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COVER NOTE

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To:	Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union
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Delegations will find attached document SWD(2020) 61 final - part 3/3.

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EUROPEAN
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SWD(2020) 61 final

PART 3/3

COMMISSION STAFF WORKING DOCUMENT

Review of the status of the marine environment in the European Union

Towards clean, healthy and productive oceans and seas

Accompanying the

Report from the Commission to the European Parliament and the Council

on the implementation of the Marine Strategy Framework Directive (Directive 2008/56/EC)

{COM(2020) 259 final} - {SWD(2020) 60 final} - {SWD(2020) 62 final}

Descriptor 5: Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters

1. MSFD FRAMEWORK

COM DEC 2017/848/EU		COM DEC 2010/477/EU
D5 Eutrophication		
D5C1 Nutrient concentrations in the water column	Nutrient concentrations are not at levels that indicate adverse eutrophication effects.	5.1 Nutrients level 5.1.1 Nutrient concentration
D5C2 Chlorophyll-a concentration	Chlorophyll a concentrations are not at levels that indicate adverse effects of nutrient enrichment.	5.2.1 Chlorophyll concentration
D5C3 Harmful algal blooms	The number, spatial extent and duration of harmful algal bloom events are not at levels that indicate adverse effects of nutrient enrichment.	5.2.4 Shift in floristic species composition
D5C4 Photic limit	The photic limit (transparency) of the water column is not reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment.	5.2.2 Water transparency
D5C5 Dissolved oxygen concentration in the bottom of the water column	The concentration of dissolved oxygen is not reduced, due to nutrient enrichment, to levels that indicate adverse effects on benthic habitats (including on associated biota and mobile species) or other eutrophication effects.	5.3.2 Dissolved oxygen
D5C6 Opportunistic macroalgae of benthic habitats	The abundance of opportunistic macroalgae is not at levels that indicate adverse effects of nutrient enrichment.	5.2.3 Abundance of opportunistic macroalgae
D5C7 Macrophyte communities of benthic habitats	The species composition and relative abundance or depth distribution of macrophyte communities achieve values that indicate there is no adverse effect due to nutrient enrichment including via a decrease in water transparency.	5.3.1 Abundance of seaweeds and seagrasses
D5C8 Macrofaunal communities of benthic habitats	The species composition and relative abundance of macrofaunal communities, achieve values that indicate that there is no adverse effect due to nutrient and organic enrichment.	
		5.1.2 Nutrient ratios 5.2 Direct effects 5.3 Indirect effects

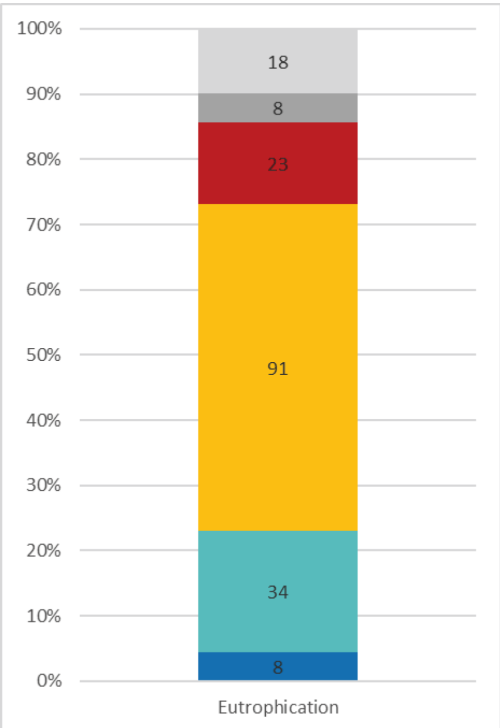
The criteria elements and threshold values of all D5 criteria shall be selected in accordance with the Water Framework Directive (WFD)[1] for coastal waters and consistent with those values for areas beyond coastal waters (if relevant).

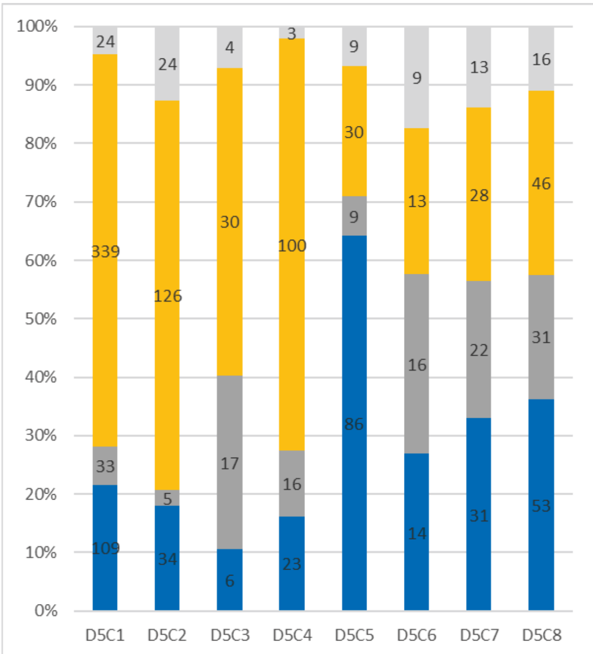
The adverse effects of nutrient inputs, especially nitrogen and phosphorus, and organic matter, has been a problem in Europe's marine waters for decades. EU water legislation addresses this problem, especially in relation to reductions of inputs and the desired quality of the aquatic environment. Important EU directives in the context of eutrophication include the Urban Waste Water Treatment Directive (Council Directive 91/271/EEC), the Nitrates Directives (Council Directive 91/676/EEC), WFD and MSFD.

Descriptor 5 focuses on minimising the adverse effects of human-induced eutrophication since it can lead to changes in the structure and functioning of marine ecosystems, which could adversely affect ecosystem health and services (Andersen et al., 2006). The MSFD addresses both pressures, which are indirectly measured by elevated concentrations of nutrients/organic matter caused by discharges, losses and deposition from human activities, and the direct and indirect effects of eutrophication. Direct effects relate to the accelerated growth of primary producers (e.g. decrease in water clarity, increased biomass of phytoplankton, harmful algal blooms and growth of opportunistic macroalgal species); whilst indirect effects relate to the consequences of such accelerated growth. These include reduced oxygen concentration in bottom waters with potential effects on benthic habitats, as well as changes in the structure (composition and relative abundance) of benthic communities (macrophytes and fauna).

2. EUTROPHICATION AND ITS CONSEQUENCES IN EU MARINE WATERS

2.1. Ongoing reporting under the MSFD





[1] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (OJ L 327, 22.12.2000, p. 1).

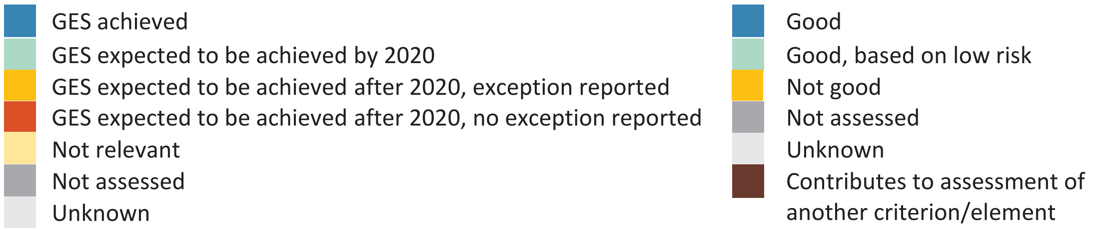


Figure 28: Latest MSFD status assessments of eutrophication (left) and associated criteria (right) under Descriptor 5. The information comes from 10 Member States' electronic reports.

For eutrophication, GES is achieved only in 8 assessments (less than 5%), while in 34 reports GES will be achieved by 2020. Around 50% of the assessments conclude that GES will be achieved only later than 2020, cases where Article 14 exceptions have been reported, but still around 10% of the cases where GES will be achieved later than 2020 have been reported with no related Article 14 exceptions.

All the criteria have been extensively used, especially the nutrient concentrations (D5C1), the chlorophyll a concentration (D5C2), the photic limit (D5C4), the dissolved oxygen concentration (D5C5) and the macrofaunal communities of benthic habitats (D5C8).

The criterion that has resulted in the highest proportion of assessments in 'good' status is the dissolved oxygen (more than 60%), followed by the benthic macrofauna (more than 30%), the macrophytes communities (D5C7) and the opportunistic macroalgae (D5C6). On the other hand, the criterion that has the smallest proportion of assessments in 'good' status (around 10%) is the harmful algal blooms (D5C3), followed by the photic limit, the chlorophyll a concentration, and the nutrient concentrations. The proportion of assessment in 'not good' status is significantly high in all the criteria.

2.2. Member States' assessments under the MSFD

A recent questionnaire run among the Member States' network of experts on Descriptor 5 allowed anticipating the content of the ongoing reporting under MSFD Art.17 for most Member States, thus enlarging the data availability and detail with respect to the previous section. The analysis of that questionnaire (Araújo et al., 2019) shows that most of the criteria are assessed by the majority of Member States, both for coastal waters and open sea. The exceptions are D5C3 (harmful algal blooms in the water column) that was assessed only by 50% of the Member States for open sea and less than 50% for coastal waters; and D5C6 and D5C7 (macroalgae from benthic habitats) that were mainly assessed in coastal waters because benthic macroalgae are not commonly found in open sea. Primary criteria (D5C1-nutrients in the water column, D5C2-Chlorophyl-a and D5C5-Dissolved oxygen) are assessed by most of the Member States (Figure 29).

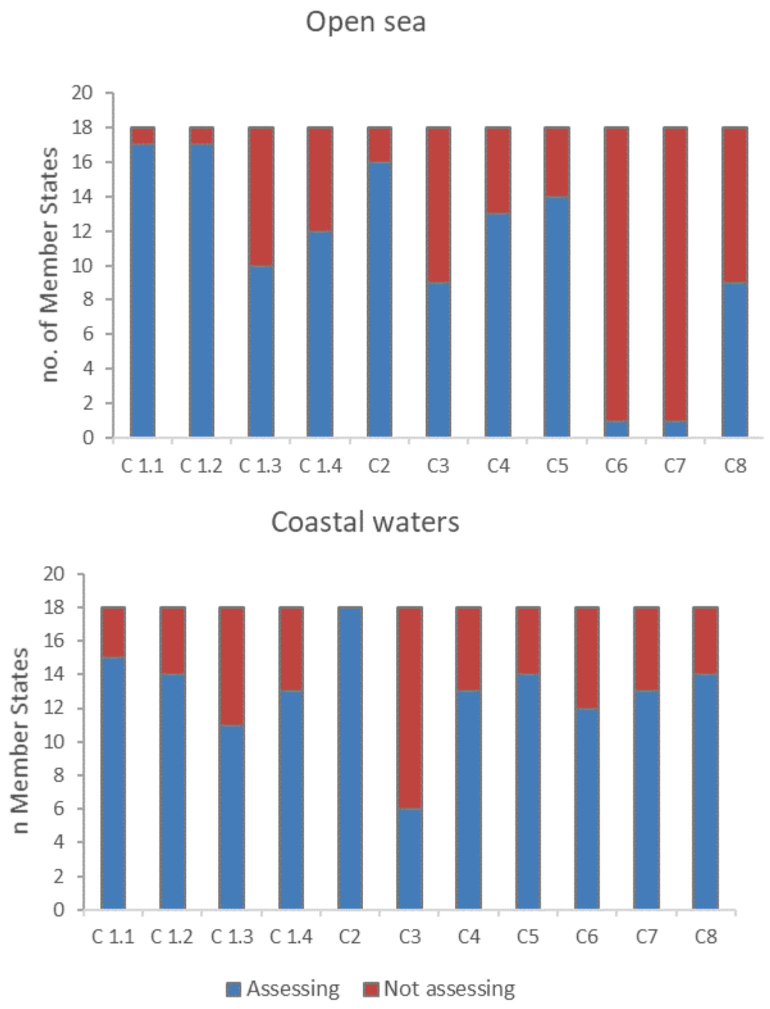
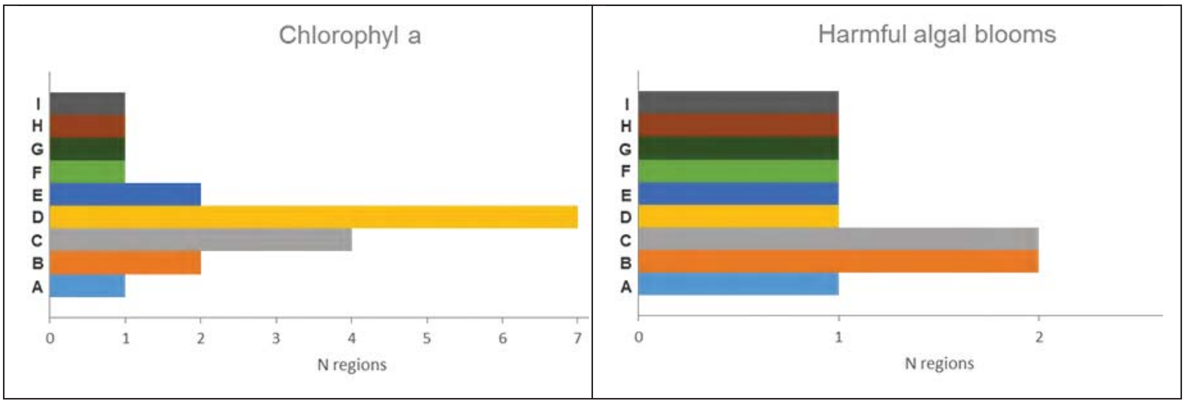


Figure 29: Criteria used at open sea and coastal waters by number of Member States.

Although Member States are assessing most of the eutrophication criteria, the degree of harmonization of methodological approaches is very low for some criteria such as Chlorophyl a, harmful algal blooms or dissolved oxygen (Figure 30 providing an example for open sea of the number of regions using different methods detailed per eutrophication criteria). The reasons for this heterogeneity and the implications for the quality of the assessment framework at the EU level need still to be explored.



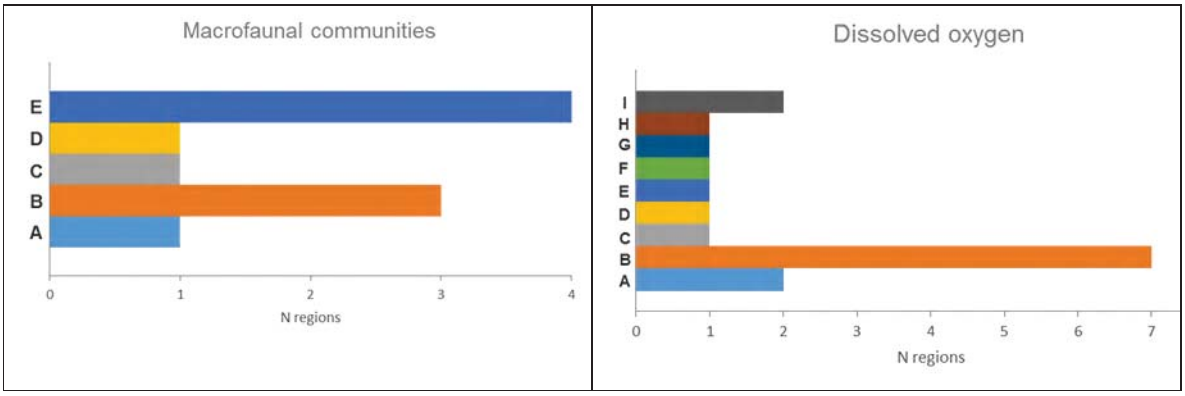


Figure 30: Illustration of the number of (sub)regions using different methods (labelled with letters) to assess eutrophication criteria in areas beyond coastal waters.

2.3. Assessment of coastal waters under the Water Framework Directive

The WFD River Basin Management Plans include an assessment of the status of surface waters, among which there are coastal waters[2]. Some biological quality elements (e.g. phyplankton) and chemical and physico-chemical ones (e.g. nutrients, oxygenation, transparency) reflect eutrophication.

Based on the analysis of the second River Basin Management Plans, phytoplankton assessment methods used by Member States include several parameters; where most Member States used phytoplankton biomass (total biomass and chlorophyll a), 10 Member States used abundance/frequency and intensity of algal blooms, and 4 Member States used the taxonomic composition of phytoplankton (Höglander et al., 2013). Threshold values, as needed to judge distance to good ecological status, were difficult to define especially in the areas with high variability of salinity (transitional waters as well in coastal waters under seasonal high influence of freshwater input).

According to WFD reporting, the proportion of coastal waters' area in less than good status in relation to phytoplankton conditions is 27%. The Black Sea is the marine region with the highest proportion of coastal waters in less than good status in relation to phytoplankton conditions (85%), followed by Baltic Sea (76%). The MSFD and all Regional Sea Conventions have considered phytoplankton (e.g. phytoplankton biomass, community composition, abundance, frequency and intensity of blooms) as a key element for integrated assessments. Still, Chlorophyll *a* remains the most widely used indicator mostly thanks to its time saving, cost-effective and reproducible analytical methods that provide easily comparable datasets (Varkitzi et al., 2018).

Nutrient conditions are also assessed under WFD. Almost half (46%) of coastal waters were not assessed for nutrients conditions. The proportion of coastal waters bodies (by area) in less than good status in relation to nutrient conditions is 20% (Figure 31). The Baltic Sea is the marine region with the highest proportion of CW in less than good status (58%), followed by Black Sea (29%).

[2] Coastal waters are defined in the WFD as surface waters up to one nautical mile on the seaward side from the territorial baseline (normally the low water mark).

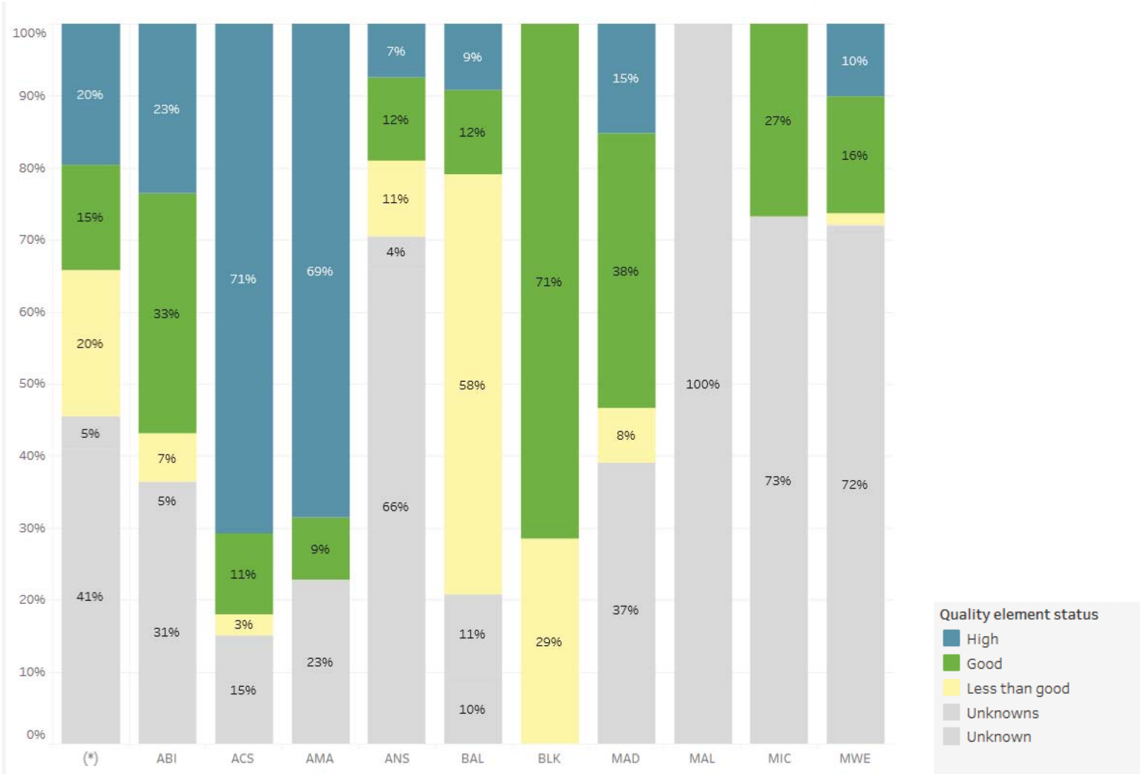


Figure 31: Nutrients (nitrogen and phosphorus) conditions in coastal water bodies by EU marine (sub)region (percentage of total area assessed as reported in the 2015 River Basin Management Plans). (*) refers to all water bodies in all marine (sub)regions. Marine sub-regions codes: ABI: The Bay of Biscay and the Iberian Coast; BLK: The Black Sea; ACS: The Celtic Seas; MAD: The Adriatic Sea; AMA: Macaronesia; MAL: The Aegean-Levantine Sea; ANS: The Greater North Sea, including the Kattegat and the English Channel; MIC: The Ionian Sea and the Central Mediterranean Sea; BAL: The Baltic Sea; MWE: The Western Mediterranean Sea. Source: WISE Water Framework Directive (data viewer).

