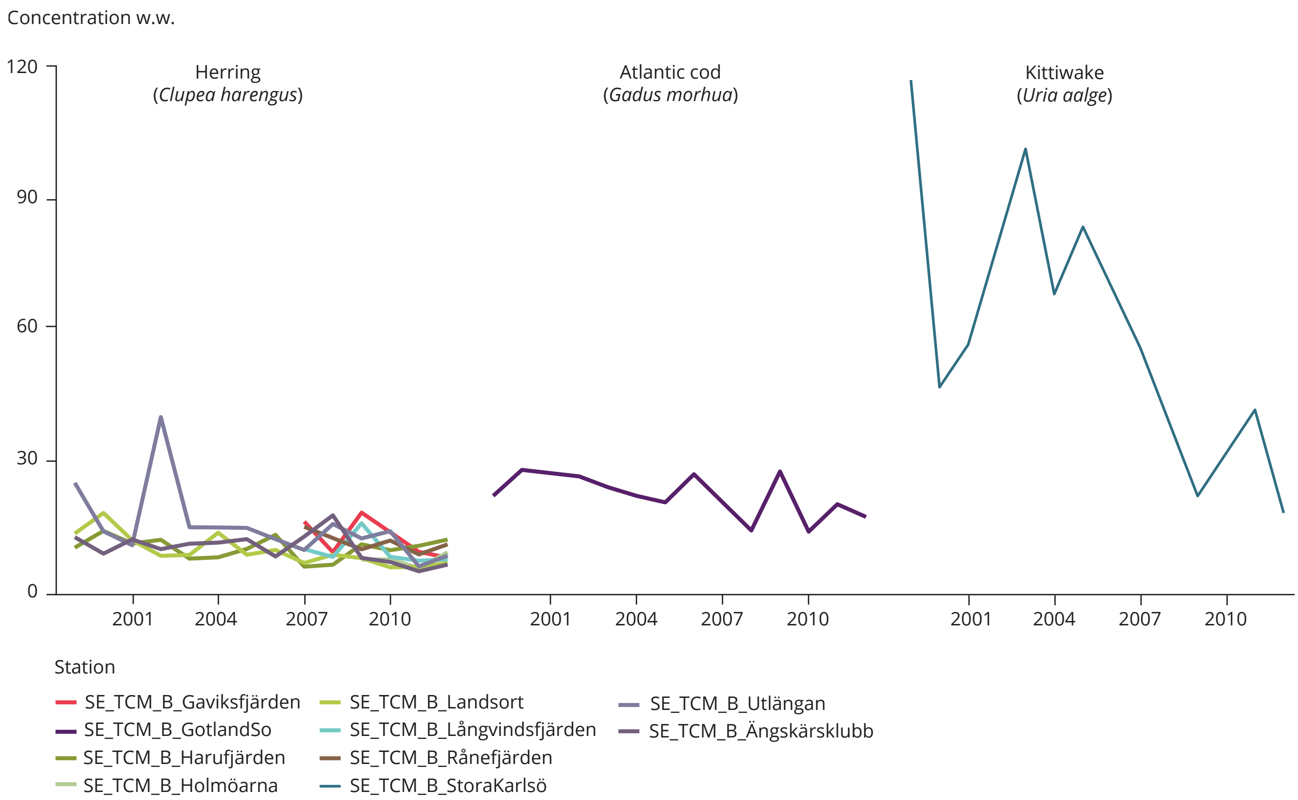
The analysis of data from the 2000-2005 period shows widespread contamination of PBDEs in the North-East Atlantic Ocean's ecosystem. Data from 2010 to 2015 indicate that concentrations in biota were declining by 10 % per year in six out of seven assessment areas. Only the Skagerrak and the Kattegat showed no change in the concentrations in biota. As there are no OSPAR criteria for assessing PBDEs in sediments, the OSPAR countries were not able to assess the significance of the concentrations found (OSPAR, 2017).

4.7 Other substances of concern

DDT is a toxic, persistent pesticide that, since 1962 (88 years after it was first synthesised) has been known to have wide-ranging, negative ecological impacts. It was used to effectively combat malaria and, as a result, the number of cases of malaria between 1946 and 1950 fell from 400 000 to virtually zero. DDT is still used in South America, Asia and Africa for this purpose. It is toxic to mammals (NPIC, 1999).

This continued use may be the reason for the observed increase in DDT concentrations in the Mediterranean Sea (Figure 4.6).

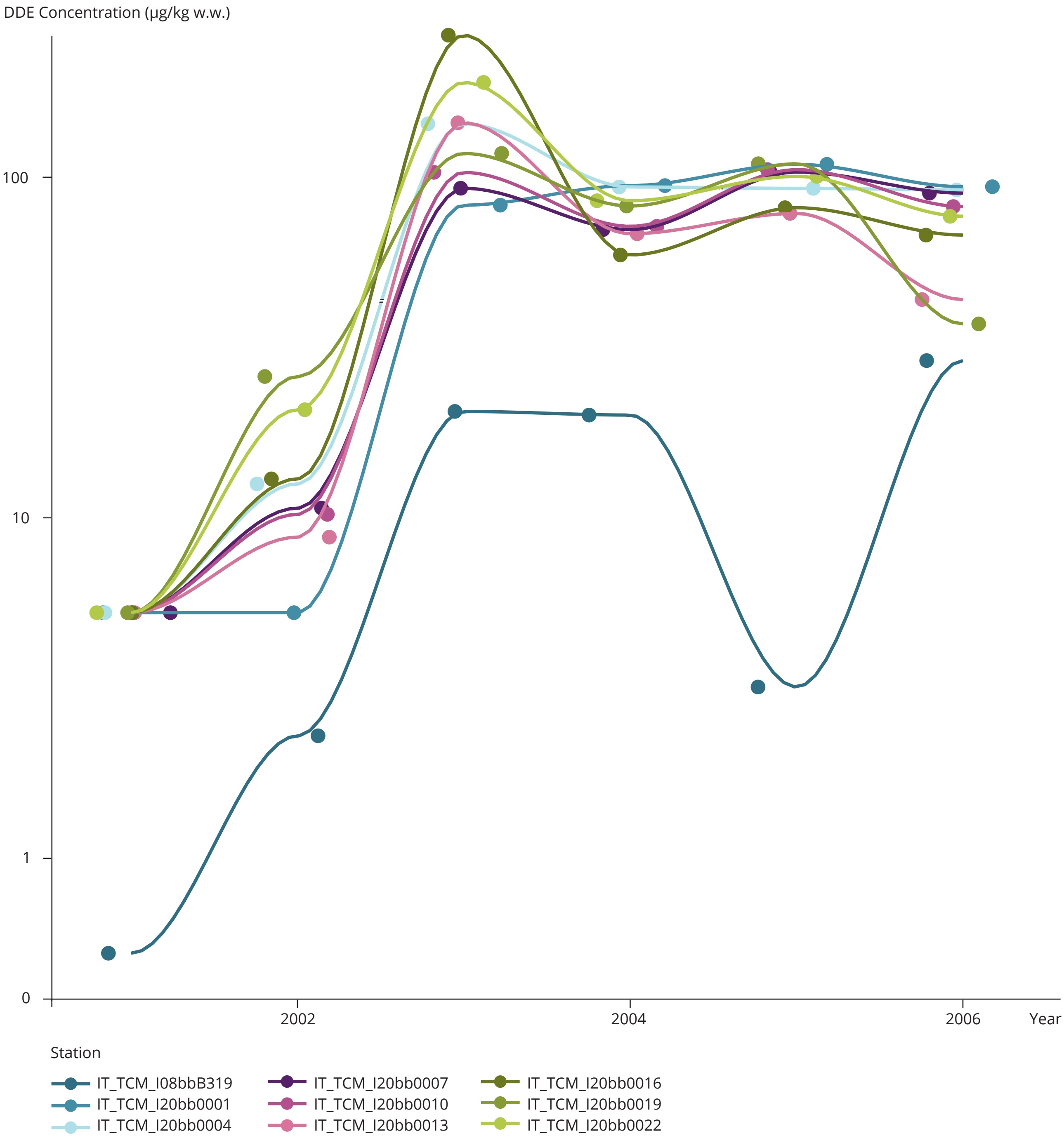
Figure 4.5 PBDE concentrations in three marine species in the Baltic Sea