There are more knowledge or reporting gaps on the WFD quality elements dealing with oxygenation (60% of unknown coastal area) and transparency conditions (70% of unknown coastal area).

2.4. Other assessments

The EEA (EEA, 2019e) just published an integrated pan-European eutrophication assessment based on existing monitoring data, agreed assessment criteria, and the application of HEAT+, which is a multi-metric indicator-based tool. The assessment outcomes are summarized below (Figure 32).

Of the 2949 assessment units (grid cells) across Europe's seas, 1749 (59 %) are classified as 'non-problem areas' and 1200 (41 %) as 'problem areas'. Overall, offshore 'problem areas' are only found in the Baltic Sea, in the south-eastern parts of the North Sea, and in some western parts of the Black Sea. In the Mediterranean Sea, problem areas are identified locally in coastal areas, mainly in the vicinity of riverine outflows.

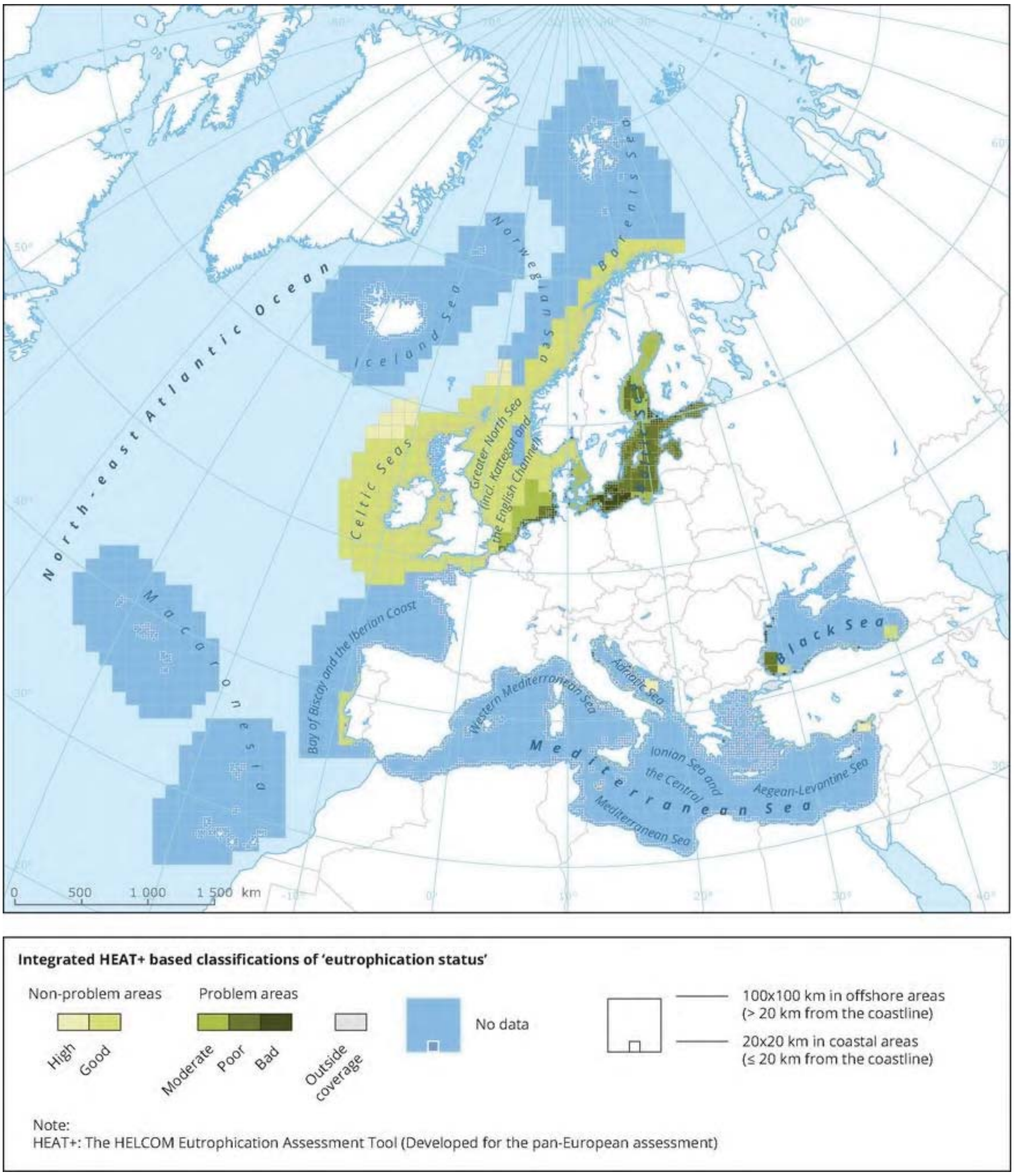


Figure 32: Interim map of eutrophication status of Europe' seas (EEA, 2019e). NPA = Non-Problem Area, PPA= Potential Problem Area, PA= Problem Area. No conclusions can be extracted for the southern European seas due to the lack of representative and robust datasets.

The major challenges for this kind of assessment is the availability of long time series and bring together local data at large scale. Based on the work underpinning this assessment, a single study looking at the past, present and future eutrophication status of the Baltic Sea based on modelled data has now been produced (see Murray et al., 2019). Baltic Sea recovery from eutrophication has already started but the ultimate effects in terms of achieving good status will only be seen many years from now (HELCOM, 2018b; Murray et al. 2019). The Mediterranean Sea and Black Sea lack good quality data, so the confidence of the assessment of eutrophication in those areas is low. There is also a need to increase the harmonization of approaches across regions.

3. OBSERVED TRENDS IN EUTROPHICATION

From the compilation of data to develop the assessment described above (EEA, 2019e), the following trends can be inferred:

- Over 1990 to 2017, no significant trends in nutrient concentrations were detected for most (74%) monitoring stations (with sufficient data) across EU marine regions; increasing trends were observed in 7% of monitoring stations and decreasing trends (i.e. an improvement in status) in 18% of monitoring stations.

- Over 2013-2017, no overall trend in oxygen concentrations was detected in the 88% of monitoring stations across EU marine regions (stable); increasing trends (i.e. an improvement in state) in only 1% of sites and decreasing trends in 10% of sites.

- The largest observed oxygen depletion occurs in the Baltic Sea followed by the Black Sea. Over 1990-2017, 11% of the monitoring stations in the Baltic Sea showed a decrease in oxygen concentrations in the water layer near the seafloor; where reduced oxygen concentrations were also observed at some monitoring stations in the coastal waters of the Black Sea.

4. TECHNICAL OBSERVATIONS

- Data/information issues include poor data availability for the Mediterranean and Black seas as well as lack of availability of long time series covering multiple decades across all EU marine regions.

- Multi-metric indicator-based eutrophication assessment tools are currently not used on a Europe-wide scale and regionally it is only used by HELCOM. Some Regional Sea Conventions lack harmonized frameworks to assess eutrophication.

- Climate change forecasts should be integrated in future updates of European nutrient management strategies. This is to account for seawater warming, which would make it more difficult to reduce eutrophication.

5. KEY MESSAGES

- Eutrophication occurs mainly in the Baltic Sea, the Black Sea, in the southern parts of the North Sea and along the North-western coast of France within the North-east Atlantic Ocean. Eutrophication is still present along coastal areas mainly in vicinity of riverine outflows within the Mediterranean Sea.

- Eutrophication remains an issue in the coastal waters all most EU marine regions. WFD ecological status assessments show that 46% of the coastal water area of Europe's seas are in less than good ecological status in terms of eutrophication. However, some countries have registered a decreasing trend on the extent of affected areas.

- The Baltic Sea is the marine region with the highest proportion of coastal waters in less than good nutrients conditions (58%), while the Black Sea is the region with the highest proportion of coastal waters in less than good phytoplankton conditions (85%).

- MSFD primary criteria (nutrients, chlorophyll a and dissolved oxygen) are assessed for the majority of Member States both for coastal and open sea waters. Methods for assessment are harmonized for most of the criteria (primary and secondary) except for Chlorophyll a and dissolved oxygen to which a high degree of variation occurs. An assessment of the need for EU level harmonization of monitoring methods for these criteria should be done in the future.

- Threshold setting methods are defined for most of the Member States and assessed criteria.

- High level of harmonization at national and regional level occurs for some regions (e.g. Baltic countries) but is less evident in some other regions.

- The results from measures to reduce nutrient inputs to transitional, coastal and marine waters and, thereby, lessen their adverse effects (i.e. eutrophication) are starting to be seen – even if there can be a time lag in terms of actual, or full, reductions of these effects. Nutrient inputs from point sources have significantly decreased; although inputs from diffuse sources, i.e. losses from agricultural activities, are still too high.

Descriptor 6: Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected

1. MSFD FRAMEWORK

COM DEC 2017/848/EU		COM DEC 2010/477/EU
D6 Sea-floor integrity / D1 Biodiversity - benthic habitats		
D6C1 Physical loss[3] of the seabed	Spatial extent and distribution of physical loss (permanent change) of the natural seabed.	6.1 Physical damage
D6C2 Physical disturbance[4] to the seabed	Spatial extent and distribution of physical disturbance pressures on the seabed.	6.1 Physical damage
D6C3 Adverse effects from physical disturbance	Spatial extent of each habitat type which is adversely affected, through change in its biotic and abiotic structure and its functions (e.g. through changes in species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), by physical disturbance.	6.1.2 Extent of seabed affected
D6C4 Benthic habitat extent	The extent of loss of the habitat type, resulting from anthropogenic pressures, does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.	1.5 Habitat extent 1.5.1 Habitat area 6.1.1 Biogenic substrata
D6C5 Benthic habitat condition	The extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions does not exceed a specified proportion of the natural extent of the habitat type in the assessment area.	1.6 Habitat condition 1.6.1 Condition typical species 1.6.2 Relative abundance 1.6.3 Habitat condition 6.2 Condition of benthic community 6.2.1 Presence of sensitive species 6.2.2 Benthic multi-metric indexes 6.2.3 Size of individuals 6.2.4 Size spectrum of benthic community
		1.4 Habitat distribution 1.4.1 Distributional range 1.4.2 Distributional pattern 1.5.2 Habitat volume

[3] Physical loss shall be understood as a permanent change to the seabed which has lasted or is expected to last for a period of two reporting cycles (12 years) or more.

[4] Physical disturbance shall be understood as a change to the seabed from which it can recover if the activity causing the disturbance pressure ceases.

2. Observed integrity of the sea-floor in EU marine waters

2.1. Ongoing reporting under the MSFD

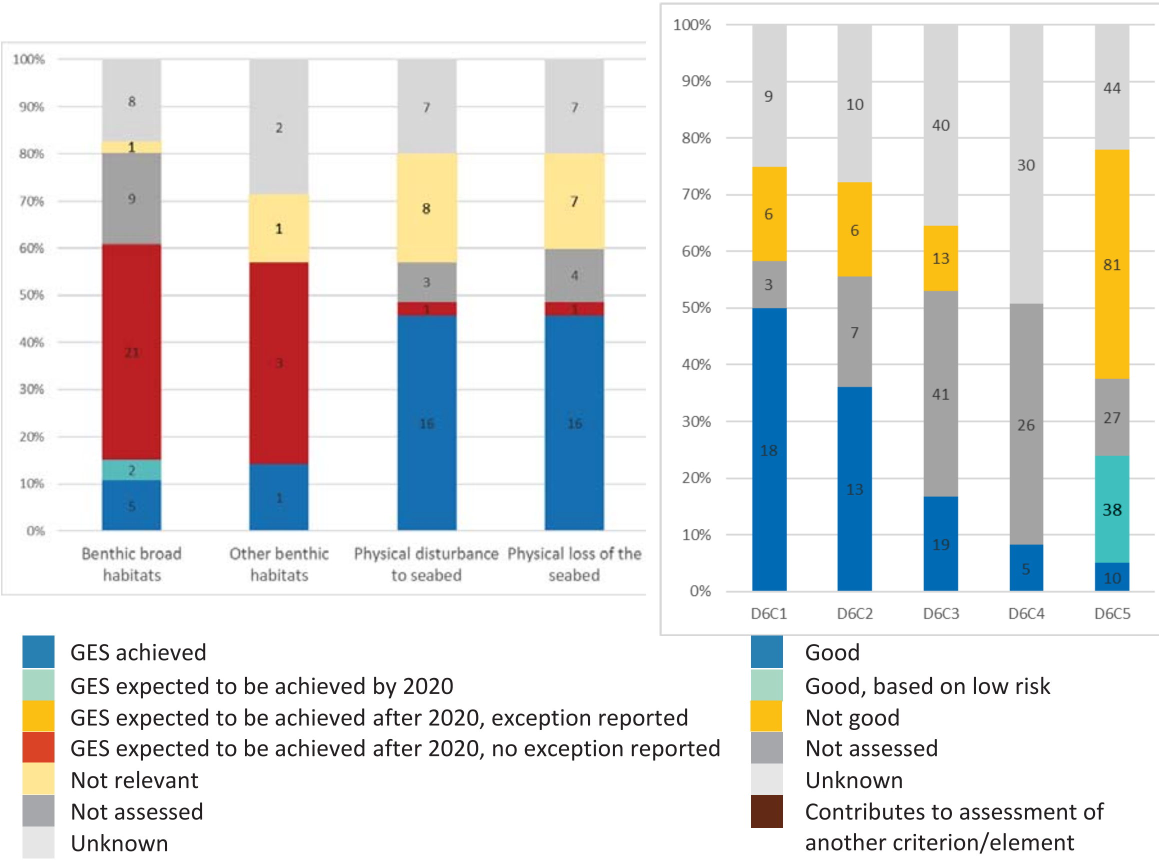


Figure 33: Latest MSFD assessments of good environmental status of benthic habitats (left) and associated criteria of sea-floor integrity (right) under Descriptor 6 (closely linked to Descriptor 1). The information comes from 10 Member States' electronic reports.

This section collects all the information related to the seabed, normally split between Descriptors 1 and 6.

GES is achieved in few cases for the status of benthic habitats (only 5 assessments on benthic broad habitats and 1 assessment on other benthic habitats), and is expected to be achieved by 2020 in very few cases as well. Most Member States have not reported exceptions under Article 14 when GES is expected to be achieved later than 2020. Regarding the overall status of seafloor integrity, both the reported assessments on physical disturbance to the seabed and on physical loss of the seabed conclude that GES is achieved in more than 45% of the cases, while only one assessment for both features has concluded that GES will only be achieved later than 2020 and where no Article 14 has been reported. In all these cases, a significant number of assessments (sometimes more than 50%) have been reported as 'not assessed', 'not relevant' or 'unknown'.

Even if the reported overall status of both the physical disturbance to the seabed and the physical loss is very similar in the overall assessments, the reports per criteria show a higher proportion of assessments in the physical loss (D6C1) being in 'good' status (around 50%), while for the physical disturbance (D6C2) there is a smaller proportion of assessments reported as 'good' (around 35%). The physical disturbance has more reports 'not assessed' or 'unknown' than the physical loss.

The most used criterion to report the status of benthic habitats is the habitat condition (D6C5), with only 10 assessments labelled as ‘good’, 38 as ‘good, based on low risk’ and 81 as ‘not good’. The adverse effects from physical disturbance (D6C3) and the habitat extent (D6C4) show 19 and 5 assessments respectively in ‘good’ status. Nevertheless, these two criteria have been reported as ‘not assessed’ or ‘unknown’ in the vast majority of the cases.

2.2. Previous MSFD reporting

In the initial assessment reported during the first cycle of MSFD implementation (in 2012), most Member States recognised the problem of **physical loss,** although the assessments were generally not performed consistently over the EU marine regions. 23% of EU waters were reported under low level of pressure from physical loss. The level of pressure and impact was not reported for 75% of EU waters and most EU waters were not assessed with relevant criteria (Figure 34). Data were particularly poor in the Mediterranean and Black Seas (ETC/ICM, 2015).

The main activities causing physical loss of seabed habitats at EU level were land claim and flood defence, port construction, solid waste disposal, renewable energy production and aquaculture. Features impacted by physical loss were mainly the predominant habitats, physical/chemical elements (transparency, current velocity, nutrient and oxygen levels) and fish. Both the total area per habitat type and the proportion of the habitat area impacted were mostly unknown (Figure 35) (ETC/ICM, 2015).

The reporting on **physical damage** was highly different between Member States. Also, the proportion of area where the pressures occur and causes impacts differed considerably between regions (Figure 34). The habitats mostly affected at EU level were the shallow sandy and muddy habitats, but this only reflects how often these habitats were reported. Again, both the total area per habitat type and the proportion of the habitat area impacted were mostly unknown (Figure 35) (ETC/ICM, 2015).

In all regions, fisheries was identified as the main human activity causing physical damage, except in the Black Sea where this was dredging (ETC/ICM, 2015).

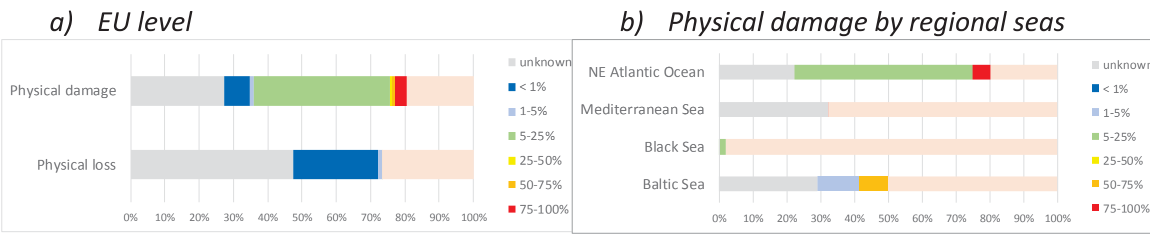
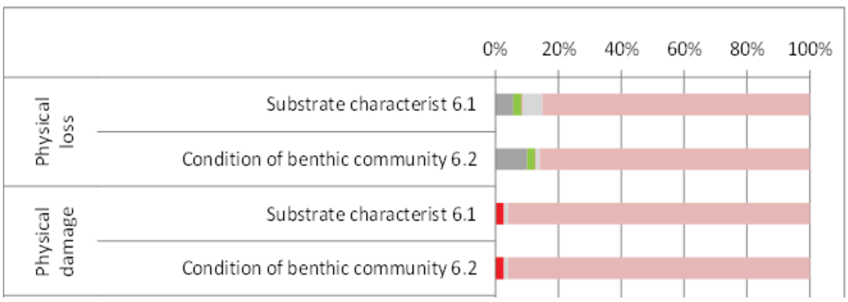


Figure 34: Percentage of area of the seabed exposed to different intensity of pressures reported during the initial assessment of the MSFD in 2012, at EU level and per marine region (ETC/ICM, 2015).



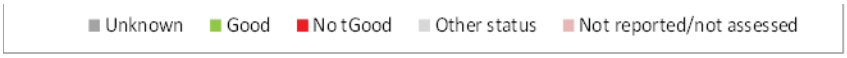


Figure 35: Percentage of area with different assessment status observed at EU level relevant to the size of the MSFD marine regions. This comes from the reported criteria of physical loss and physical damage to the seafloor reported during the initial assessment of the MSFD in 2012 (ETC/ICM, 2015).

2.3. Other assessments

2.3.1. Status of benthic habitats

The following table summarises the assessments of benthic habitats done by Regional Sea Conventions, the Habitats Directive and IUCN. It complements the biodiversity analysis under Descriptor 1 and contributes to the overall assessment of status of marine ecosystems.