Notes: Concentrations of PBDEs in three species in the Baltic Sea: herring (*Clupea harengus*), Atlantic cod (*Gadus morhua*) and kittiwake (*Uria aalge*).
w.w. wet weight.

Source: HELCOM, 2010.

Figure 4.6 **DDT trends in mussels in the Mediterranean Sea**



Notes: Concentrations of DDTs in Mediterranean mussel (*Mytilus galloprovincialis*) for selected stations along the Italian coast. w.w. wet weight.

Source: EIONET, 2018.

With regard to radioactive substances, solid progress has been made in both the Baltic Sea and the North-East Atlantic Ocean. In the Baltic Sea, it is estimated that pre-Chernobyl levels will be achieved sometime before 2025 for the radioactive isotope cesium^{137} (HELCOM, 2018b). Similarly, OSPAR has made substantial progress in reducing discharges, emissions and general losses of radioactive substances, i.e. a 2.5-fold reduction in discharges of total alpha and a 12-fold reduction in discharges of total beta (excluding tritium), since the baseline period of 1995-2001 (OSPAR, 2017).

In summary, it appears that (1) available information on substances and time series varies from substance to substance across the regional seas, and (2) the comprehensive policy framework and associated efforts have managed to reduce concentrations of some known hazardous substances in the marine environment, even though there are some that have yet to reach the agreed thresholds or concentration levels (Map 3.5). This is partly because of the persistent properties of some of these substances and also because emissions and discharges still occur in some instances.

5 Synthesis and outlook

- Contamination of Europe's regional seas continues to be a large-scale challenge, though progress is observed.
- Concentrations of some well-known contaminants appear to be declining, though not all of them meet the agreed thresholds.
- Positive effects of the significant efforts to reduce input to the marine environment are observed for some ecosystem features.
- Key politically agreed targets will not be achieved on time, e.g. the Generation Target and the targets for a good environmental status set out in the MSFD will not be met by 2020.
- Persistent substances remain in marine ecosystems and avoiding upstream use of persistent and hazardous substances is essential to reaching long-term policy commitments.
- To reach the policy visions of achieving clean, non-toxic European seas, a profound transition is needed in how we address pollution in our seas.

For decades, Europeans have had a shared vision of a marine environment with close to zero concentrations of man-made, synthetic substances and near background levels of naturally occurring substances. To achieve this vision, Europe has developed one of the most advanced and comprehensive policy and legislative frameworks in the world.

The reason behind these efforts is simple. Human health effects, as well as environmental impacts due to exposure to contaminants, are many and well documented. Human health effects include cancer, decreased fertility, skin allergies, cardiovascular diseases and dementia, to mention a few. Environmental effects include loss of ecosystem function and their services, e.g. contamination of seafood, reduced top predator fertility and the development of imposex.

Overall, this current attempt to map 'problem areas' and 'non-problem areas' shows that Europe, while on the right track for some substances, has not yet achieved its vision of a clean marine environment with low levels of contaminants. Contamination levels remain elevated across European seas (in approximately 85 % of the assessment units or 75 % of the area assessed; Map 3.5), though with some improvements, i.e. lower concentration levels are observed for individual and/or groups of substances (Figure 4.1; Figure 4.2).

However, no regional sea is identical to any other, whether looking at oceanic characteristics or the geopolitical setup. As a result, the specific challenges faced concerning contaminants in the marine environment varies from one regional sea to another.