Negative trends or low status	IUCN	European seabed habitats have undergone a red list assessment where 257 benthic marine habitat types (EUNIS 4) were included: 61 in the Baltic Sea, 86 in the North-east Atlantic Ocean, 47 in the Mediterranean Sea, and 63 in the Black Sea. About one fifth of the habitats were classified as threatened and an additional 11% were Near Threatened (Gubbay et al., 2016). More than half of the habitat types were data deficient, and no classification was possible to make. The highest proportion of threatened habitats was found in the Mediterranean Sea (32%), followed by the North-east Atlantic (23%), the Black Sea (13%) and then the Baltic Sea (8%). Majority of the assessed seagrass habitats, estuarine habitat types and infralittoral mussel beds were classified at least as Near Threatened but even Critically Endangered. Across all the threatened habitat types, the two main reasons for the status were either reduction in extent over 50 years or reduction in quality over the past 50 years (Gubbay et al., 2016).
Mixed or no clear trends	Habitats Directive	In the 2013 Article 17 Habitats Directive reporting, the overall summary of the 8 marine habitat types was that 66% of the habitats were assessed as being in Unfavourable Favourable Conservation Status. Most unfavourable-bad habitats were found in the marine Atlantic, Baltic and Mediterranean regions. Reported assessments for the Black Sea where mainly unfavourable-inadequate whereas in the Macaronesian region, the largest status class was unknown (EEA, 2013b)
	OSPAR	A first OSPAR assessment shows that 86% of the assessed areas in the Greater North Sea and the Celtic Seas are physically disturbed, of which 58% had higher disturbance. Consistently, fishing pressure occurs in 74% of all assessed areas (Figure 36), which is very likely to affect the ability of habitats to recover (OSPAR, 2017f).
	HELCOM	For benthic habitats in the Baltic Sea (Figure 37), there is indication of good status in 29% of the open sea areas assessed (restricted to soft bottom habitats). Coastal areas show good status in 44% of the assessed Baltic Sea region (HELCOM, 2018a).
Insufficient data	UNEP-MAP	Assessment of Mediterranean seabed habitats is mainly qualitative due to the lack of ground-truth data and standardized monitoring for most of offshore habitats. This includes the lack of baseline data at the regional scale for many habitats exposed to abrasion by bottom-trawling fisheries. This has so far restricted the ability to identify a sustainable condition for habitats under continuously high-pressure levels. However, the extent of special habitats are under threat and in decline.

	Bucharest Convention	In the Black Sea the demersal fishery takes place in the coastal areas above the halocline, but data to assess extent of physical damage to predominant and special habitats was not available in time to be included in this report.

Table 13: Conclusions from different assessments about the status of benthic habitats in the European seas.

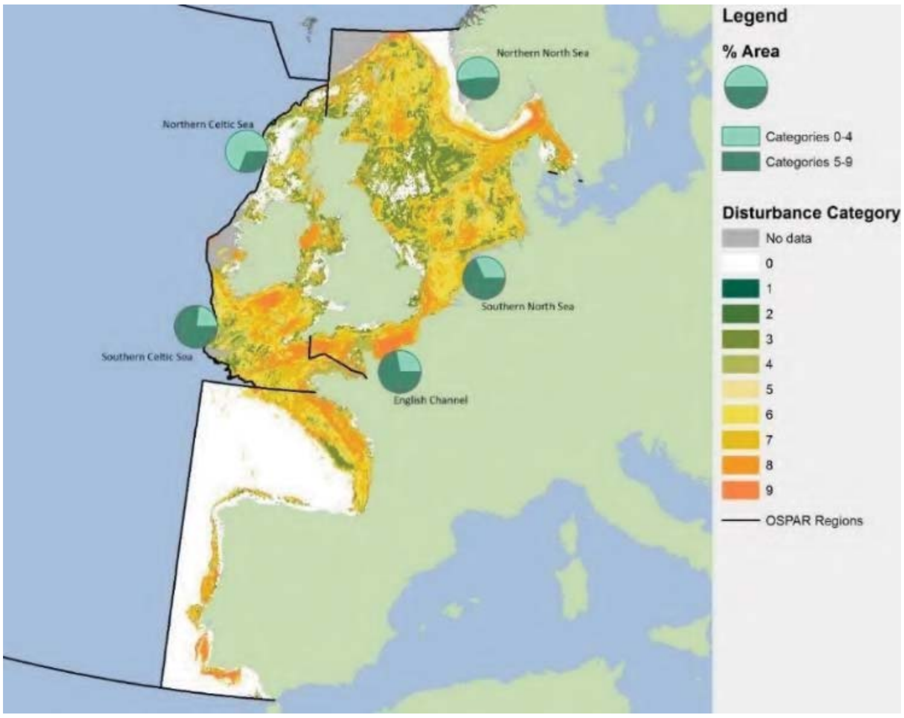


Figure 36: OSPAR assessment of the Extent of Physical Damage to Predominant and Special Habitats. Spatial distribution of aggregated disturbance using the 2010–2015 data series across OSPAR sub-regions. Disturbance categories 0–9, with 0= no disturbance and 9= highest disturbance. Pies show percentage area of OSPAR sub-regions in disturbance categories 0–4 (none or low disturbance) and 5–9 (high disturbance) across reporting cycle (2010–2015). The percentage was not included for the Bay of Biscay and Iberian Coast due to the lack of complete data. Source: OSPAR (2017f).

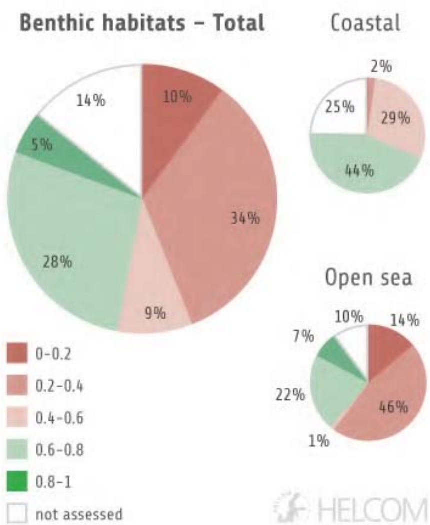


Figure 37: Integrated assessment of benthic habitats in the Baltic Sea. Status is shown in five categories based on integrated biological quality ratios (BQR). Values of at least 0.6 correspond to good status. The assessment is based on the core indicators 'State of the soft-bottom macrofauna community' and 'Oxygen debt' in open sea areas, with some variability among sub-basins. Coastal areas were assessed by national indicators. White sectors represent unassessed areas (including areas not assessed due to the lack of indicators or data and all Danish coastal areas). Source: HELCOM (2018a).

2.3.2. Pressures on benthic habitats

Human activities causing local physical loss or disturbance of seabed habitats and their biota are: exploitation (e.g. fishing for demersal species, extraction of mineral resources and harvesting of seaweed); construction (e.g. wind farms, oil platforms, pipelines, coastal structures); maritime traffic (e.g. dredging of shipping and boating lanes, harbours, anchoring sites); and dumping (of e.g. dredged spoils and other waste). Currently data are only available for the analysis of the pressure perspective (i.e. physical loss and physical disturbance) and its link to human activities.

Offshore renewable energy installations may have multiple effects on marine ecosystems and biodiversity, like obstruction of sea migration routes and seabird fishing, disturbance and loss of seafloor communities, noise pollution or electromagnetic fields, but also cause potential restrictions on fisheries and new structures that may result in de facto refugees (Boero et al. 2017). The disturbance and loss of the seabed occurs mainly during the construction and decommission phases.

A recent analysis (ETC/ICM, 2019b) mapped all human activities in the European seas and showed the probability of those activities to cause physical loss or physical damage to the seafloor, using pressure and sensitivity analyses. Results are calculated for three zones: the so-called coastal strip (from the coastline to 10 km offshore), continental shelf/slope (as far as 1000 m depth) and offshore (beyond 1000 m depth). As the assessment units are 10×10 km, the area affected cannot be assessed accurately and is likely to be overestimated. The use of those grid cells has the aim of combined effect assessments of multiple pressures.

Physical loss of the seabed

Around 23 % of the coastal strip in Europe's marine regions was assessed to be affected by physical alterations consistent with 'physical loss' of the seabed, riparian zone or shore. Alterations were caused, for instance, by port facilities, wind farms, oil and gas installations, urbanisation, flood protection, land claim and land drainage, as well by exploitation of fish, shellfish and minerals. According to the Member States reporting on coastal water hydro-morphological status under the WFD, similar human activities caused pressure in 9 % of the coastal waters as defined in WFD (WISE WFD data viewer).

According to ETC/ICM (2019b), habitat loss took place in 16 % of the assessed grid cells in the Baltic Sea, 2 % in the North-east Atlantic Ocean, 4 % of the Mediterranean Sea, and 4 % in the Black Sea area (Figure 38), in all cases highly concentrated in the coastal zone.

An alternative estimate points that about 1500 km^2 of benthic habitats have been lost in the Baltic Sea, which is less than 1 % of the actual sea area (HELCOM, 2018a).

Human activities causing habitat loss were sand and gravel extraction; removal of hard substrate or biogenic reefs; dredging of the seabed; continued, long-term disposal of waste material and dredged matter and construction (e.g. wind farms, coastal structures). Habitat loss typically occurs near cities and at ports, as well as at dredged deposit and aggregate extraction sites. In coastal waters, infrastructure development, coastal defences, dredging of navigation routes, and land claim are the main activities causing habitat loss but the estimate of their spatial extent is not accurate due to lack of data. Offshore, the construction of oil and gas installations and of windfarms (mainly in the North Sea) are other activities causing habitat loss (ETC/ICM, 2019b).

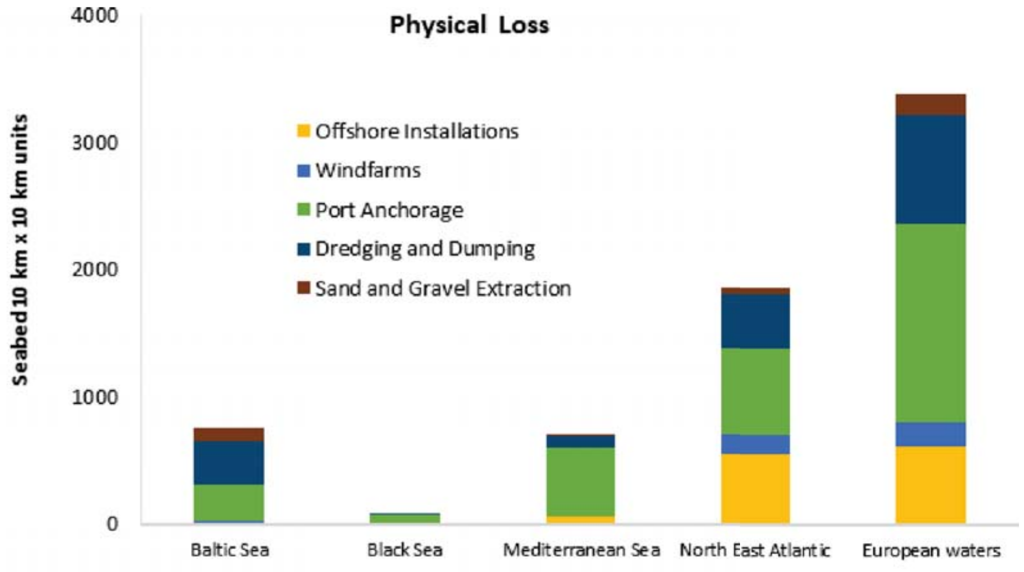


Figure 38: Extent of seabed at all depths (10x10 km units) estimated to have some physical loss per regional sea and for all Europe's seas together. The area is split between different human activities causing physical loss. As the assessment units are 10×10 km, the area is likely overestimated, given that habitat loss only occurs in the actual locations at which the related human activity takes place. Source EEA (2019b).

Physical disturbance to the seabed

The physical disturbance to the seabed is caused by nine human activities that often overlap and damage the sea bottom by abrasion or siltation. About 23 % of entire Europe's seabed is under 'physical disturbance' pressure (Figure 39 and Figure 40), markedly concentrated in the coastal strip (79 %) and the shelf/slope area (43 %).

Per marine region, the highest percentage of Europe's seabed under physical disturbance is estimated in the Baltic Sea (79 %) followed by the Mediterranean and Black seas, and the North-east Atlantic (see Table 14).

	Coastal strip (10 km from the coastline)	Continental shelf/slope (to 1 000 m depth)	Beyond 1 000 m depth	Total
Baltic Sea	*93 %*	*71 %*	*N.A.*	*79 %*
North-east Atlantic	*75 %*	*37 %*	*1 %*	*18%*
Mediterranean Sea	*81 %*	*62 %*	*9 %*	*36 %*
Black Sea	*74 %*	*41 %*	*0 %*	*26 %*

Table 14: Estimates of combined physical disturbance to the seabed of Europe's seas. The pressure is calculated for 10 km × 10 km assessment units and, thus, can be overestimated.

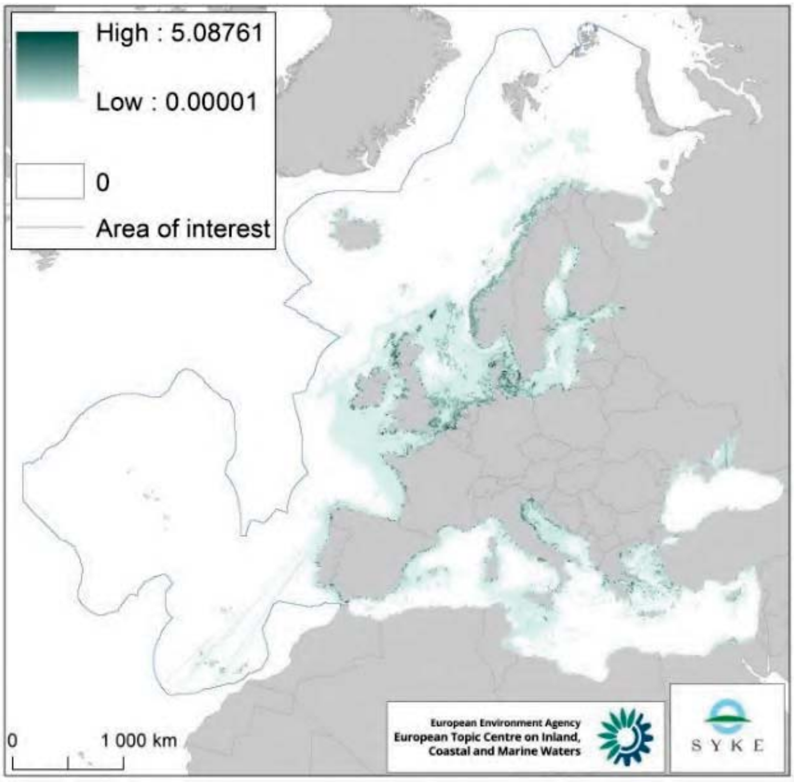


Figure 39: Spatial distribution of the physical disturbance to Europe's seabed. Source: EEA (2019b).

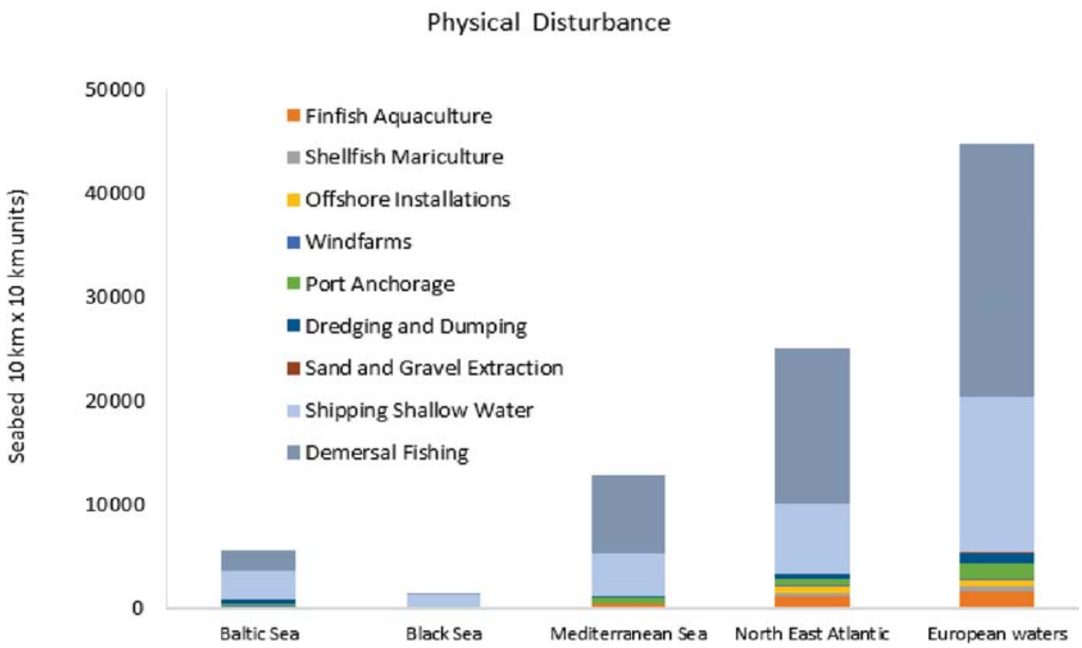


Figure 40: Seabed area (number of 10 km x 10 km units) estimated as physically disturbed across all Europe's seas together. The area is split between different human activities causing physical disturbance. Demersal trawling is likely to be underestimated due to data gaps. Source: EEA (2019b).

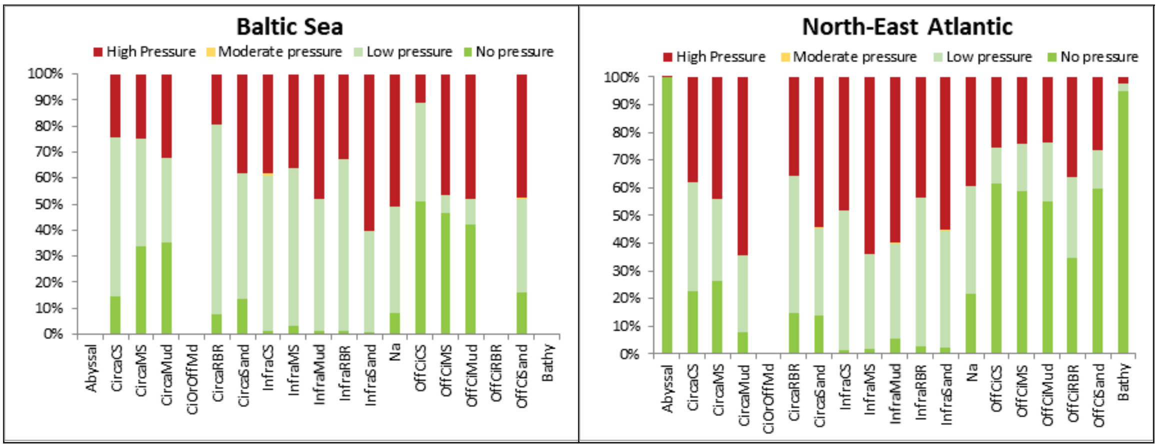
A specific analysis evaluated the extent of bottom trawling (the main pressure on the seabed according to ETC/ICM, 2015), derived from the spatial distribution of demersal fishing activities, and provides an indication of the spatial extent of potential physical disturbance and of its potential adverse effects. According to ETC/ICM (2019b), 15 % of the assessment units were trawled at least once across Europe's seabed over the period 2011-2016, although this figure increased to 35 % when focusing on the shelf/slope area only. Another pressure, shipping in shallow waters (down to 50 m depth), potentially causes physical disturbance in 75% of the Baltic Sea, 26 % of Black Sea, 17% of Mediterranean Sea and 9 % of the North-east Atlantic Ocean.

A more detailed analysis shows that the Baltic Sea has a high proportion of physically disturbed seabed habitats (40 %), and this is much higher in the sub-basins where bottom-trawling is practiced and sand and gravel extraction are more intensive (HELCOM, 2018a).

No OSPAR assessment is available for the southern parts of the North-east Atlantic Ocean as data was not available from the Spanish fleet, but ETC/ICM (2019b) shows that the Iberian Atlantic coastal areas are also under physical disturbance from other human activities such as shipping in shallow waters and sand and gravel extraction. In the Mediterranean Sea, ETC/ICM (2019b) shows that physical disturbance pressure from all relevant human activities was high in all the coastal and shelf/slope areas, with areas of high pressure around Spain and the Adriatic and Aegean seas as well as the sea around Balearic Islands, Malta and Sicily. In the Black Sea, physical disturbance was most extensive in the Sea of Azov and in its Northwest parts (Figure 39 and Figure 40).

There are currently no EU-level threshold values that would allow an assessment of the impacts from physical disturbance against good environmental status for Descriptor 6. An EU-level Technical Group on Seabed has been recently set up under the MSFD Common Implementation Strategy to hold relevant discussions, compile scientific advice and get agreements about methodologies and threshold values.

ETC/ICM (2019b) also made a first attempt to estimate the combined effects from multiple pressures on benthic broad habitats in the 10 km x 10 km marine grid units. Figure 41 shows the proportion of broad benthic habitats under combined 'high', 'moderate', 'low' or 'no pressure'. The largest area of seabed habitats under combined 'high pressure' is found in the Baltic Sea (37%), followed by the North-east Atlantic Ocean (7 %), Black Sea (6 %) and Mediterranean Sea (4 %) (note that waters from non-EU countries are included in all the four regions). The habitats under highest pressure are all infralittoral and circalittoral habitat types, where physical disturbance, sediment contamination and impacts from non-indigenous species are highest. Eutrophication and physical loss affect a smaller area, although there are also large data gaps in the analysis of eutrophication.



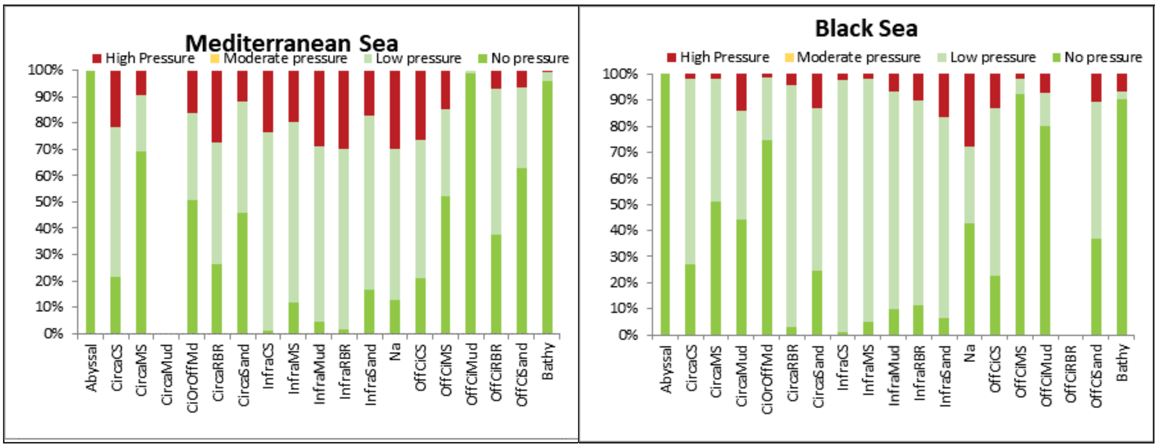


Figure 41: Combined effects of multiple pressures on benthic (broad) habitats[5] across Europe's seas including (i) the indirect effects of nutrient enrichment (eutrophication), (ii) sediment contamination, (iii) non-indigenous species impacts, (iv) hydro-morphological alterations, (v) physical disturbance, and (v) physical loss. 'High pressure' relates to status thresholds and indicates a disturbed state exceeding such thresholds. Source: ETC/ICM (2019b).

3. TEMPORAL TRENDS

There are no data to estimate temporal changes in physical disturbance or physical loss of Europe's seabed. However, trends in the associated human activities indicate that intensity of dredging and sand and gravel extraction has been variable during the last two or three decades, although slowly increasing in the northern marine regions (ETC/ICM, 2019b). No trends are available for the southern marine regions. Demersal trawling activities are, however, in decline in the Mid-Atlantic Ridge, oceanic seamounts, and the Azores archipelago, where demersal fisheries peaked in 1980-90s but have significantly declined after 2010 (ICES, 2018c). In the Greater North Sea, the surface abrasion by bottom trawling was relatively stable during 2009-2015 (ICES, 2017).

4. MAIN IMPACTS

Benthic biota, both plants/algae and invertebrate fauna, are a source of food and other nutritional outputs for people. They are also sources of raw, including genetic, materials used directly by people, e.g. seagrass pellets used as housing insulation material, or in the manufacture of goods, e.g. medicines. In addition, these biota are involved in the regulation and maintenance of marine ecosystems through bioturbation, nutrient cycling, reproductive output, primary and secondary production, etc. These roles played by benthic biota serve to control or modify the biotic and abiotic parameters defining people's ambient environment by, for example, cleaning seawater from anthropogenic waste and toxicants, sequestering atmospheric carbon, protecting people and their goods

[5] Habitats and the abbreviations used in the graphs: Abyssal = Abyssal seabed; Bathy = Bathyal seabed; OffCiCS = Offshore Circalittoral Coarse Sediment; OffCiMS = Offshore circalittoral Mixed Sediment; OffCiMud = Offshore circalittoral Mud; OffCiRBR = Offshore circalittoral Rock and Biogenic Reef; OffCiSand = Offshore circalittoral Sand; CircaCS Circalittoral Coarse Sediment; CircaMS = Circalittoral Mixed Sediment; CircaMud = CircalittoralMud; CiOrOffMd = Circalittoral or Offshore Circalitoral Mud ; CircaRBR = Circalittoral Rock and Biogenic Reef; CircaSand = Circalittoral Sand; InfraCS = Infralittoral Coarse Sediment; InfraMS = Infralittoral Mixed Sediment; InfraMud = Infralittoral Mud; InfraRBR = Infralittoral Rock and Biogenic Reef; InfraSand = Infralittoral Sand; Na = Not Available.

from flooding. Finally, benthic biota have physical, experiential, intellectual, representational, spiritual, emblematic, or other cultural significance, for example, they can underpin or enhance people's recreation and leisure activities (Haines-Young and Potschin, 2013; Culhane et al, 2019). All these human, active or passive, uses of marine ecosystems are at risk from the impacts of physical loss and physical disturbance pressure on seabed habitats and their biota. This is in addition to marine food web impacts and possible associated reductions in marine ecosystem resilience.

Human activities causing the loss of a specific seabed habitat have different impacts on the biota living in it, depending on the habitat type and the in situ physical conditions. For example, building a wind mill over a soft or sandy substrate will replace the habitat and its biota with an artificial hard substrate and its associated (and possibly different) biota; whereas building over a rocky substrate will not completely change the original biota. Artificial structures, such as seawalls and piles, host high animal diversity, but that is still lower than found naturally on rocky reefs and is not representative of the natural biological community either; in addition artificial structures show a higher diversity of non-indigenous species (Bulleri and Chapman, 2010; Mayer-Pinto, 2017).

Human activities causing physical disturbance of seabed habitats through changes to sedimentation and turbidity have high impacts on any vegetated (mainly infralittoral) habitat. For example, coastal structures have been shown to increase rates of sedimentation in the surrounding area (Bertasi et al., 2007). Hard substrate seabed habitats are particularly vulnerable to sedimentation as they are characterised by sessile organisms, which would get smothered. The amount of damage depends on water currents, which may clean the habitat surface if the sediment load is not too high. Shallow hard substrates are also inhabited by macroalgae, which require specific light conditions and are affected by turbidity. Deep muddy habitats are likely the least affected by any extra sedimentation as they are mainly characterized by burrowing organisms. However, demersal trawls leave deep tracks, causing abrasion, which take long to recover. Shallow soft substrate seabed habitats typically host dense meadows of seagrasses, which are very sensitive to any disturbance in water quality, over-sedimentation or fragmentation (Orth et al., 2006).

5. TECHNICAL OBSERVATIONS

- Operational definitions of 'physical disturbance' and 'physical loss' were made available by ICES (via workshop, ICES, 2018b), but have not yet been adopted at the EU level.

- An EU-level Technical Group on Seabed has been recently set up under the MSFD Common Implementation Strategy to hold relevant discussions, compile scientific advice and get agreements about methodologies and threshold values. Those threshold values will allow an assessment of the impacts from physical disturbance against good environmental status for Descriptor 6.

- There is limited availability of activity and pressure data. This is, in particular, in relation to fishing, where the métier data was not detailed enough to allow adequate assessment of the Mediterranean and the Black Seas; and the OSPAR assessment lacked data on the Spanish fleet.

- Periodical or permanent oxygen depletion (usually fostered by eutrophication) cause damage of benthic habitats. The number and coverage of hypoxic areas is not improving despite implementation of nutrient reduction measures. Widespread oxygen depleted areas are observed in Baltic Sea and Black Sea, aggravated due to natural conditions and climate change. These aspects were not considered in the current study of seafloor damage.

6. Key messages

- Seabed habitats are under significant pressure across European seas from the combined effects of demersal fishing, coastal developments and other activities. About one fifth of the European seabed habitats are classified as threatened, although more than half of the habitat types are data deficient. Physically disturbance may affect 86% of the Greater North Sea and the Celtic Seas. There are large knowledge gaps in the Mediterranean and Black Seas. It is likely that the impaired status of benthic habitats will influence marine biodiversity due to the amount of species depending directly or indirectly on these habitats.

- During the first MSFD implementation cycle, fisheries was identified as the main human activity causing physical damage on the seafloor (except in the Black Sea where this was dredging), while physical loss of seabed habitats was mainly caused by land claim and flood defence, port construction, solid waste disposal, renewable energy production and aquaculture.

- Current level of knowledge and data availability are insufficient to allow a common understanding and assessment at the EU level of all aspects of this descriptor. One independent assessment presented in this section (ETC/ICM, 2019b) illustrate the probable extent of physical loss and physical disturbance based on the extent of the human activities causing them. This analysis is done at EU scale with relatively low resolution (i.e. 10x10km grid cells):

  - Overall, 23 % of the EU's coastal strip can be affected by physical loss of seabed habitats. This percentage drop to 2% in continental shelf/slope areas and less than 1% beyond that.

  - The extent of seabed habitat loss is region-specific and estimated as highest in the relatively shallow Baltic Sea.

  - Overall, about 43 % of Europe's shelf/slope seabed (down to 1000 m depth) can be under physical disturbance, which is mainly caused by bottom trawling (35 %). The percentage of physical disturbance increases to 79 % when focusing in the coastal strip.

  - Per marine region, the highest percentages of Europe's seabed under physical disturbance are found in the Baltic Sea where 79 % of the region is potentially disturbed, 36 % in Mediterranean Sea, 26 % in the Black Sea and 18 % in the North-east Atlantic Ocean. The physical disturbance in the coastal zone of any of the four regions is over 74 %.

  - When considering and ranking the combined effects of multiple pressures on Europe's seabed, the largest area under combined 'high pressure' is found in the Baltic Sea (37%), followed by the North-east Atlantic Ocean (7 %), Black Sea (6 %) and Mediterranean Sea (4 %).

Descriptor 7: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems

1. MSFD FRAMEWORK

COM DEC 2017/848/EU[6]		COM DEC 2010/477/EU
D7 Hydrographical change		
D7C1 Alteration of hydrographical condition	Spatial extent and distribution of permanent alteration of hydrographical conditions (e.g. changes in wave action, currents, salinity, temperature) to the seabed and water column, associated in particular with physical loss of the natural seabed.	7.1 Spatial characterisation of alterations 7.1.1 Extent of area affected
D7C2 Adverse effects of alteration of hydrographical conditions	Spatial extent of each benthic habitat type adversely affected (physical and hydrographical characteristics and associated biological communities) due to permanent alteration of hydrographical conditions.	7.2 Impact of hydrographical changes 7.2.1 Extent of habitats affected 7.2.2 Change in habitats

Regarding methods for monitoring and assessment:

(a) Monitoring shall focus on changes associated with infrastructure developments, either on the coast or offshore.

(b) Environmental impact assessment hydrodynamic models, where required, which are validated with ground-truth measurements, or other suitable sources of information, shall be used to assess the extent of effects from each infrastructure development.

(c) For coastal waters, the hydromorphology data and relevant assessments under the WFD shall be used.

Descriptor 7 overlaps with parts of the WFD for coastal waters and in respect to the hydromorphological objectives in the context of river basin management plans. Other frameworks that may contribute to the assessment of this Descriptor are the Environmental Impact Assessment Directive 2011/92/EU, on the assessment of the effects of certain public and private projects on the environment, and the Strategic Environmental assessment Directive 2001/42/EC, on the assessment of the effect of certain plans and programmes on the environment (González et al., 2015).

Anthropogenic alterations of the natural hydrography of coastal waters are included in assessments under the WFD, but hydromorphology is a supporting element only addressed for areas in 'high' biological and physico-chemical status (i.e. in water bodies where the status is less than good, hydromorphological state is not taken into account as a component of the ecological status assessment). A technical review of biological quality assessment methods used across the EU found that there are few methods that are

[6] Descriptor 7 had no specific Task Group report for the update of the GES decision, which probably hampered its development and a common understanding on how to assess, monitor and report permanent alterations of hydrological conditions in marine areas.

sensitive to hydromorphological pressures (van de Bund and Poikane, 2015). Therefore, hydromorphological pressures and their effects can remain undetected in the WFD assessment process.

2. CHANGES IN HYDROGRAPHICAL CONDITIONS IN EU MARINE WATERS

2.1. Ongoing reporting under the MSFD

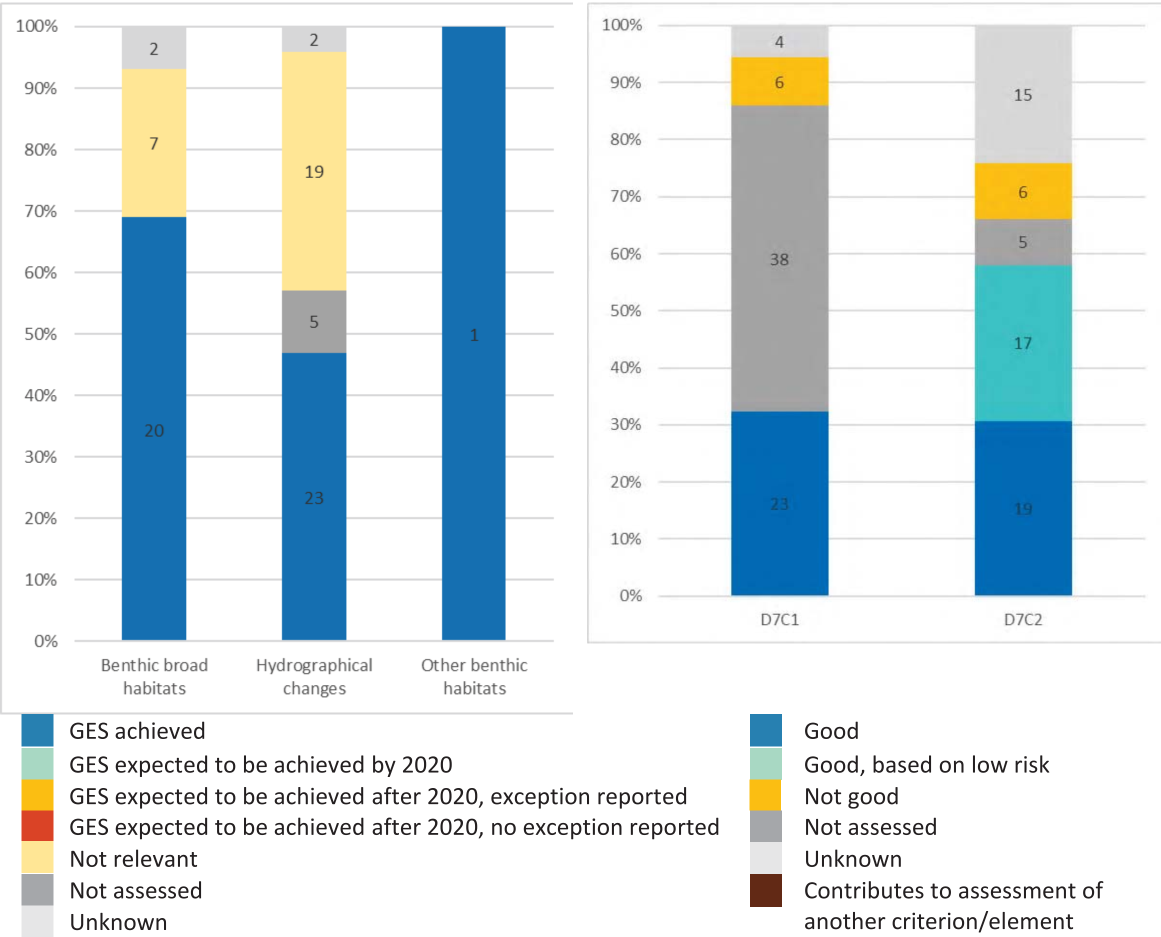


Figure 42: Latest MSFD assessments of good environmental status of the hydrographical conditions per feature (left) and per criteria (right) under Descriptor 7. The information comes from 10 Member States' electronic reports.

For hydrographical changes, the reporting information shows that GES is achieved in more than 45% of the assessments, while in more than 30% of the assessments it has been reported as 'not relevant'. In regards to the adverse effects on benthic habitats, most of the assessments reported the GES is achieved, while in some of them have been reported as 'not relevant' or 'unknown'.

The criterion on permanent alterations of the hydrographical conditions (D7C1) has been reported as 'not assessed' in more than 50% of the cases, in 'good' status over 30% of the cases and in 'not good' only in a few assessments. The adverse effects from permanent alteration of the hydrographical conditions (D7C2) have been reported as 'good' or 'good, based on low risk' in almost 60% of the cases and as 'not good' in less than 10%.

2.2. Member States' assessments under the MSFD

Permanent hydrographical changes can occur due to changes in the thermal or salinity regimes, changes in the tidal regime, sediment and freshwater transport, current or wave action and changes in turbidity. The degree of change and the period over which such change occurs varies considerably, depending on the type of modification. Under the MSFD Descriptor 7, the variables analysed in marine and coastal waters are mainly salinity, sediment ratio, currents, waves, turbidity, temperature and density. The cumulative impact on the ecosystem from pressures resulting from the alteration of hydrographical conditions is intimately linked to the assessments of biodiversity and eutrophication (Descriptors 1, 4, 5 and 6).

Descriptor 7 focuses on permanently altered hydrographical conditions (often at a localized scale), which predominantly arise from a structural alteration of the coast or seabed: coastal activities causing topographical changes (e.g. land claim, barrages, sea defences) and coastal and offshore infrastructures (e.g. ports, wind farms, oil rigs, pipelines, heat and brine outfalls from power stations or desalination plants). Hence, the pressure is the change in morphology of the seabed/coast or change in habitat (e.g. from sediment to concrete) that causes hydrographical changes. These changes of the hydrographical conditions consequently will act as a pressure that is impacting the habitat or even the ecosystem. Assessment for this descriptor should take into account the cumulative 'impact' of all these 'localized activities' that act as pressures, linking them also to the associated physical loss and damage. Assessment of the degree of change can be related to both the water column and the seafloor, and consequently to their biological communities (González et al., 2015).

Member States' provided very different information and level of detail in their initial assessment of physical variables for Descriptor 7 under the first MSFD implementation cycle. The assessment of GES was mostly qualitative (González et al., 2014). Only Italy incorporated a quantitative threshold in its definition of GES ('not more than 5% of the extension of the coastal marine water bodies […] present impacts due to changes in the thermal regime and salinity'). In the last MSFD reporting, several Member States (e.g. the Netherlands) considered that they already achieved GES for Descriptor 7, since they do not record recent major alterations of their hydrological conditions. To date, we do not have a European overview of the alteration of hydromorphological conditions.

2.1. Other assessments

According to the 2nd river basin management plans of the WFD, 31% of the area of coastal water bodies are in high or good hydromorphological quality status, 2% is less than good and the rest (67%) is unknown (actually 11 coastal Member States did not assess hydromorphological quality elements at all in coastal waters)[7]. Looking at the WFD reporting on pressures, an estimated 28 % of EU's coastline is affected by hydro-morphological pressures causing changes in seawater movement, salinity and temperature[8].