5.2 Baltic Sea

The analyses reveal that most parts of the Baltic Sea can be considered 'problem areas' with respect to contaminants. The total number of assessment units is 275 and only 18 are classified as 'non-problem areas' (6.5 %). The matrix 'water' is monitored and assessed in only 63 units, four of which are classified as 'non-problem areas'. Classification of the matrix 'sediment' has been carried out in 97 places — 75, or 77.3 %, are considered 'problem areas'. 'Biota' is the best monitored matrix. This is assessed in 198 units, 21 of which have been found to be 'non-problem areas'. 'Bio-effects' is the least monitored matrix and is assessed in only 16 places, 11 of which are classified as 'non-problem areas'.

The group of substances giving rise to most of the classifications of 'problem areas' in the Baltic Sea is 'metals' (in 98 out of 257 problem areas; Table 5.1) followed by 'other organohalogens' (n = 57). When excluding mercury from the classifications (as it is highly persistent, widely distributed and near impossible to remove once in the environment), the remaining metals are still a cause for concern; mercury only drives 27 classifications out of the 98 driven by metals. When excluding mercury from the analysis, the number of classifications driven by organohalogens increases to 60 (from 57). Additional analyses excluding specific groups of substances have been conducted but are not discussed here (see Annex 8).

With the given availability of data, it has been possible to carry out assessments for most parts of the Baltic Sea. However, there is room for improvement with regard to data coverage in certain areas, e.g. offshore in the northern and central parts of the Baltic Sea, along the west coast of Latvia and in some coastal regions of Finland and Sweden.

The most recent HELCOM assessment reaches similar conclusions, i.e. that 'the current contamination status is elevated in all parts of the Baltic Sea, mainly driven by polybrominated flame retardants and mercury' and, therefore, contaminants are still a cause for concern (HELCOM, 2018b, 2017). It should be noted that these similar conclusions are reached despite differences in the definition of assessment units (in order to make a pan-European assessment grid) and in the number of selected substances, e.g. inclusion of 'bio-effects' in the EEA assessment.

5.2 Black Sea

In the Black Sea, the analyses reveal that most parts assessed are classified as 'problem areas'. A total of 62 units have been assessed and 12 are classified as 'non-problem areas' (21 %). The majority of the classifications are based on the matrix 'water' (n = 56) as only 19 and 12 include assessments of 'sediments' and 'biota', respectively.

The Black Sea differs from the three other regions in that the group of contaminants with the highest contamination ratios is not metals, but other organohalogens (Table 5.1).

There seems to be a need to improve data availability from some countries and to improve the quality of the monitoring network, i.e. by increasing the focus on the monitoring of 'sediments' and 'biota'. Access to existing data from Russia would, beyond any doubt, improve not only the spatial coverage, but also the robustness of the assessment carried out.

5.3 Mediterranean Sea

Most of the coastal areas of the Mediterranean Sea assessed are classified as 'problem areas' (n = 330); only 24 out of 354 assessment units (6.8 %) are classified as 'non-problem areas'. The matrix 'water' has been assessed in 247 places, 'sediment' in 153 places and 'biota' in 161 places. 'Bio-effects' have not been addressed at all, as no data were available.

Metals drive the classification of 132 out of 330 'problem areas', equivalent to 40.0 % (Table 5.1). Excluding mercury from the calculations, 117 areas are triggered by metals other than mercury.

For the Mediterranean Sea, there is currently a bias towards coastal monitoring units, as only two offshore units have been assessed because of limited spatial coverage of the data set available for this study. Thus, there seems to be a need for improvements in monitoring activities, especially regarding offshore coverage.

5.4 North-East Atlantic Ocean

The matrices 'water', 'sediment', 'biota' and 'bio-effects' are assessed in 275, 511, 482 and 118 assessment units, respectively. Consequently, the North-East Atlantic Ocean is the most intensively monitored region in Europe with a total of 850 units having been assessed.

The spatial coverage in most sub-regions of the North-East Atlantic Ocean is adequate for assessment purposes, e.g. in the Greater North Sea, including the English Channel and the Kattegat, in the Celtic Seas and in the coastal waters of the Iberian Peninsula.