The WFD reporting of the morphological conditions in coastal waters show that the Adriatic is the sub-region with the highest proportion of coastal waters achieving the

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[7] Hydromorphological quality elements status, https://www.eea.europa.eu/themes/water/european-waters/water-quality-and-water-assessment/water-assessments/quality-elements-of-water-bodies

[8] WISE WFD data viewer, https://www.eea.europa.eu/data-and-maps/dashboards/wise-wfd.

good status (78% of the area reported in high status and 1% in good status), followed by the Celtic Seas (62% of the area reported in high status and 9% in good status). However, the status of the morphological conditions have been reported as unknown for the 100% of five different (sub)regions, and to a large extent in others (69% of the Bay of Biscay and Iberian Coast, 60% of the Baltic and 56% of the North Sea) (Figure 43).

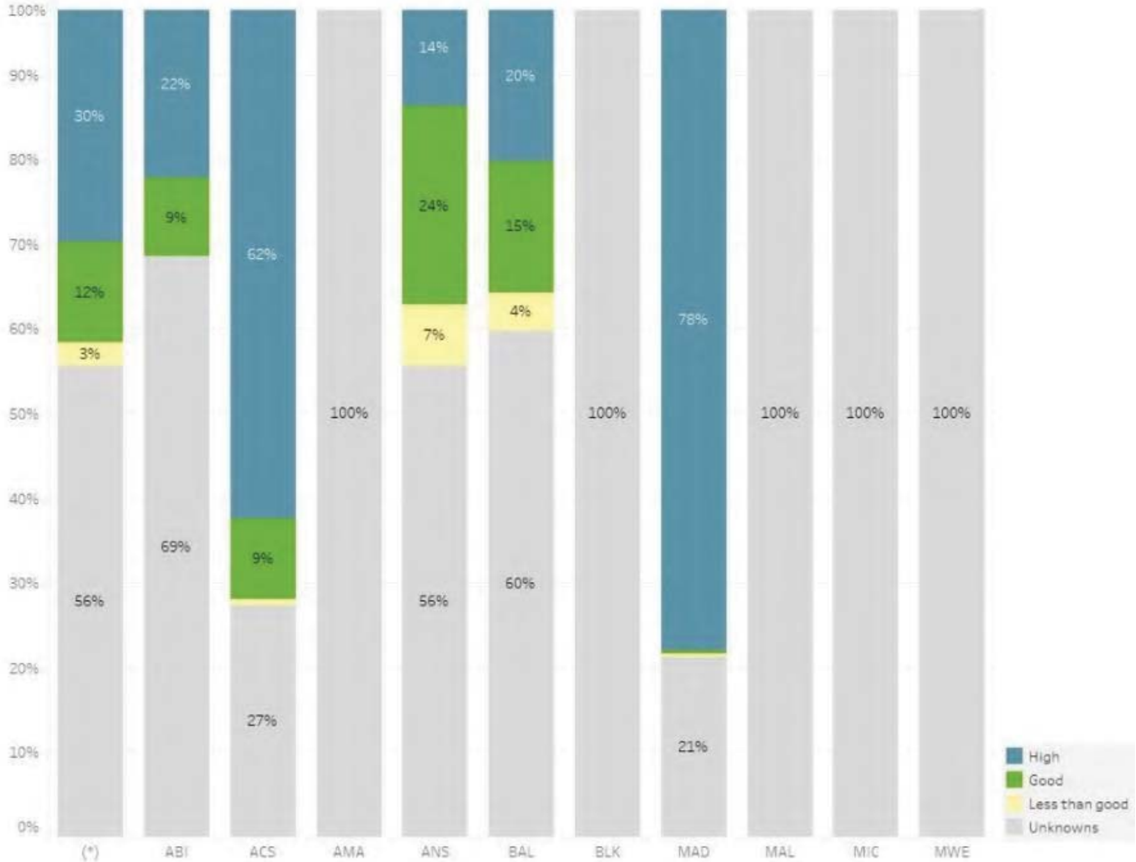


Figure 43: Morphological conditions in coastal water bodies by marine (sub)region (percentage of total area assessed). as reported in the 2015 River Basin Management Plans). (*) refers to all water bodies in all marine (sub)regions. Marine sub-regions codes: ABI: The Bay of Biscay and the Iberian Coast; BLK: The Black Sea; ACS: The Celtic Seas; MAD: The Adriatic Sea; AMA: Macaronesia; MAL: The Aegean-Levantine Sea; ANS: The Greater North Sea, including the Kattegat and the English Channel; MIC: The Ionian Sea and the Central Mediterranean Sea; BAL: The Baltic Sea; MWE: The Western Mediterranean Sea. Source: WISE Water Framework Directive (data viewer).

According to the Member States reporting of hydro-morphological status of coastal waters, ~9 % of the coastal strip is affected by pressures causing hydro-morphological changes, such as seawalls, breakwaters, groins, protective islands, surfing reefs, beach nourishment or dune stabilisation.

An independent assessment (ETC/ICM, 2019b) shows that windfarms and oil and gas installations are the most frequent human-made structures liable to cause hydrographical pressure in the EU's offshore waters. Offshore energy installations are present in almost 800 (10 km×10 km) grid cells, representing less than 0.5% of a total assessed offshore area (234 692 cells). The highest concentration is in the North-east Atlantic region with presence in 700 cells, representing 0.7% of assessed offshore area (101 943 cells) (Figure 44). However, there is no region-wide assessment available to estimate the adverse effects of these installations on benthic and/or water column habitats.

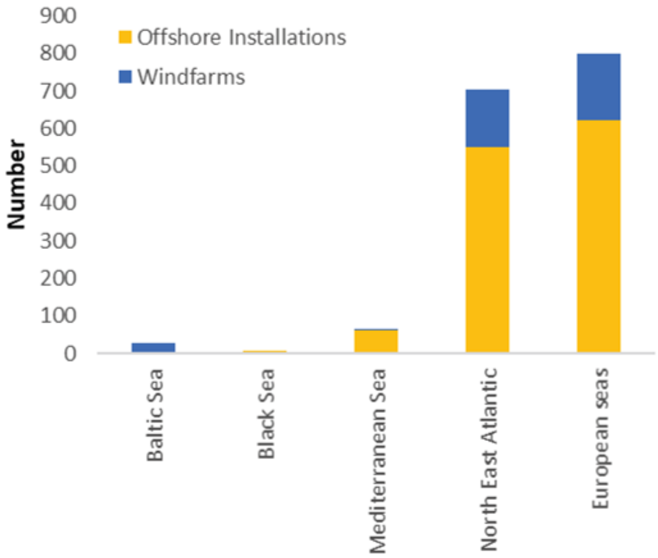


Figure 44: Number of offshore energy installations in 10 km × 10 km grid cells (ETC/ICM, 2019b).

River damming has also a major impact in marine hydrographical changes, among others modifying the freshwater input and the sediments' load. For example, damming may have played an important role in the distinct increase of eastern Mediterranean salinities over the last 40–50 years (Rohling et al., 2015). Intense water abstraction and the consequent decrease of water flow (like the 60% decrease of water flow linked to irrigation in the Ebro river basin since the 1960s, Sánchez-Chóliz and Sarasa, 2015) similarly affect coastal hydrography.

The impact of climate change (i.e. changes in temperature, salinity, currents, acidification) is prominent for marine and coastal hydrographical conditions. However, MSFD Descriptor 7 is specifically linked to changes related to infrastructure developments and, thus, no monitoring of such indirect effects is foreseen under the scope of MSFD reporting. Given the conceptual discrepancies on the assessment of this descriptor, the identification of quantitative threshold values for GES is particularly challenging.

3. Temporal trends and links with broader climate aspects

As just mentioned, the effects of climate change *per se* are not under the scope of MSFD Descriptor 7. However, given their important role in shaping the oceanographic and physical conditions and the lack of harmonised information reported under MSFD this Descriptor, we reflect here some documented trends in hydrographical conditions and on acidification at large scale.

Some open data sources[9] allow for the assessment of long-term trends of hydrological variables like salinity, temperature, currents, waves or turbidity. For instance, the Copernicus Ocean State Report (von Schuckmann et al., 2018) reflects changes in salinity across the four EU marine regions over the past 24 years, and increases in

[9] Specific MSFD monitoring programs can be complemented by observational and modelling data coming for example from the European Marine Observation and Data Network (EMODnet), the Copernicus Marine Environment Monitoring Service (CMEMS) or the European Environment Agency environmental indicators.

temperature in all four regions since 1870 which has been particularly rapid since the late 1970s. The increase in surface salinity affects largely the Mediterranean Sea and the warming trend seems more acute in the Black Sea. However, these data are available only on a regional scale, whereas most pressures/impacts from infrastructure constructions and physical disturbances are confined on rather small areas.

In general, coastal hydrographical changes are predicted to increase in the future as human developments in coastal regions, tourism, shipping and other maritime activities increase (OECD, 2016). Also, the more frequent flood and storm events and the rise of the sea level occurring and forecasted as a result of anthropogenic climate change may lead to an increase of protective structures in coastal areas (EEA, 2017a, 2017b). While flood and storm increases have been mainly predicted in northern European shores, sea level rise has already been observed across all Europe's seas (EEA, 2017b).

Currently, the ocean absorbs approximately 25% of all the CO_2 that humans emit each year. Ocean acidification in recent decades has been occurring 100 times faster than during past natural events over the last 55 million years. Ocean surface pH has declined from 8.2 to below 8.1 over the industrial era (EEA, 2016). This decline corresponds to an increase in oceanic acidity of about 30% (NOAA, 2019). We could consider acidification as a pollution problem caused by the disproportionate addition of CO_2. Observed reductions in surface water pH are nearly identical across the global ocean and throughout continental European seas, except for variations near the coast. Ocean acidification is affecting marine organisms and could alter marine ecosystems. Corals, mussels, oysters, and other marine calcifiers have difficulties constructing their calcareous shell or skeletal material when the concentration of carbonate ions in water decreases. Of equal importance is the effect of acidification on primary producers (such as phytoplankton) as it changes the bioavailability of essential nutrients, such as iron and zinc.

4. FURTHER DEVELOPMENTS UNDER THIS DESCRIPTOR

It seems necessary to better define and monitor specific parameters under Descriptor 7. Hydrological and hydromorphological alterations related to climate change, constructions, or offshore infrastructures, among others, are likely to increase dramatically. Modelling studies (e.g. scenario with and without the construction) could help identifying the pressure and potential impact from it, establishing close links with the environmental impact assessments. Additionally, the cumulative pressure of localized activities and global changes may have to be considered.

An example relevant for future Descriptor 7 analyses is the environmental impact from the construction of offshore wind farms. We have some good knowledge on many of the short-term effects on the physics of the marine system, however, we are far from fully understanding the ecological significance of those effects, and only just beginning to understand possible long-term changes. Potential connections exist between offshore wind farms, the subsequent alteration of oceanographic processes and changes to local sediment, nutrient, or phytoplankton regimes, but these connections are usually not investigated. Current numerical modeling is still not capable to predict the effects of large-scale constructions, cumulative effects of several structures, or effects at the coast. Even more, the potential risk of offshore wind farms on marine life, for instance, to whales and seals' sense of hearing or the impact from lighting a turbine tower on some bird species is largely unknown. On the other hand, the de facto protection provided by the wind farm from fishing or shipping activities could create an ideal habitat for some species.

5. Technical observations

- The cumulative impacts from Descriptor 7 need to be considered together with the assessments of seabed and water column habitat under Descriptors 1 and 6.

- Despite of legally required environmental impact assessment for the installation of new constructions, these often ignore the long-term effects on habitats and on the ecosystem, as for instance in case of the brine deposal into the sea by desalination plants. This could be covered by Descriptor 7.

- A number of experts and Member States have contrasting views on the definition of Descriptor 7, also including indirect changes in hydrographical variables and associated biological impacts caused by climate change, even if that would not fall within the scope of this Descriptor (for instance, some Member States included acidification in their monitoring programs). Further development of specific guidance for the assessment of GES for Descriptor 7 may be needed, including possible data sources and approaches. This could build, amongst others, on OSPAR (2012) and Salas Herrero (2018).

- As large part of human activities directly responsible for hydrographical pressure take place in river basins or in coastal waters, partly falling under the WFD, Descriptor 7 is closely linked to the WFD. Complementarity between WFD and MSFD assessments could be better defined.

6. Key messages

- Descriptor 7 focuses on permanently altered hydrographical conditions (often at a localized scale), which predominantly arise from a structural alteration of the coast or seabed: coastal activities causing topographical changes (e.g. land claim, barrages, sea defences) and coastal and offshore infrastructures (e.g. ports, wind farms, oil rigs, pipelines, heat and brine outfalls from power stations or desalination plants).

- Member States' provided very different information and level of detail in their initial assessment of physical variables for Descriptor 7 under the first MSFD implementation cycle. The information about GES assessments, trends or thresholds values with respect to Descriptor 7 is too scarce and scattered to allow for a suitable assessment of the descriptor at large scale. The criteria and methods used should be further harmonised.

- The WFD reporting shows that about 28% of EU's coastline is affected by permanent hydrographical changes, including seawater movement, salinity or temperature. 31% of the area of coastal water bodies are in high or good hydromorphological quality status, but 67% is unknown.

- Offshore energy installations can affect less than 0.5% of the total assessed EU offshore area, with the highest concentration in the North-east Atlantic region.

Descriptor 8: Concentrations of contaminants are at levels not giving rise to pollution effects

1. MSFD FRAMEWORK

COM DEC 2017/848/EU		COM DEC 2010/477/EU
D8 Contaminants		
D8C1 Contaminants in environment	The concentrations of contaminants in water, sediment or biota should be below agreed threshold values in coastal, territorial and beyond territorial waters. The list of pollutants and threshold values are set by Directive 2000/60/EC, Directive 2008/105/EC or (sub)regional cooperation[10].	8.1 Concentration of contaminants 8.1.1 Concentration of contaminants
D8C2 Adverse effects of contaminants	The health of species and the condition of habitats (such as their species composition and relative abundance at locations of chronic pollution) are not adversely affected due to contaminants including cumulative and synergetic effects.	8.2 Effects of contaminants 8.2.1 Level of pollution effects
D8C3 Acute pollution events	The spatial extent and duration of significant acute pollution events (as defined in Article 2(2) of Directive 2005/35/EC) are minimised.	8.2.2 Occurrence and impact of acute pollution
D8C4 Adverse effects of acute pollution event	The adverse effects of significant acute pollution events on the health of species and on the condition of habitats (such as their species composition and relative abundance) are minimised and, where possible, eliminated.	8.2.2 Occurrence and impact of acute pollution

Contaminants shall be understood to refer to single substances or to groups of substances. As stated in the WFD, “hazardous substances” means substances or groups of substances that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances, which give rise to an equivalent level of concern. According to the COM DEC 2017/848/EU, for consistency in MSFD reporting, the grouping of substances shall be/are agreed at Union level.

[10] The eventual grouping of substances shall be agreed at Union level.

2. Contaminants in EU marine waters: concentrations and trends

2.1. Ongoing reporting under the MSFD

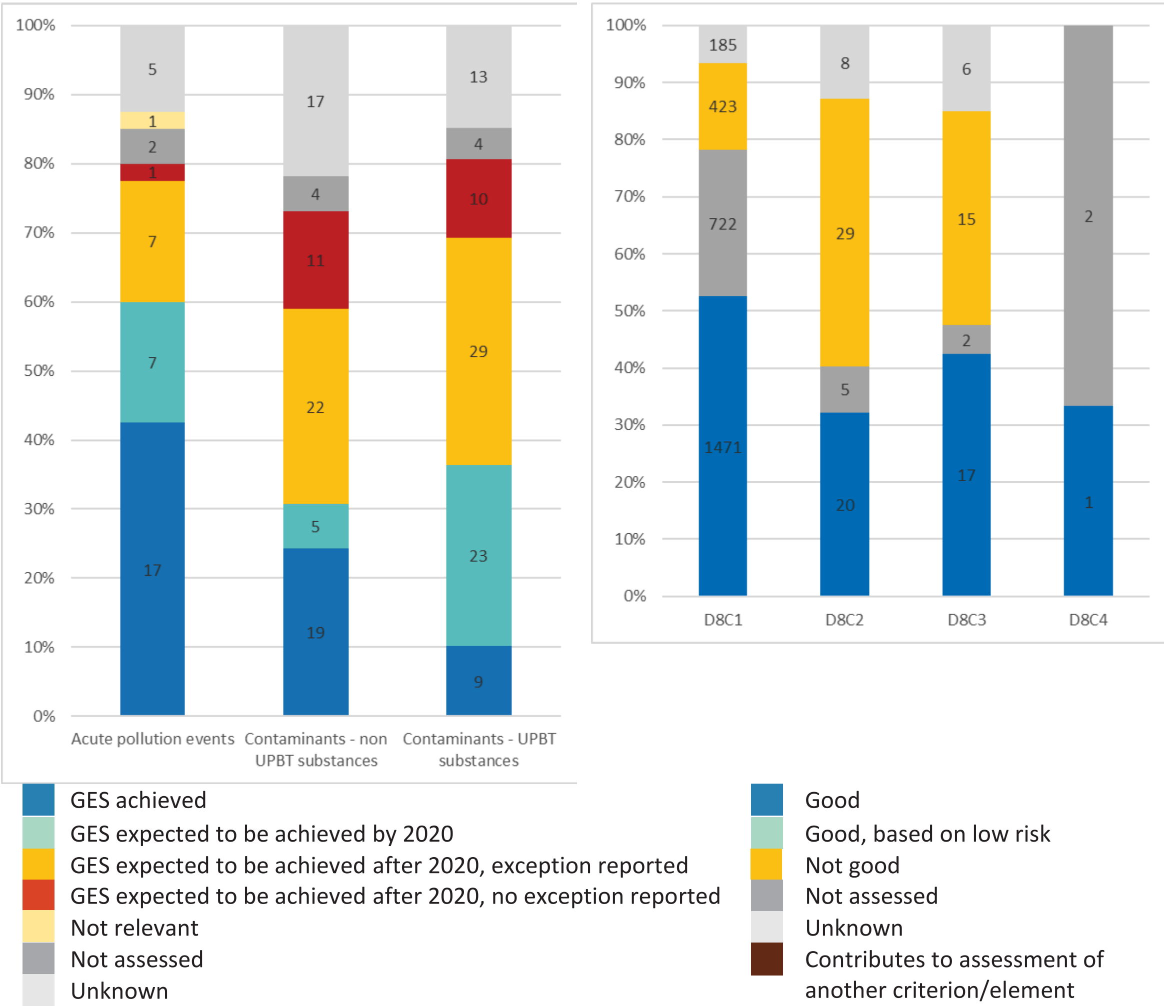


Figure 45: Latest MSFD assessments of good environmental status for contaminants and associated criteria under Descriptor 8. The information comes from 10 Member States' electronic reports.

For acute pollution events, GES is achieved in more than 40% of the assessments and will be achieved by 2020 in other 20%. Therefore in around 60% of the cases GES will be achieved by 2020. However, this is not the case for the concentrations of contaminants in the environment, where GES is achieved in only 9 assessments of "ubiquitous persistent, bioaccumulative and toxic" substances (UPBT) and in 19 assessments on non-UPBT. A high proportion of assessments of UPBT concluded that GES will be achieved by 2020. For all contaminants, around 30% of the assessments expect GES to be achieved later than 2020 with an Article 14 exception reported.

The most used criterion is the assessment of contaminants in the environment (D8C1), even if it has been reported as 'not assessed' and 'unknown' in a number of cases (722 and 185 assessments respectively). For this criterion, the assessments have resulted in a 'good' status in more than 50% of the cases and in a status 'not good' only in less than 20%.