Of the 850 assessment units, only 182 were classified as 'non-problem areas' (21.4 %), while 668 were classified as 'problem areas'. For the matrices 'water' and 'biota', most of the classifications resulted in 'problem area' designations. Only 14 (5.1 %) and 37 (7.7 %) of the classifications, respectively, were 'non-problem areas'. For 'sediment', the picture was better. Here, 290 (56.8 %) of the classifications were 'non-problem areas' and for 'bio-effects' 74 out of 118 units, or 62.7 %, were classified as 'non-problem areas'. This divergence between 'sediment' and 'bio-effects' and the other matrices should be examined.

Table 5.1 Triggering substances in the regional seas

	Substance	Number of assessment units (+Hg)	Number of assessment units (-Hg)
Baltic Sea	Metals	98	71
	Other organohalogens	57	60
	Organobromines	43	45
	PAHs	23	23
	PCBs	12	12
	Imposex	12	13
	Organotins	10	10
	Organochlorines	2	2
Black Sea	Other organohalogens	26	27
	PCBs	13	13
	Metals	9	6
	PAHs	2	2
Mediterranean Sea	Metals	132	117
	Other organohalogens	85	93
	PAHs	49	52
	PCBs	40	42
	Organobromines	22	23
	Organochlorines	2	2
North-East Atlantic Ocean	Metals	294	230
	Organobromines	211	214
	PCBs	63	70
	Other organohalogens	60	76
	PAHs	20	24
	Imposex	14	15
	Organotins	5	6
	Organochlorines	1	2

Notes: +Hg, including mercury; -Hg, excluding mercury.

The groups of substances giving rise to most 'problem area' designations are metals (n = 294), as in the Mediterranean Sea and the Baltic Sea, and organobromines (n = 211; Table 5.1).

When excluding mercury from the analysis, 637 assessment units were classified as 'problem areas', meaning that only 31 were triggered by mercury. Although a direct comparison between the North-East Atlantic Ocean and the Baltic Sea is not possible because of different physical and chemical features in the two regions, it seems that mercury is not as big a problem in the North-East Atlantic Ocean as it is in the Baltic Sea.

OSPAR reached similar conclusions, while solid reductions are observed for many monitored substances, e.g. some of the most toxic contaminants, such as the PCB congener CB118, mercury and cadmium, are likely to continue to pose a risk for marine organisms in the near future (OSPAR, 2017).

In general, when looking at data and data coverage across the four regional seas, three key findings emerge as well as a key conclusion:

- Data coverage appears to be adequate for carrying out an assessment in many places, especially coastal areas, enabling a classification of contamination status in 1 541 assessment units.
- Data coverage and the substances monitored vary considerably between regional seas.
- Differences exist between the regional seas regarding which substances are of concern, i.e. which substances trigger the 'problem area' classification.

Overall, contamination of the marine environment continues to be a large-scale challenge across the regional seas, though progress is observed.

5.5 Some progress is observed, but contamination persists

Despite the fact that Europe's seas are still contaminated, it is also clear that for many individual substances progress is observed. It seems that the concentrations of known individual substances or groups of substances, including heavy metals, PAHs, organotins, PBDEs and radioactive materials, are declining in many areas (Figure 4.3; Figure 4.4; Figure 4.5). This may be a direct effect of the advanced and comprehensive policy and regulatory frameworks put in place to reduce contaminants in Europe's environment, as well as the subsequent preventive actions taken by Member States and industries. Similar findings are observed for European freshwater ecosystems. This indicates that some effective measures have been implemented (EEA, 2018b).

Such reductions can have a positive and visible impact on ecosystem features. This is aptly illustrated by one of the most sensitive indicators available from Europe's regional seas — the HELCOM indicator for productivity of the white-tailed eagle (Figure 5.1). As a top predator, it is highly vulnerable to substances accumulating in the food web, such as DDT or PCBs.