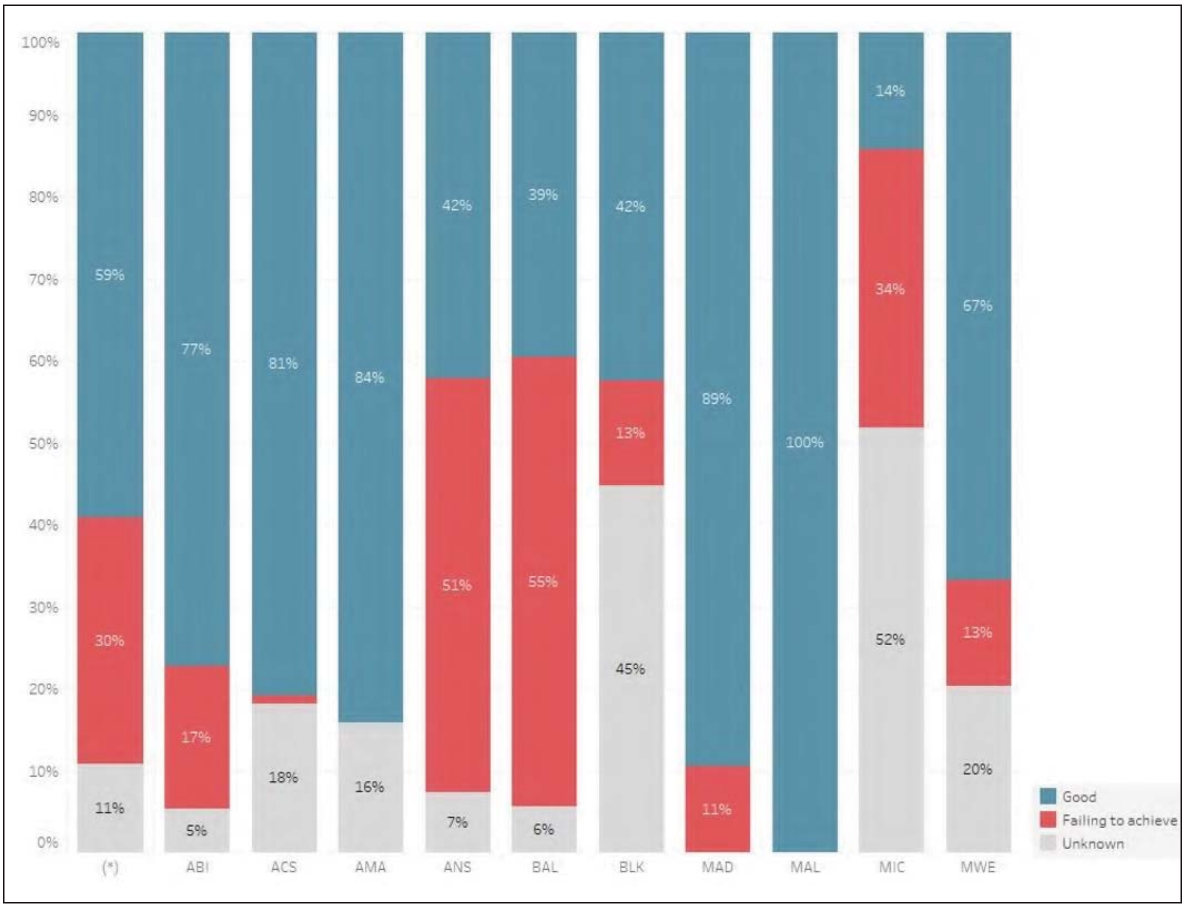
There have been some assessments on the adverse effects of contaminants (D8C2) and on significant acute pollution events (D8C3), resulting in 'good' status only the around

30% and 40% of them respectively. The adverse effects of significant acute pollution events (D8C4) have only been reported in one case as ‘good’ and in two occasions as ‘not assessed’.

2.2. EU assessments of contaminants in the marine environment

Chemical contaminants (pesticides, heavy metals, pharmaceuticals, persistent organic pollutants, etc.) can end up in the marine environment and cause harmful effects to the marine ecosystems. Europe has since the 1980s put far-reaching politically agreed commitments in place for reducing pollution in the marine environment[11]. Concerning the MSFD Descriptor 8, Member States have to consider the Priority Substances and River Basin Specific Pollutants already identified under the WFD, and establish, through regional or subregional cooperation, a list of additional contaminants that may give rise to pollution effects.

The assessments of the chemical status of coastal water bodies reported under the WFD show that the Aegean-Levantine Sea is the subregion with the highest proportion of waters achieving the good chemical status (100% of the area assessed), followed by the Adriatic (89% of the area assessed) and the Macaronesia (84% of the area assessed), while the Baltic Sea is the region with the highest proportion of waters failing to achieve the good status (55% of the area assessed), followed by the North Sea (51% of the area assessed) (Figure 46). A proportion of the waters in the Ionian Sea and Central Mediterranean and in the Black Sea have been reported with an unknown status (52% and 45% of the area assessed respectively).



[11] For an overview of the history and political commitments, refer to EEA (2019f). For a comprehensive list of potential chemical contaminants in the marine environment, refer to Tornero and Hanke (2017).

Figure 46: Chemical status of coastal water bodies by marine (sub)region as a percentage of total area assessed. For more information or late updates check the WISE WFD data viewer.

The chemical status should also be assessed in territorial waters, but only seven countries[12] have reported a few assessments, and therefore the information has not been included here. The good chemical status means that no concentrations of priority substances exceed the relevant level established in the Environmental Quality Standards Directive 2008/105/EC (as amended by the Priority Substances Directive 2013/39/EU). The substances that have produced most failures of the chemical status are mercury and its compounds (77% of the total area failing), brominated diphenylethers (36% of the total area failing) and tributyltin-cation (23% of the total area failing), with variations depending on the (sub)region.

An independent assessment (EEA, 2019f) has identified 'non-problem areas' and 'problem areas' for Europe's seas[13] (Figure 47). Out of the 1541 marine units that could be assessed, 1305 (85 %) have been classified as being 'problem areas' with respect to contamination. The percentage of 'non-problem areas' is higher in the North-east Atlantic (21 %) and the Black Sea (19 %) with respect to the Baltic Sea and Mediterranean Sea (both with 7 %). However, these results should be interpreted with caution since they are affected by the list of substances being monitored and by the spatial coverage. This analysis is based upon all substances for which monitoring data is available and for which threshold values are agreed upon. Chemical status is based upon a subset of substances.

[12] Belgium, Denmark, Estonia, Italy, Romania, Slovenia and Sweden.

[13] This integrated assessment of contaminants in Europe's seas is based on an application of the CHASE tool (used by HELCOM), upon data for 145 substances, using independent (not MSFD-agreed) data, methodologies and threshold values, and the 'one-out, all-out' rule.

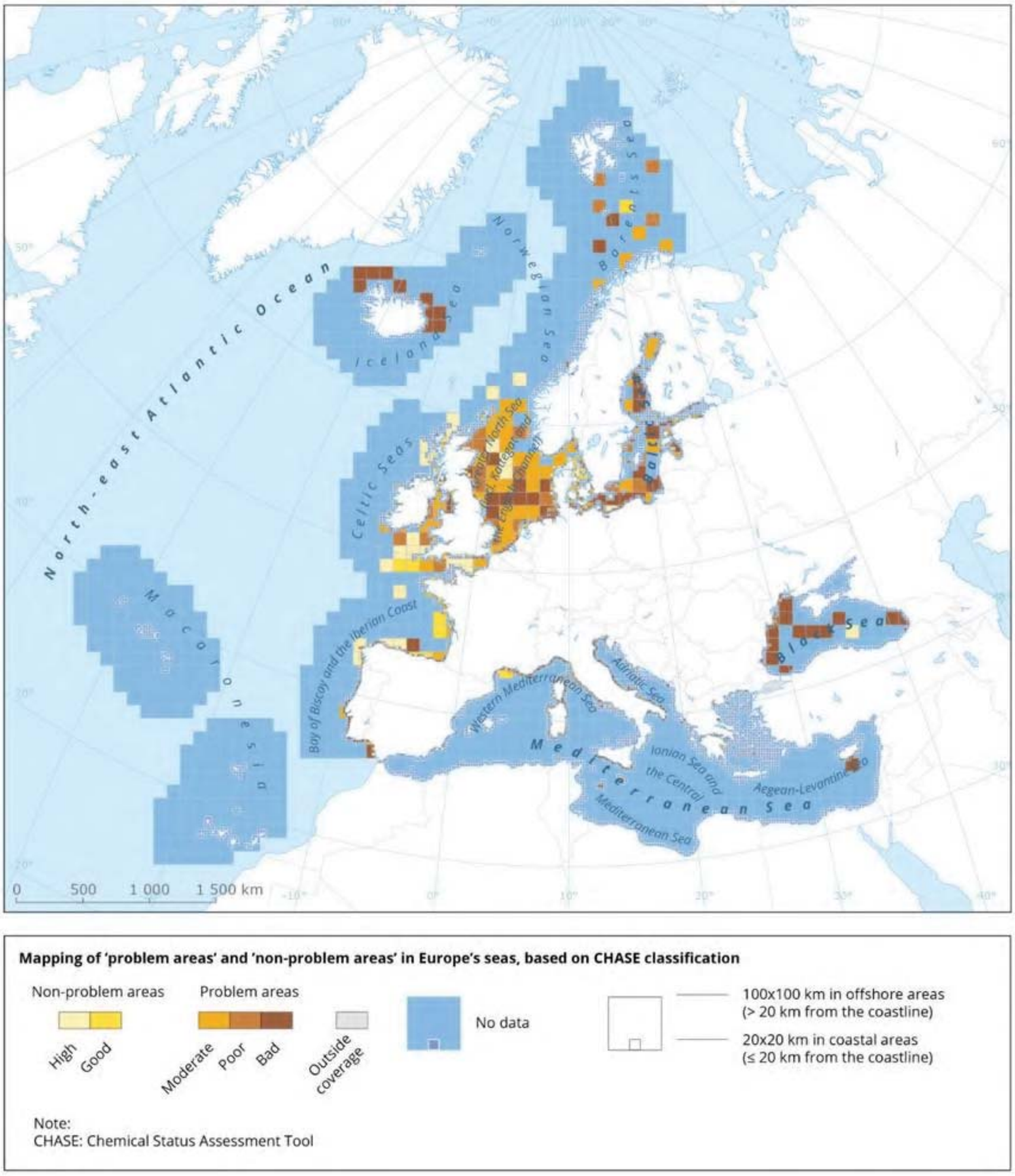


Figure 47: Mapping of 'problem areas' and 'non-problem areas' in Europe's seas (EEA, 2019f). Assessment includes also non-EU countries, this is not directly related to MSFD purposes.

Many areas in Europe are classified as being 'problem areas' indicating that they are impaired with respect to concentration of contaminants and agreed threshold levels. Metals are identified as the group of substances most often triggering a problem area indicating that the inputs of metals to Europe's marine ecosystems have not yet been reduced to or below critical levels. Inputs of organohalogens, organobromines and polychlorinated biphenyls (PCBs) are apparently also close to the critical levels in relation to the environmental standards (EEA, 2019f).

2.3. Regional assessments of contaminants in the marine environment

Baltic Sea

Contaminants	Status in different matrices
Polybrominated biphenyl ethers (PBDE)	Concentrations above threshold in fish in all areas

Cadmium	Concentrations above threshold in most areas (Eastern Gotland Basin, the Bornholm Basin, the Arkona Basin and coastal waters of the Gdańsk Basin, the Kattegat, Great Belt and The Sound).
Lead	Concentrations exceeded thresholds in Western Gotland Basin, Bornholm Basin, Arkona Basin, Kiel Bay and the Bay of Mecklenburg, as well as in some of the coastal areas in Gulf of Finland and Gdańsk Basin.
Mercury	Concentrations exceeded the threshold level in almost all monitored sub-basins indicating, that is the Bothnian Sea, Northern Baltic Proper, Westernand Eastern Gotland Basins, Bornholm Basin, Arkona Basin, the Kiel Bay and the Kattegat. Only some coastal areas of the Kattegat achieved good status.
Polychlorinated biphenyls (PCBs), dioxins and furans	Good status in the majority of coastal and open sea areas. PCBs were responsible when the overall good status was not achieved (at some stations, in the Eastern Gotland Basin, the Arkona Basin and in the Kiel Bay). The concentrations of dioxins and furans in fish were below the threshold value in all monitored areas. However, there are areas where data are absent and thus extended monitoring is required to enable a status evaluation in the entire Baltic Sea.
Perfluorooctane sulphonate (PFOS), Hexabromocyclododecane (HBCDD) and polyaromatic hydrocarbons (PAHs)	Overall good status
Radioactive substances (Cesium-137)	Concentrations in herring, flatfish and surface waters still above the pre-Chernobyl levels that constitute the boundary for good status, i.e. threshold value.

Table 15: Overview of the chemical status (concentrations of contaminants against threshold values) of the Baltic Sea assessed by HELCOM (2018a).

Overall assessment: The pressure on the marine environment from concentration of contaminants is high in all parts of the Baltic Sea, mainly due to the group of brominated flame retardants (PBDE) and mercury. The four most contaminated areas in the integrated assessment, using the available core indicator results, were the Arkona Basin, the Eastern Gotland Basin, the northwestern coastal areas of the Bothnian Sea and the Kiel Bay, which all had the highest contamination scores in biota.

Trends: A direct comparison between the current assessment period (2011-2016) and the previous holistic assessment is not possible due to methodological differences between the two assessments. The overall contamination has neither improved neither deteriorated. Nevertheless, some relevant changes can be seen. For instance, PCBs and dioxins were amongst the substances with highest contamination ratios in the previous assessment, while they do to not appear to be a major driver of the current integrated assessment status. Moreover, substances that were previously assessed (e.g. hexachlorocyclohexane (HCH, lindane) and dichlorodiphenyltrichloroethane (DDT)) are no longer considered as of significant concern.

North-east Atlantic Ocean

Pollutants and matrix	**Status**	**Trends**
PAH concentrations	Values are above OSPAR Background Assessment Concentrations (BACs), but	(1995–2015): The Northern North Sea, Skagerrak and

in shellfish	below levels Environmental Assessment Criteria (EACs), that is below concentrations likely to harm marine species. Data are limited to the coastal zone, because shellfish are not found in open waters. It is suggested to use the monitoring of PAH metabolites in fish bile to extend the biota monitoring to open waters. There is a lack of monitoring data, particularly in Arctic waters.	Kattegat, Irish Sea, and Northern Bay of Biscay show no statistically significant change in PAH concentrations. Declining PAH concentrations are observed in the Southern North Sea, English Channel, Irish and Scottish West Coasts and the Iberian Sea), with mean annual decreases in concentration of between 6.5% and 3.2%.
PAH concentrations in sediments	Values are below the United States Environmental Protection Agency (EPA) sediment quality guidelines Effects Range-Low (ERL) in all contaminants assessment area, so adverse biological effects in marine species are unlikely. As before, there is a lack of monitoring data, particularly for Arctic Waters and some parts of the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast.	(1995–2015): Concentrations decreased in the Gulf of Cadiz and the English Channel. No statistically significant trend was found in the Northern North Sea, Southern North Sea, Irish and Scottish West Coasts and the Irish Sea.
PCBs concentrations in biota (fish liver and shellfish)	Six out of seven PCB congeners were below the EAC in all OSPAR assessment areas. However, one of the most toxic PCBs (PCB118) is close to or above the EAC in eight of the 11 assessment areas (Northern North Sea, Norwegian Trench, English Channel, Southern North Sea, Skagerrak and Kattegat, Irish Sea, Iberian Sea and Northern Bay of Biscay).	(1995–2014): Overall, concentrations are reducing slowly.
PCBs in sediments	Only PCB 118 is close to or above the EAC (in the English Channel, Southern North Sea and Irish Sea). There is a lack of monitoring data for some parts of the OSPAR Maritime Area, particularly in Arctic Waters, some parts of the Celtic Seas and the Iberian Coast and Bay of Biscay.	(1995–2015): concentrations are decreasing in the Northern North Sea, Southern North Sea and Gulf of Cadiz. No statistically significant change in the Irish and Scottish West Coast and the Irish Sea.
PBDE concentrations in biota	They are not assessed against a threshold value because there is no available EAC and the WFD Environmental Quality Standard is not agreed within OSPAR. Therefore, it is not possible to assess the environmental significance of the concentrations observed. The highest concentrations were found in the English Channel and the Irish Sea, and the lowest in the Iberian Sea. These differences could be due to differences in the contamination loads, but also be influenced by differences in the species monitored.	(2010–2015): mean concentrations are decreasing in the majority of assessed areas. No statistically significant change in the Skagerrak and Kattegat.
PBDE concentrations in sediments	They are not assessed against a threshold value because there is no available EAC. Overall, concentrations are low and often below detection levels. The lowest concentrations are found in the Gulf of	(2010–2015): Monitoring sites are limited. Temporal trend analyses were performed for the Northern North Sea and Irish Sea. Concentrations are declining

	Cadiz and the highest in the Greater North Sea.	in Irish Sea and show no statistically significant change in the Northern North Sea.
TBT concentrations in sediments	Especially at offshore locations, they are often very low, even below the limit of detection, so most countries have stoped monitoring. The Southern North Sea is the only area for which a reliable assessment is available.	In the Southern North Sea, decreasing trends are found for three compounds (monobutyltin, dibutyltin and tributyltin).
Metal (Hg, Cd, Pb) concentrations in biota	Concentrations in fish (mainly flatfish in open water) and shellfish (mainly blue mussels at coastal sites and oysters in the Bay of Biscay and the Irish coast) are overall below the maximum levels established in Food legislation (EC 1881/2006), but above natural background concentrations.	(Since 2009): Hg concentrations show no significant change or a downward trend in most assessment areas. However, Cd levels are increasing in the Southern North Sea and needs to be investigated.
Metal in sediments	The highest Hg and Cd concentrations are found in the English Channel. Pb concentrations are highest in the Gulf of Cadiz. The lowest concentrations for all heavy metals are in the Irish and Scottish West Coast. Cd levels are below ERL in all assessed areas. Pb concentrations are at or above the ERL in the English Channel, Southern North Sea, Northern North Sea, Irish Sea, Gulf of Cadiz, and below the ERL only in the Irish and Scottish West Coast. Hg concentrations are at or above the ERL in Southern North Sea, English Channel and Gulf of Cadiz.	(2005-2015): There is a decreasing trend in Cd levels in the Southern North Sea, but there are no statistically significant trends in other areas. For Hg, there is an overall decreasing trend with the exception of the English Channel. Lead concentrations show no statistically significant change in four assessment areas and a downward trend in the Southern North Sea and an upward trend in the Gulf of Cadiz. The different trend patterns between sediments and biota can be due to the fact that the response of sediments to measures to reduce heavy metals is expected to be slower than for biota, since the upper sediment layer (top few centimetres) sampled for analysis can represent several years of sedimentation and thus integrate heavy metal inputs over the corresponding period.

Table 16: Overview of the chemical analysis of the North-east Atlantic Ocean by OSPAR (2017a).

<u>Mediterranean Sea</u>

In the assessment published by the Barcelona Convention (UNEP-MAP, 2018), significant number of quality assured datasets are only available for cadmium, mercury, and lead. For other contaminants covered during long time under MEDPOL, like chlorinated compounds, there are no enough new available data to allow for an accurate assessment of the Mediterranean (apart from known hotspots). Emerging contaminants, such as phenols, pharmaceutical compounds, personal care products or polycyclic fragrances are currently under investigation. Some conclusions on the status are:

- Pb levels in mussels were above maximum levels established in food regulation in 8% of assessed stations. The areas of concern are the coasts of southeast Spain, Italy and Croatia (known hotspots). Regarding coastal sediments, levels were above ERL in 15% of assessed stations.

- Hg levels in coastal sediments were above the ERL in 53% of stations. The problematic areas are the NW Mediterranean, the Adriatic Sea, the Aegean Sea and the Levantine Sea basins (associated with industrial exploitation of mines).

- Cd levels in coastal sediments were above the ERL in 4% stations.

Black Sea

At the time of preparation of this report, there was no regional assessment carried out by the Black Sea Commission or MSFD report by Bulgaria[14]. Hence, this section analyses the text report submitted by Romania under Article 17 of the MSFD. The threshold values used are the WFD Environmental Quality Standard and, in their absence, methodologies adopted in other marine regions (namely OSPAR):

- Bad status is found for PAHs, lindane, heptachlor and cyclodiene pesticides in water and for PAHs and PCBs in sediments.

- Cd levels are above the threshold values in 26% of samples of water with variable salinity.

- Copper (Cu) has bad status in marine sediments from offshore areas and nickel (Ni) has bad status in all assessed areas.

- Trends: During the last period reported (2012-2017) there is a tendency for stabilization of heavy metal and organic pollutant concentrations when compared to the previous period (2006 -2011), although there are no clear trends.