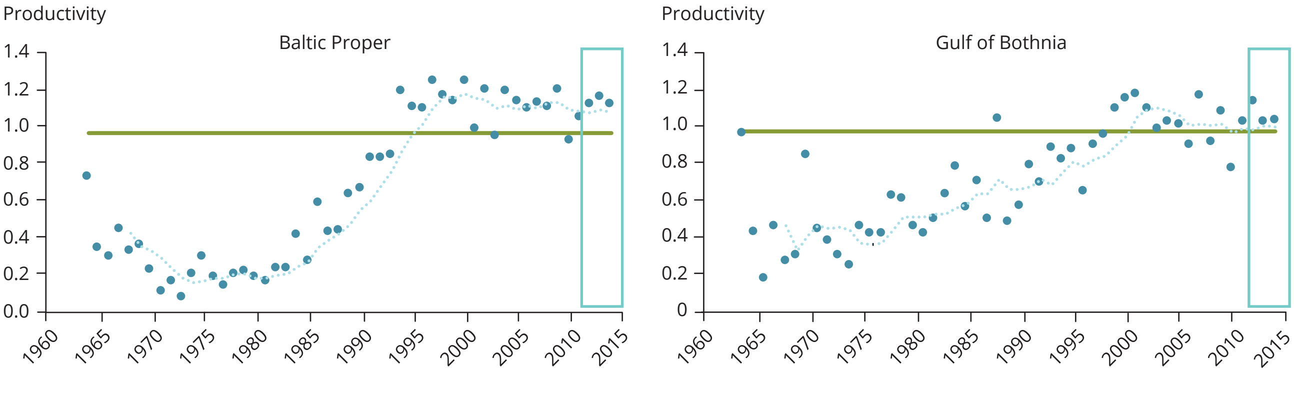
The recovery of the white-tailed eagle in the Baltic Sea is therefore a very positive sign of the recovery of some marine biodiversity features from the effects of particular persistent contaminants (HELCOM, 2018b). It indicates that bans of toxic, persistent substances indeed have a positive effect, albeit only after decades of enforcement of the bans.

Despite such inspirational results from the combined knowledge and actions generated by political visioning, scientific knowledge, industry actors and the expertise of environmental managers, it is also clear that most European marine areas (85 %) still have concentration levels above agreed thresholds for one or more substances (Figure 3.2; Map 3.5). Similarly, trends have not yet been broken, neither for all monitored substances (Figure 4.6) nor in all areas (Figure 3.2) (OSPAR, 2017; HELCOM, 2018b).

Getting back to background levels for naturally occurring substances will also be a significant challenge, despite the recent decrease in the concentrations of some metals. Looking over a historic period, there is evidence of a distinct increase in metals in specific localities related to intensified human influence (e.g. mining) during the Roman Era and the Industrial Revolution or abrupt climate change events. During these periods, lead and copper (and to a lesser degree mercury, zinc and arsenic) increased in marine sediments (Figure 5.2) (Mil-Homens et al., 2016).

Add to this legacy the discovery of new substances every day, a tripling of manufactured goods imported to Europe between 2000 and 2015 — including countries with less comprehensive regulative frameworks — and some 3.5 million contaminated sites in Europe (Milieu Ltd et al., 2017), and it appears likely that the challenge of contaminants will persist for the coming decades.

Figure 5.1 White-tailed eagle productivity in the Baltic Sea



Notes: Mean annual productivity of white-tailed eagle (*Haliaeetus albicilla*), estimated as the number of nestlings per occupied territory in coastal sub-populations of the Baltic Proper and Gulf of Bothnia (based on data from Sweden). The green line illustrates the threshold value of the core indicator. The blue box identifies the assessment period 2011-2015.

Source: HELCOM (2018b).

Consequently, and in conclusion, historic visionary political commitments (e.g. the Generation Target) and more recently agreed EU targets (e.g. the descriptor on contaminants that is part of the Marine Strategy Framework Directive's goal of achieving good environmental status in Europe's regional seas) remain unlikely to be met within the agreed timeframe when looking across Europe's seas (Table 1.1).

Similar observations made by OSPAR and HELCOM, as well as data and information made available from projects such as EMODNET Chemistry, the EMBLAS project and the study for a non-toxic environment, support this conclusion despite differences in data and assessment approaches.