2.4. Significant acute pollution events

D8C3 and D8C4 of the MSFD relate to significate acute pollution events and link to Directive 2005/35/EC on ship-source pollution. Monitoring for this two criteria shall be established as needed once the acute pollution event has occurred, rather than being part of a regular monitoring programme under Article 11 of the MSFD. This section summaries information coming from the Baltic Sea and the Mediterranean Sea regions.

In HELCOM, the volume of oil is considered to be the most relevant metric to evaluate the effect of oil spills on the marine environment. Oil spills detected in annual aerial surveillance, both number and size, have decreased in all sub-basins of the Baltic Sea. 2016 was the lowest ever recorded with 53 mineral oil spills or a reduction 35% compared to 2015 (HELCOM, 2017; Figure 48). Nevertheless, in the assessment period of 2011-2016 the estimated annual average volume of oil exceeded the threshold value in the Bothnian Bay, The Quark, The Bothnian Sea, The Åland Sea, the Eastern Gotland Basin, the Western Gotland Basin, the Great Belt and the Kattegat. The threshold value is defined based on a modern baseline using the reference period 2008-2013 when the estimated volume of oil was considered to be at a historically low level.

[14] The EMBLAS II project (EMBLAS, 2018) provides information about chemical contaminants in the Black Sea.

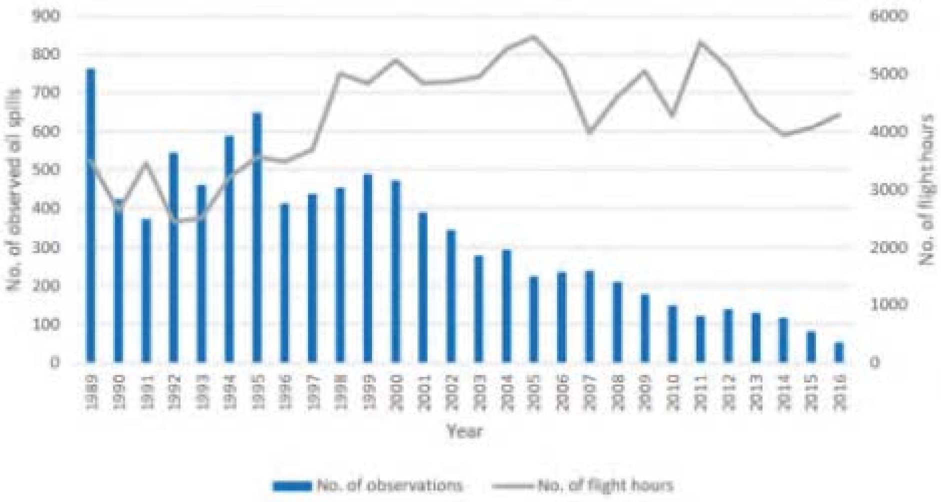


Figure 48: Number of flight hours and confirmed oil spills in the Baltic Sea during aerial surveillance 1988-2016 (HELCOM, 2017).

In the Mediterranean region, the assessment of oil and hazardous noxious substances pollution from ships is carried out on the basis of pollution reports (POLREP) sent by the Contracting Parties to the Barcelona Convention to REMPEC. These reports provide details on the incidents, including the position, extent, characteristics, sources and cause, trajectory of pollution, the forecast and likely impacts, as well as sea state and meteorological information. There is no obligation for countries to carry out environmental surveys of sea and shorelines affected by a spill. There is a significant downward trend in accidental pollution from ships, for both oil and hazardous noxious substances. Deliberate discharges of oil occur at high level along busy traffic lanes, although data are insufficient to establish a trend. There is little information on the impact of pollution events caused by shipping on biota.

3. IMPACTS: EFFECTS OF CONTAMINANTS ON THE HEALTH OF SPECIES AND THE CONDITION OF HABITATS

Contaminants in the marine environment cause adverse effects on marine species. Recent studies of populations of killer whales (*Orcinus orca*) show adverse effects of PCB on their reproduction, threatening >50% of the global population. This may cause the disappearance of killer whales from the most contaminated areas within 50 years despite PCB having been banned for 30 years. These waters include areas in the North-east Atlantic Ocean, around the UK, and in the Mediterranean Sea, around the Strait of Gibraltar (Desforges et al., 2018).

D8C2 (the evaluation of biological effects caused by contaminants) is a secondary criterion of the MSFD. Still, the biological effects (imposex) associated for instance with TBT pollution are monitored by many countries, rather than TBT itself.

In the HELCOM region, good status for imposex is found in the Kattegat, the Sound and the Great Belt. There is also a general decreasing trend of imposex levels. However, sediments still represent a potential source of TBT in harbours and shipping lanes. When considering all available data (sediment, water and imposex) using the one-out-all-out rule, the sediment status (fail status) in the southern Kattegat override the achieve imposex status[15].

Other indicators of biological effects caused by hazardous substances assessed in the Baltic region include the rate of embryo malformations and the status of white-tailed sea eagle reproduction. The rate of embryo malformations indicates reproductive toxicity due to the presence of hazardous substances in the bottom sediments. Assessments have been carried out in in the waters of Finland and Sweden and the threshold value has not been achieved at all stations within each basin, indicating potential toxic effects. The variability of the malformation rate is much greater within a basin than between the Bothnian Sea and the Baltic proper[16].

The status of white-tailed sea eagle reproduction is assessed in the coastal waters of all the countries bordering the Baltic Sea, up to 10 kilometres from the coast line, by evaluating 'productivity' and two supporting variables 'brood size' and 'breeding success'. White-tailed sea eagle productivity reached the good status (i.e. all three threshold values) in most coastal areas of the Baltic Sea[17].

In the OSPAR region, imposex is overall at or below the regional Environmental Assessment Criteria, but is not yet at natural background levels in any of the areas assessed. Compared to the OSPAR assessment in 2010, levels of imposex have markedly improved although high imposex levels are still found in some areas like the Skagerrak and Kattegat, Celtic Sea, Northern Bay of Biscay and particularly the Iberian Sea (OSPAR, 2017d).

In the Mediterranean region, the assessment of biological effects is still in an initial phase (i.e. method uncertainty assessments and confounding factors evaluations), which limits the implementation in the long-term marine monitoring networks (UNEP-MAP, 2018).

As for the Black Sea, Romania has not reported on biological effects in the last MSFD Article17 reporting.

Contaminants in the marine environment can impact human health promoting cancer, decreased fertility, skin allergies, cardiovascular diseases, or dementia to mention a few effects. For example, phthalates can cause reduced fertility in humans and they have been found in high concentrations in Europe's seas; from Bergen, Norway, to the German Bight, North Sea (AMAP, 2017). One phthalate (DEHP) is listed as Priority Substances under the WFD illustrating some of the existing efforts to reduce people's exposure to such substances. The adverse effect on human health via commercial fish and shellfish is dealt by Descriptor 9.

4. TECHNICAL OBSERVATIONS

- New monitoring options should be explored in order to find a cost-effective and consistent way to account for the constantly increasing number of potential contaminants in the marine environment, including potential combined effects.

[15] See http://www.helcom.fi/baltic-sea-trends/indicators/tbt-and-imposex

[16] See http://www.helcom.fi/baltic-sea-trends/indicators/reproductive-disorders-malformed-embryos-of-amphipods

[17] See http://www.helcom.fi/baltic-sea-trends/indicators/white-tailed-eagle-productivity

- Non-target screening techniques and specific targeted joint monitoring approaches spanning marine regions could improve assessments of Descriptor 8. They could aim at (a) assessing the same sub-set of substances and group of substances across all marine regions looking at i) data from water, ii) sediment, iii) biota, and iv) information about biological effects; and (b) a broader approach scanning some station for a wider selection of substances of concern.

- There is room for improvement through further data mining and further developments of the quality of the monitoring networks, i.e. better spatial coverage, especially in the Mediterranean and Black Seas.

- Assessments are mainly limited to the substances already covered under the WFD and few contaminants prioritized under the Regional Sea Conventions (mainly OSPAR and HELCOM). Methodological approaches should be properly harmonized.

- The monitoring of some legacy pollutants for which measures are already in place (e.g. bans of TBT, PCB, DDT, etc.) should be reviewed. For instance, non-pesticidal use of TBT is still ongoing in some countries and DDT is still used in Asia and Africa, which could be the reason for an observed increase in DDT concentrations in the Mediterranean Sea (EEA, 2019f). Moreover, these substances are very persistent and therefore are still present in the marine environment at significant concentrations.

- Some monitored substances cannot be included in the assessments due to an absence of agreed threshold values. Methodologies and threshold values should account for the specificity of the region.

5. KEY MESSAGES

- Available information on substances and time series varies from substance to substance across the regional seas. It could be preferable to establish consistent long-term time series for a sub-set of contaminants across the four marine regions.

- The development of measures under the various EU legislation and globally to combat chemical pollution has led to a reduction of concentrations of some known hazardous substances in the marine environment, such as DDTs, PCBs, TBT. The harmful effects of TBT (imposex) have continued to decrease markedly due to global action taken at the International Maritime Organization (IMO) to ban the use in antifouling paints for ships. Following a proposal of the European Union, the IMO is now working towards banning cybutryne, another harmful biocide used in antifouling paints. Cybutryne affects photosynthesis and is toxic for algae, seagrass and corals.

- Moreover, in the Baltic Sea, the number of detected oil spills, i.e. acute pollution events, has significantly decreased, indicating that the measures implemented to reduce pollution from oil in recent years have been successful.

- In the OSPAR area, measures have led to decreases in the discharges, spills and emissions of hydrocarbons and other harmful chemicals from offshore oil and gas installations.

- However, there are concentrations of contaminants above agreed thresholds in large parts of the coastal, territorial and offshore waters across all the marine regions in Europe. Pressure on the marine environment from contaminants is high in all parts of the Baltic Sea, particularly due to mercury, PBDE, and the radioactive isotope Cesium-137.

- In the North-east Atlantic Ocean, contaminant concentrations have continued to decrease in most areas, especially for PCBs. Nevertheless, concentrations are not yet at background levels. There are still concerns in some localised areas, especially regarding levels of mercury, lead and PCB118 and some local increases of PAHs and cadmium in open waters.

- In the Mediterranean Sea, there are known coastal hotspots, especially due to Pb contamination in biota and mercury in sediments, where the need for further measures and actions has been already recognized.

- There is no regional assessment for the Black Sea. Data provided by Romania indicate there are still pollution problems, particularly with organic pollutants such as pesticides, PCBs and PAHs and metals like nickel and cadmium. When integrating the results obtained for individual compounds within each contaminant group on the one out-all out principle, bad status is found for most contaminant groups in all evaluated areas.

Descriptor 9: Contaminants in fish and other seafood for human consumption do not exceed levels established by Union legislation or other relevant standards

1. MSFD FRAMEWORK

COM DEC 2017/848/EU		COM DEC 2010/477/EU
D9 Contaminants in seafood		
D9C1 Contaminants in seafood	The level of contaminants in edible tissues[18] of seafood[19] caught or harvested in the wild does not exceed the maximum levels laid down in Regulation (EC) No 1881/2006 (for the contaminants listed in that Regulation) or the threshold values establish through (sub)regional cooperation (for additional contaminants).	9.1 Levels, number and frequency of contaminants 9.1.1 Levels of contaminants in seafood
		9.1.2 Frequency of exceeding regulatory levels

MSFD Descriptor 9 aims at assessing the contamination status of the marine environment from a human health perspective. It provides that contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards. The contaminants assessed under Descriptor 9 are mainly those for which regulatory levels have been laid down under Regulation (EC) No 1881/2006 and further amendments. However, according to the Commission Decision (EU) 2017/848, Member States can choose to not consider certain contaminants and/or include additional ones, based on risk assessments. The selection of these contaminants as well as the establishment of their threshold values shall be done through (sub)regional cooperation.

[18] Muscle, liver, roe, flesh or other soft parts, as appropriate.

[19] Including fish, crustaceans, molluscs, echinoderms, seaweed and other marine plants.

2. CONTAMINANTS IN MARINE FISH AND OTHER SEAFOOD IN EU WATERS: CONCENTRATIONS AND POTENTIAL IMPACTS

2.1. Ongoing reporting under the MSFD

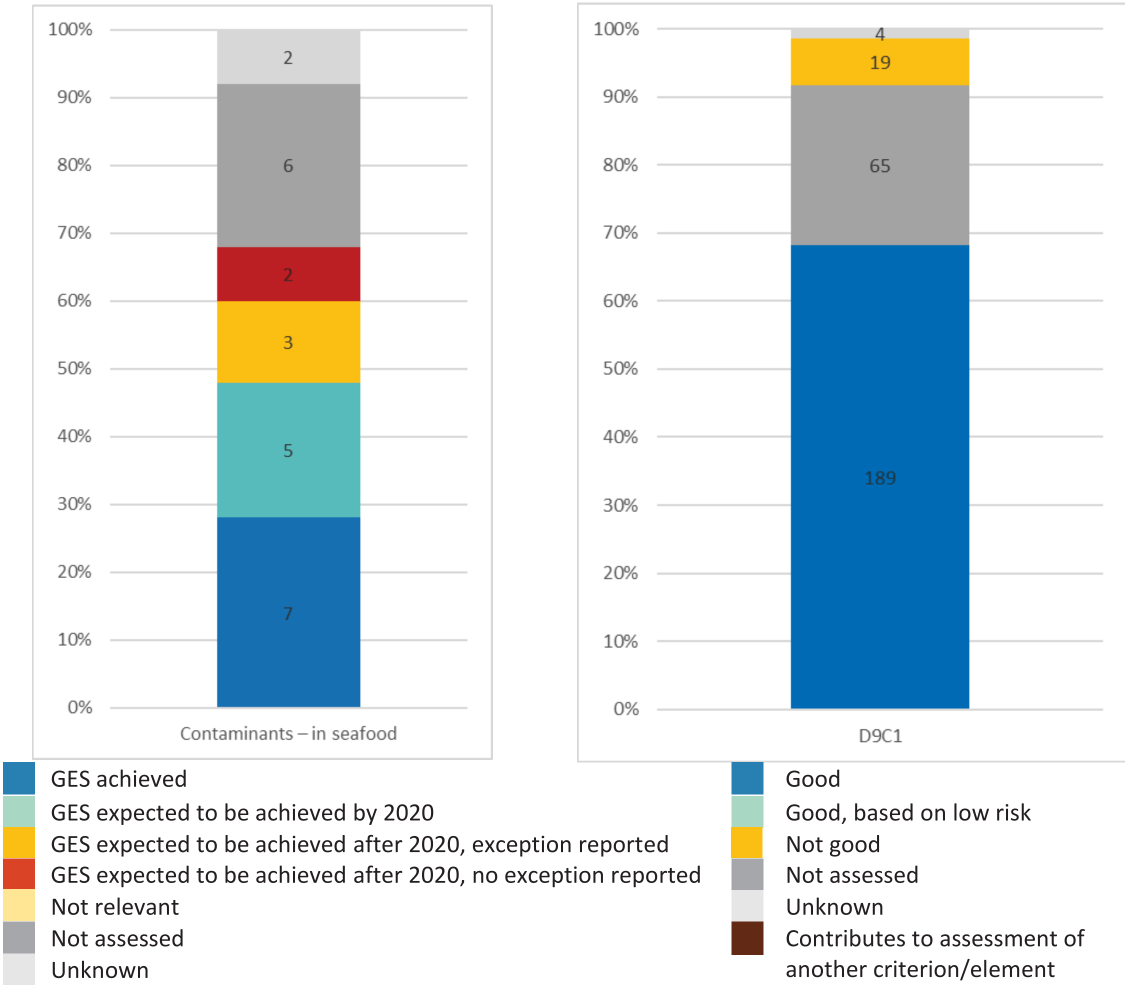


Figure 49: Latest MSFD assessments of good environmental status for contaminants in seafood and the associated criterion under Descriptor 9. The information comes from 10 Member States' electronic reports.

For contaminants in seafood, almost 30% of the overall assessments that have been reported are in GES, while around 20% will achieve GES by 2020. There are a number of assessments that have concluded that GES will be achieved later than 2020 (3 for which an exception has been reported under Article 14 and 2 where no exceptions have been reported). More than 30% of the assessments are 'not assessed' or 'unknown'.

The only criterion under this descriptor (contaminants in seafood) has a relative high number of assessments with conclusions, reaching 'good' status in almost 70% of the cases, 'not good' in less than 10%, and 'not assessed' or 'unknown' in about 25% of the cases.

2.2. Member States' assessments under the MSFD

Fish and fish products have a crucial role in nutrition and global food security, as they represent a valuable source of nutrients and micronutrients of fundamental importance for diversified and healthy diets (FAO, 2018). However, fish and seafood may also be a source of toxic pollutants for higher-level organisms in the food web, including humans. Health risks for consumers with fish-rich diets have been associated with high exposure to specific chemical contaminants, such as mercury and methyl-mercury (Fréry et al., 2001; Budnik and Casteleyn, 2019), polybrominated diphenyl ethers (PBDEs) (Cade et al., 2018), polychlorinated biphenyls (PCBs) (Bocio et al., 2007), and perfluorinated compounds (Schuetze et al., 2010). These contaminants have the potential to cause negative health effects, including neurodevelopmental disorders in children, cardiovascular problems, endocrine disruption, and carcinogenicity (von Stackelberg et al., 2017). Therefore, it is essential to keep contaminants in food at levels toxicologically acceptable for the safety of consumers.

The following information has been extracted from the reports under MSFD Article 17 submitted in paper form until the end of March 2019[20].

General aspects of Descriptor 9 reporting:

- Overall, the assessment of Descriptor 9 is based on the data coming from the food monitoring established at national (or local) level according to the Food regulation (EC) No 1881/2006[21].

- The time between the publication of the Commission Decision (EU) 2017/848 (May 2017) and the reporting under MSFD Article 17 (October 2018) might not have been sufficient to trigger a descriptive evaluation of Descriptor 9. Specific monitoring for MSFD has been indicated only by one Member State (Italy), although the coverage of the sampling is not enough to allow for an adequate assessment of the descriptor.

- Some additional data coming from other sources of information (e.g. bibliographic studies or national projects) have been also used by some Member States for their MSFD assessments (e.g. Greece, Germany).

- Generally, the Descriptor 9 assessments only include the substances specified in the Food regulation 1881/2006 (and its amendments) and the threshold levels considered are the maximum levels for fish and fishery products included in that regulation (Table 17).

Contaminant	Maximum levels	Regulation
Metals		
Cadmium (Cd)	0.050, 0.10, 0.2 or 0.30 mg/kg ww muscle meat of fish, depending on the fish species. 1 mg/kg ww bivalve molluscs and cephalopods (without viscera). 0.5 mg/kg ww crustaceans, excluding brown meat of crab and excluding head and thorax meat of lobster and similar large crustaceans.	Commission Regulation (EC) No 629/2008[22]

[20] Review of MSFD text reports from 10 Member States: BE, DE, NL, SE from North-east Atlantic; DE, EE FI, LV, SE from Baltic Sea; EL, IT from Mediterranean Sea; RO from Black Sea. MSFD reporting is not yet available for other Member States.

[21] Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs

[22] Commission Regulation (EC) No 629/2008 of 2 July 2008 amending Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs

Lead (Pb)	0.30 mg/kg ww muscle meat of fish. 1.5 mg/kg ww bivalve molluscs. 1 mg/kg ww cephalopods (without viscera). 0.5 mg/kg ww crustaceans, excluding brown meat of crab and excluding head and thorax meat of lobster and similar large crustaceans.	Commission Regulation (EC) No 1881/2006
Mercury (Hg)	0.5 mg/kg ww fishery products. 0.5 or 1 mg/kg ww muscle meat of fish, depending on the fish species.	Commission Regulation (EC) No 1881/2006 and 629/2008
Dioxins and PCBs		
Sum of dioxins (WHOPCDD/F-TEQ)	3.5 pg/g ww muscle meat of fish and fishery products.	Commission Regulation (EC) No 1259/2011[23]
Sum of dioxins and dioxin-like PCBS (WHO-PCDD/F-PCB-TEQ)	6.5 pg/g ww muscle meat of fish and fishery products.	Commission Regulation (EC) No 1259/2011
PCBs (Sum of PCB28, PCB52, PCB101, PCB138, PCB153, and PCB180 (ICES – 6))	75 ng/g ww muscle meat of fish and fishery products.	Commission Regulation (EC) No 1259/2011
Polycyclic aromatic hydrocarbons		
Benzo(a)pyrene	5 µg/kg ww fresh bivalve molluscs.	Commission Regulation (EC) No 835/2011[24]
Sum of benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene and chrysene	30 µg/kg ww fresh bivalve molluscs.	Commission Regulation (EC) No 835/2011

Table 17: Substances and maximum levels for fish and seafood set in EU food regulations. ww=wet weight.