5.6 Towards clean, non-toxic European seas?

This gives rise to the obvious question — what do we need to learn from past decades of successes and failures when trying to achieve policy visions concerning contaminants in the 2020s?

Firstly, we have to realise that these substances are and will be an integrated part of our life and well-being. Therefore, the pressures on the marine environment will most likely continue to increase, whether as a result of climate change, demographics or increased production and consumption, unless we actively maintain efforts to reduce point source pollution and increase efforts to reduce diffuse pollution. However, we should take heart in the fact that it is possible for society to reduce these pressures, as demonstrated by the white-tailed eagle and the positive trends observed for discharges and emissions of some substances.

Secondly, rather than being stuck in traditional behavioural patterns, now is the time to focus on cooperation, and the sharing and integration of information. This can be between scientists, industries and environmental managers seeking innovative solutions for describing or reducing the pressures. This assessment illustrates on a small scale how a scientific approach developed in one regional sea can be applied across Europe's seas in a transparent way if data are made available. Whether or not, one agrees with the application of a specific indicator, assessment approach, and individual thresholds is less important than enabling a fruitful and transparent dialogue. Cooperation must be at the forefront of the solutions needed to face the extensive challenge of achieving clean, non-toxic seas.

Specifically, for the marine environment, cooperation could further include joint, fully coordinated monitoring programmes, closing the gaps within and across regional seas while also monitoring a wider range of substances. It could also help deepen our knowledge of lesser-studied substances. A targeted approach could also help explore alternative monitoring and assessment approaches focusing on critical parameters, e.g. on the cocktail effects of exposure to multiple substances both in the environment and in seafood.

Thirdly, this assessment illustrates the extent of the challenges faced. Whether we look at it in a spatial context, via the diversity and persistence of substances or the complexity of interactions of substances within the environment, in a production/consumption context or even from a global systemic perspective, it is clear that future policy solutions need to be fully integrated to better support sustainability and environmental objectives.

The root of most problems suffered by European seas in regard to contaminants is the low rate and speed of policy implementation combined with the sheer volume of substances and the toxicity and persistence of some substances. Consequently, there may be less of a need to come up with new 'thematic' policies, or legislative initiatives, or to reiterate existing deadlines. Instead, our aim should focus on the implementation and integration of existing policies and therefore fulfil the intentions behind 'thematic' political visions.

When we first started to be aware of the effects of hazardous substances on the marine environment, marine biodiversity and our health, we developed a change in sentiment. This was translated into a sober and shared resolve to tackle this type of pollution, a resolve to protect our health, as well as the marine environment and its biodiversity, against indiscriminate discharges and contaminants, and the dumping of waste at sea, among other actions. This resolve was the key determining factor in the change in the way we cooperate on joint environmental challenges, such as hazardous substances across our regional seas, within Europe and beyond.

Given the sheer number of new substances, and growing production and consumption, we need, yet again, a profound change in the way in which we address contaminants in our seas. We cannot continue to keep extending agreed policy targets and commitments without jeopardising the seas and the natural capital upon which we depend. Consequently, this transition has to embrace not only how we address pollution in Europe's seas, but also how we produce and consume, including looking beyond the boundaries of Europe.

Box 5.1 Lessons learned

This report on contaminants in Europe's seas was planned in 2015, and preparatory work, including the testing of the CHASE+ tool, was carried out in 2016. During 2017 and 2018, work was focused on accessing quality assured data, analyses and writing.

In the initial phases (2015-2016), concerns were raised in relation to data access on a pan-European scale and whether or not it would be possible to attain adequate data coverage in the northern and southern regional seas, in particular in the North Atlantic, the Mediterranean Sea and the Black Sea.

Perhaps the most important discovery is that data sets for contaminants are available in all sub-regions and that the spatial coverage is better than anticipated. Having said that, there are two main lessons learned that should be highlighted:

- We are aware of the presence of additional data sets, but we have not been successful in getting permission to include these in the report for various legitimate reasons.

- Some of the data collections, which in principle should be easy to access and download, are unfortunately not yet operational from an end-user perspective.

From our understanding, there seems to be many more data available and there is clearly a potential for following up on the present study and attaining a higher spatial coverage.

Another key lesson learned is that using a multi-metric indicator-based assessment tool, such as CHASE+, has enabled the first ever comprehensive mapping of 'problem areas' and 'non-problem areas' in Europe's regional seas — and has also led to important conclusions regarding the effectiveness of measures that aim to reduce discharges, losses and emissions of contaminants to the marine environment.

For example, it has not previously been demonstrated on a pan-European scale that:

- Contaminants in marine, coastal and transitional waters in Europe pose a large-scale problem.

- Although improvements have been made and are documented for a broad range of substances, the overall target of a clean and non-toxic marine environment have only been attained in a few areas.

Therefore, it is the hope of the EEA that this report will be updated at regular intervals with more and new data, leading to a better understanding of how to achieve a non-toxic marine environment in Europe.

As a final reflection, we somehow need to rekindle that shared resolve if we truly want to achieve our policy visions of having clean, non-toxic European seas.

Abbreviations and acronyms

7th EAP	Seventh Environment Action Programme
AMAP	Arctic Monitoring and Assessment Programme
BAP	Benzo[*a*]pyrene
CHASE	Chemical Status Assessment Tool
Cd	Cadmium
CR	Contamination ratio
CS	Contamination score
Cu	Copper
DDT	Dichlordiphenyltrichlorethane
DOME	Data portal used by OSPAR, HELCOM, AMAP and expert groups in the management of chemical and biological data for regional marine assessments
EBM	Ecosystem-based management
EEA	European Environment Agency
ETC/ICM	European Topic Centre on Inland, Coastal and Marine Waters
EU	European Union
HCB	Hexachlorobenzene
HELCOM	Helsinki Commission (www.helcom.fi)
Hg	Mercury
ICES	International Council for the Exploration of the Sea
MSFD	Marine Strategy Framework Directive
OSPAR	OSPAR Commission (www.ospar.com)
NPA	Non-problem area
PA	Problem area
PAH	Polycyclic aromatic hydrocarbon

Pb	Lead
PCB	Polychlorinated biphenyl
PBDE	Polybrominated diphenyl ether
POP	Persistent organic pollutant
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RSC	Regional Sea Convention
SDG	Sustainable Development Goal
TBT	Tributyltin
UN	United Nations
US EPA	United States Environmental Protection Agency
UV	Ultraviolet
WFD	Water Framework Directive
WSSD	World Summit on Sustainable Development
Zn	Zinc

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Overview of online supplementary material

The following annexes are available as online supplementary material at https://water.europa.eu/marine/topics/pressures/contamination

Annex 1: Definition of assessment units

Annex 2: CHASE+ R script

Annex 3: Threshold values

Annex 4: Normalisation and aggregation methods

Annex 5: Detailed description of key data sources

Annex 6: Summary of CHASE+ classifications

Annex 7: Detailed maps per region

Annex 8: Additional CHASE+ classifications with different groups of substances excluded

Annex 9: Summary of 1 541 individual CHASE+ classifications

The following ETC/ICM technical background reports have been produced in preparation and support of this thematic report on contaminants in Europe's seas.

Andersen, J.H., et al., 2016, *Coding and initial testing of an indicator-based tool for integrated assessment of chemical status. Current status and next steps*, ETC/ICM task 1.6.1.g deliverable 1, 40 pp.

Green, N. and Murray, C., 2016, *Indicator-based tool for integrated assessment of chemical status: testing of CHASE. Norwegian contaminant data for biota*. ETC/ICM task 1.6.1.g deliverable 5, 47 pp.

Harvey, T, et al., 2016, *Steps toward indicator-based assessments of 'environmental status' in Europe's seas*, ETC/ICM task 1.6.1. g deliverable 4, 61 pp.

Korpinen, S., et al., 2015, *Review of thematic multi-metric indicator-based assessment tools*, EEA/NSV/13/002 – ETC/ICM, 51 pp.

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