- There is little information on additional contaminants. Some substances (e.g. As, Cu, Zn, PBDE, PCBs, PFOs, TBT, HBCDD, radionuclides, etc.) are also measured in fish and/or seafood by some Member States, but there is no GES assessment due to the lack of thresholds values specified in the food legislation. An assessment for specific substances (e.g. PBDE) can be provided since there is a WFD Environmental Quality Standard based on human health risks.

- According to the Commission Decision (EU) 2017/848, the scale of assessment for Descriptor 9 should be the catch or production area in accordance with Article 38 of Regulation (EU) No 1379/2013[25]. Depending on the Member States, samples coming from food monitoring programmes can be or not georeferenced, so the required scale of assessment is not always possible. Table 18 provides the information on the origin of the samples available in the reports provided by Member States.

[23] Commission Regulation (EC) No 1259/2011 of 2 December 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels for dioxins, dioxin-like PCBs and non dioxin-like PCBs in foodstuffs

[24] Commission Regulation (EC) No 835/2011 of 19 August 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels for polycyclic aromatic hydrocarbons in foodstuffs

[25] Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules (OJ L 165, 30.4.2004, p. 1).

- Moreover, according to the 2017 Decision, within each region or subregion, Member States shall ensure that the temporal and geographical scope of sampling is adequate to provide a representative sample of the specified contaminants in seafood in the marine region or subregion. Since Descriptor 9 focuses on commonly consumed species (with a very local profile), care should be taken to make a selection of species for monitoring in order to assure a representative and good coverage of the entire (sub)region.

- Regional assessments are not available and there is no work in progress within the Regional Sea Conventions for either the monitoring and assessment of relevant contaminants in seafood or the establishment of thresholds values.

	MS	Sampling areas	Species
North-east Atlantic	BE	FAO fishing zone 27: South North Sea (27.4c) the Channel (27.7d) the Western Channel (27.7e).	Fin fish (flounder, sole), cartilaginous fish (shark, ray), crustaceans (gray shrimp), bivalve molluscs (shell Saint Jacques), cephalopods (squid).
	DE	No current D9 nationwide evaluation because, under food law, there are no requirements on the labelling of the areas of origin of the fish, so georeferenced information on the location of the sampled fish is not available. However, a recent study (Fliedner et al., 2018) has showed that georeferenced samples of the German environmental specimen bank (ESB) can be suitable for D9 assessments, although only coastal areas of the North Sea are covered. The marine sampling sites of the ESB are located in the coastal areas of the Central North Sea (FAO/ICES Division 27.4.b). The two North Sea sampling areas are part of the National Park Wadden Sea, more precisely of the National Parks and Biosphere Reserves “Lower Saxony Wadden Sea”, and “Schleswig-Holstein Wadden Sea”.	ESB study: Blue mussel (*Mytilus edulis*) and eelpout (*Zoarces viviparus*) (overall, the mussel samples are fully suitable for D9 assessments. The eel is suitable with the restriction that it is not a common food fish).
	NL	North Sea: Partly from close to the coast, partly from the pelagic part.	Sea fish (e.g. cod, whiting, haddock, herring, sea bass, plaice, tongue, dab), mussels, shrimps, North Sea crab.
	SE	North Sea.	Mussel, perch, herring. The National Food Administration's dioxin control refers to herring, sprats, salmon and trout.
Baltic Sea	DE	Since there is no nationwide evaluation, results from the food monitoring of Schleswig-Holstein and Mecklenburg-Western Pomerania for mussels in coastal waters (up to 12 nm) and herring in the western Baltic (ICES boxes 22 and 24) are used for D9 assessment. Moreover, georeferenced samples are available from the ESB study: Baltic Sea West of Bornholm (FAO/ICES Subdivision 27.3d.24).	Herring (Clupea harengus) and mussels. ESB study: Blue mussel (*Mytilus edulis*) and eelpout (*Zoarces viviparus*).
	EE	ICES 28-1: Gulf of Riga ICES 28-1: Opening of the Baltic Sea ICES 28-2: Western Gulf of Finland (mouth) ICES 32: East of the Gulf of Finland (Gulf of Finland).	Baltic herring, perch, sprat, flounder, river lamprey, salmon.
	FI	Kvarken and the Gulf of Bothnia, Aland Archipelago and Northern Baltic Sea (The Gulf of Finland).	Baltic herring, whitefish, perch, smelt, sprat, pike, pikeperch, cod, scallop, perch.
	LV	Gulf of Riga Proper Baltic Sea.	Cod, flounder.

	SE	Gulf of Bothnia Proper Baltic Sea.	Mussel, perch, and herring. The National Food Administration's dioxin control refers to herring, sprats, salmon and trout.
Black Sea	RO	Marine Waters (BLK_RO_RG_MT01). No evaluation (no data available) for waters with variable salinity (BLK_RO_RG_TT03), coastal (BLK_RO_RG_CT) and broad (BLK_RO_RG_MT02).	Particularly molluscs of commercial interest (*Rapana venosa and Mytilus galloprovincialis*).
Mediterranean Sea	EL	Adriatic Sea Ionian and Central Mediterranean Aegean and Levantine and Seas	Fish and shellfish collected by food authorities and data from literature*: Mullus barbatus, Boops boops, Mytilus galloprovincialis, Mullus surmuletus, Coris julis, Eutrigla gurnardus, Spicara smaris, Serranus cabrilla,Mugil cephalus, Sarpa salpa, Siganus rivulatus, Liza saliens, Engraulis encrasicolus, Merluccius merluccius, Atherina boyeri, Sardina pilchardus, Parapenaeus longirostris, Loligo vulgaris*.
	IT	Adriatic Sea Ionian and Central Mediterranean Western Mediterranean	Data from specific monitoring for MSFD: *Mullidae, Merluccidae*, *Muricidae*, bivalve molluscs.

Table 18: Available information on sampling areas and species in the ongoing reporting of Descriptor 9 under Article 17 of the MSFD.

<u>*Conclusions about the status of Descriptor 9:*</u>

- The overall status for the contaminants included in the food legislation is good. However, the levels of dioxins and dioxin-like PCBS are above thresholds values in some fish species from some areas of the Baltic Sea (Table 19).

- The concentrations of other relevant substances have been measured, but the data are scarcely provided in the Member States text reports.

- Mussels and eels from the Environmental Specimen Bank study, which can be considered representative of German marine waters (Fliedner et al., 2018), present concentrations of tributyltin (TBT) below the OSPAR Environmental Assessment Concentration and concentrations of hexabromocyclododecane (HBCDD) and perfluorooctane sulfonic acid (PFOS) below the biota Environmental Quality Standard of the WFD. However, the levels of PBDE are above the WFD Environmental Quality Standard, which refers to protection goal “human health”.

- The levels of DDT are below the limit of detection in herring from the Western Baltic Sea (ICES boxes 22 and 24).

- DDT and PCBs concentrations in *Mullus barbatus* and *Boops boops* collected from eight marine locations in Greece during 1994-2014 are low and below the threshold levels set for human health by other food authorities (Hatzianestis, 2016).

- Romania has established national threshold values for DDTs, HCB, lindane, aldrin, dieldrin and aldrin[26]. These thresholds were exceeded in some samples of molluscs (*Rapana venosa* and *Mytilus galloprovincialis*): around 2% of samples for DDTs, HCB, lindane, and aldrin; 20% for aldrin; and 11% for dieldrin.

- As said above, other contaminants are also measured but not evaluated due to the lack of threshold values (e.g. As, Cu, Zn, Ni, Cr, petroleum hydrocarbons, etc.).

- Regarding radionuclides, the concentrations of Cs-137 are below thresholds (600 Bq kg-1 fresh weight) in Greece and in several parts of the North-east Atlantic. Other radionuclides (Cs-134, Sr-90, and I-31) are below limits of detection in the Wadden Sea of Lower Saxony (Germany).

Area	**Cd**	**Pb**	**Hg**	**Dioxins and dioxin like PCBs**	**Non-dioxin like PCBs**	**PAHs**
Baltic Sea	GES (< thresholds in herring, sprat, flounder, perch)	GES (< thresholds in herring, sprat, flounder, perch)	GES (< thresholds in herring, sprat, flounder, perch)	No GES (> thresholds in herring (Gulf of Riga, Gulf of Finland and Gulf of Bothnia) and flounder)	GES (< thresholds in fish)	GES (< thresholds in fish)
Black Sea	GES (3% samples above thresholds in molluscs, *Rapana venosa* and *Mytilus galloprovincialis*)	GES (< thresholds in molluscs)	No determined	No determined	No determined	GES (5.7% samples above thresholds in molluscs, *Rapana venosa* and *Mytilus galloprovincialis*)
Mediterranean Sea	GES (only three cases above thresholds in shellfish)	GES (< thresholds in fish and bivalves)	GES (< thresholds in fish and bivalves)	GES (< thresholds)	GES (< thresholds)	GES (< thresholds)
North-east Atlantic	GES (< thresholds in fish and mussels)	GES (< thresholds in fish and mussels)	GES (< thresholds in fish and mussels)	GES (< thresholds in fish and mussels)	GES (< thresholds in fish and mussels)	GES (< thresholds in fish and mussels)

Table 19: Status of the contaminants included in the food legislation in the different marine regions (according to the information reported for MSFD by 10 Member States).

2.3. Other assessments

There are many studies in the literature related to contaminants in fish and seafood for human consumption in EU marine waters. This section provides some examples in order to complement the information provided by Member States under MSFD as well as to include areas for which MSFD reporting has not yet been completed.

[26] National legislation for pesticides: Order 147/2004 on the approval of sanitary and veterinary safety rules for pesticide residues in products of animal origin.

Contaminants included in EU food regulation 1881/2006 and amendments

Metal concentrations (Hg, Cd, Pb) in fish and seafood from different European locations are normally below the established regulatory levels, e.g.:

- In gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) collected off the Corsica coast in the Northwestern Mediterranean (Marengo et al., 2018).
- In gilthead seabream and seabass from fish markets from the Aegean and Cretan Sea (Renieri et al., 2019).
- In mussels (*Mytilus galloprovincialis*) collected from coastal areas from the gulf of Naples (Italy) (Arienzo et al., 2019).
- In different fish species (*Sardina pilchardus*, *Mullus barbatus*, *Mullus surmuletus*, *Merluccius merluccius* and *Parapenaeus longirostris*) collected from the Sicilian coast (southern Italy) (Traina et al., 2018).
- In most consumed species of fish (whitefish and bluefish), and other seafood (crustaceans and bivalve molluscs) from fish markets and supermarkets from the Canary Islands (Spain) (Rodríguez-Hernández et al., 2017).
- In ray fish (*Raja clavata*) caught in the Mid-Atlantic region (Azores, Portugal) (Torres et al., 2016).
- In Swordfish (*Xiphias gladius*) collected around Corsica Island (Mediterranean Sea (only one specimen was reported to exceed Pb limits) (Gobert et al., 2017).

Nevertheless, fish is recognized to present high concentrations of these metals (Bosch et al., 2016; Berntssen et al., 2017) and consequently, there are guidelines that recommend to limit or avoid consumption of some fish species (e.g. trophic-level predatory fish such as shark, swordfish, and king mackerel), particularly for young children and pregnant and breastfeeding women (www.fda.gov/fishadvice). For example, a statistically significant and positive association was found between fish and shellfish consumption and hair Hg concentrations in 4 year-old children from Menorca (Spain) (Junqué et al., 2017). Moreover, swordfish (*Xiphias gladius*) collected from FAO areas from EU countries like Spain and Portugal and imported in Italy were considered to pose an alert for children with the present fish consumption volume (Esposito et al., 2018).

Fish from certain areas may contain relatively high levels of dioxins and dioxin-like PCB, for example in the Baltic Sea (EFSA, 2018). The concentrations of these compounds have declined since the late 1970s, but there are still concerns regarding consumption of finfish with a high oil content and acceptable exposure to these compounds (Berntssen et al., 2017).

PCB levels in marine fish from Bulgarian Black Sea were found lower than those reported from other regions and did not seem to pose a health risk (Stancheva et al., 2017).

Other contaminants

Other metal and metalloids relevant for seafood include arsenic (As), nickel (Ni) and chromium (Cr). Concerning As, a legal limit does not exist, but the International Agency for Research on Cancer has included this element into the list of carcinogens for humans. Findings indicate that fish and seafood are likely to be the main source of As dietary intake (Filippini et al., 2018). Fish concentrations of As are usually lower than 5 mg/kg fw, although higher concentrations have been reported in Northeast Arctic cod (up to 100 mg/kg fw). High levels can also be found in shellfish (Chiocchetti et al., 2017). Potential human exposure to As associated with fish consumption has been also reported (Rodriguez-Hernandez et al., 2016; Traina et al., 2018).

In the frame of the ECsafeSEAFOOD project[27], a variety of halogenated flame retardants were measured in commercial seafood samples from European countries. PBDEs were frequently detected and found at levels above the WFD Environmental Quality Standard. Mussels and seabreams presented the highest concentrations. The levels of hexabromocyclododecane (HBCD), found in half of the samples, were below the WFD Environmental Quality Standard, while other compounds such as tetrabromobisphenol A (TBBPA) and hexabromobenzene (HBB) did not occur as frequent, but their concentrations were not insignificant (Aznar-Alemany et al., 2017).

Polychlorinated naphthalenes (persistent organic pollutant (POP) under Stockholm convention) were detected in all samples of fish (including sardines, sprats, sea bass, mackerel, herring, grey mullet and turbot) harvested from UK marine waters, and extending north to Norwegian waters and to the Algarve in the South (Fernandes et al., 2015).

3. Observed trends

Some trends compared to the previous MSFD assessments from 2012 have been reported in the current Member States' text reports:

- GES is maintained in the North-east Atlantic Ocean region (the concentrations were also below thresholds in the past MSFD assessments in 2012).
- There is a decreasing trend in Pb concentrations in marine molluscs from the Black Sea of Romania compared to the previous assessment period (2006-2011).
- There is stability of organochlorine pesticide concentrations in marine molluscs of commercial interest from the Romanian part of the Black Sea compared to the assessment period 2006-2011.
- A conservative downward trend of Pb and Hg concentrations can be deduced in herring from the German part of the Western Baltic Sea (ICES boxes 22 and 24).
- It seems to be an improvement in the status of metals in the Italian part of the Mediterranean (Adriatic Sea, Ionian and Central Mediterranean and Western Mediterranean). In the 2012 MSFD assessments, the concentrations were above thresholds while they are below thresholds in the current MSFD reporting (although the coverage of the assessed area is lower in 2018 compared to 2012).

[27] Priority environmental contaminants in seafood: safety assessment, impact and public perception, http://www.ecsafeseafood.eu/

- There are decreasing trends (2016-2018) of dioxins in herring and salmon from the Finish part of the northern Baltic Sea, although concentrations in salmon still are on average higher than the threshold value (EU Fish III Project[28]).

- Considered the current trends in emissions, environmental levels of dioxins and dioxin-like PCBs are not expected to achieve GES in the Baltic Sea for Descriptor 9 by 2020.

- There is a pronounced multiannual variability for Cd in marine molluscs from the Black Sea of Romania, which, as a whole, show increasing levels in the period 2012-2017.

4. TECHNICAL OBSERVATIONS

- Currently, the assessment of MSFD Descriptor 9 is essentially based on the data coming from the food monitoring established at national (or local) level according to the food regulations. Food legislation sampling is not intended to provide information on the status of marine waters.

- Little information is available for non-regulated contaminants. There are many substances of concern for the marine environment with potential for accumulation in fish and seafood used for human consumption (e.g. arsenic, methylmercury, PBDE, perfluorinated compounds and emerging brominated compounds PFOs). As seafood is an important dietary source, monitoring of contaminants in fish is recommended in order to provide data to support the setting of standards at international level.

- The MSFD requires that GES has to be achieved or maintained for a specified region or subregion and the species monitored for Descriptor 9 shall be relevant to the marine region or subregion concerned. This implies that the geographical origin of the samples should be known. However, georeferenced samples are often difficult to obtain. In fact, monitoring programs on human exposure often lack the necessary information to link the samples and results to specific subregions. Moreover, these monitoring programs do not consider other contaminants of relevance in fish and other seafood.

- Descriptor 9 focuses on popular and commonly eaten species, which can have a very local profile and do not necessarily represent a good coverage of the (sub) region. Therefore, care should be taken when selecting the species for monitoring in order to make results comparable between (sub) regions. The selection of a limited number of target species from the most consumed species and the traceability of the catching or harvesting location would be advisable.

- It would be beneficial to improve the communication and information exchange between health and environmental institutions in order to increase the possibility to use health information arising from chemical contamination of seafood for the assessment of the quality of the marine environment.

[28] https://www.ruokavirasto.fi/en/organisations/scientific-research/scientific-projects/previous/Food-safety-and-quality-research/eu--fish-iii/

5. Key messages

- 2018 MSFD assessments for Descriptor 9 mainly focus on the few chemical contaminants regulated under food legislation (Pb, Cd, Hg, polycyclic aromatic hydrocarbons, polychlorinated biphenyl and dioxins).

- Overall, the concentrations of those contaminants are below the maximum levels established under food legislation. However, certain fish and fishery products from the Baltic region regularly exceed the maximum limits of dioxins and dioxin-like PCBs, although the concentrations have significantly decreased. This has led to the prohibition of sales of salmon in the area.

- All reported trends under Descriptor 9 of the MSFD are stable or decreasing, with the exception of cadmium in the Black Sea.

- Synergies between MSFD and programs of Regional Sea Conventions optimise monitoring costs and efforts. However, Regional Sea Conventions have not so far developed indicators for the assessment of the status of fish and seafood contamination in relation to human health as required by Descriptor 9.

- Despite there is a strong link between the two MSFD descriptors dealing with contaminants (Descriptors 8 and 9), assessment of seafood related to human health is different from monitoring biota for environmental purposes. On the other hand, concentrations exceeding the regulatory levels for foodstuff will likely also affect the ecosystem because food regulatory levels are usually higher than thresholds for assessing environmental pollution. It would be desirable to improve monitoring activities considering Descriptor 9 in conjunction with requirements for Descriptor 8.

Descriptor 10: Properties and quantities of marine litter do not cause harm to the coastal and marine environment

1. MSFD FRAMEWORK

COM DEC 2017/848/EU		COM DEC 2010/477/EU
D10 Marine litter		
D10C1 Litter	The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment.	10.1 Characteristics of litter in marine and coast 10.1.1 Trends in litter on shore 10.1.2 Trends in litter in water column
D10C2 Micro-litter[29]	The composition, amount and spatial distribution of micro-litter on the coastline, in the surface layer of the water column, and in seabed sediment, are at levels that do not cause harm to the coastal and marine environment.	10.1 Characteristics of litter in marine and coast 10.1.3 Trends in micro-plastics
D10C3 Litter ingested	The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned.	10.1 Characteristics of litter in marine and coast 10.2.1 Trends in litter ingested
D10C4 Adverse effects of litter	The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.	10.2 Impacts of litter on marine life

MSFD Descriptor 10 is providing a framework for the quantitative assessment of marine litter and its impacts in different compartments of the marine environment and for the identification and implementation of mitigation measures, in order to protect the environment from harm caused by marine litter. Special attention should be put on the location of sources and pathways of litter and micro-litter.

The different environmental compartments include the shoreline, the water surface and water column and the seafloor, which are considered for macro litter (> 5 mm in the largest extension) and micro-litter (< 5 mm) assessments through the MSFD criteria D10C1 and D10C2. The direct impact of litter on biota is considered through criterion D10C3 concerning litter ingestion and through D10C4 regarding entanglement and other harm. D10C3 and D10C4 may be assessed in any species of birds, mammals, reptiles, fish or invertebrates established through (sub)regional cooperation.

[29] Particles <5 mm classified in the categories ‘artificial polymer materials’ and ‘other’.

2. MARINE LITTER IN EU MARINE ENVIRONMENT

2.1. Ongoing reporting under the MSFD

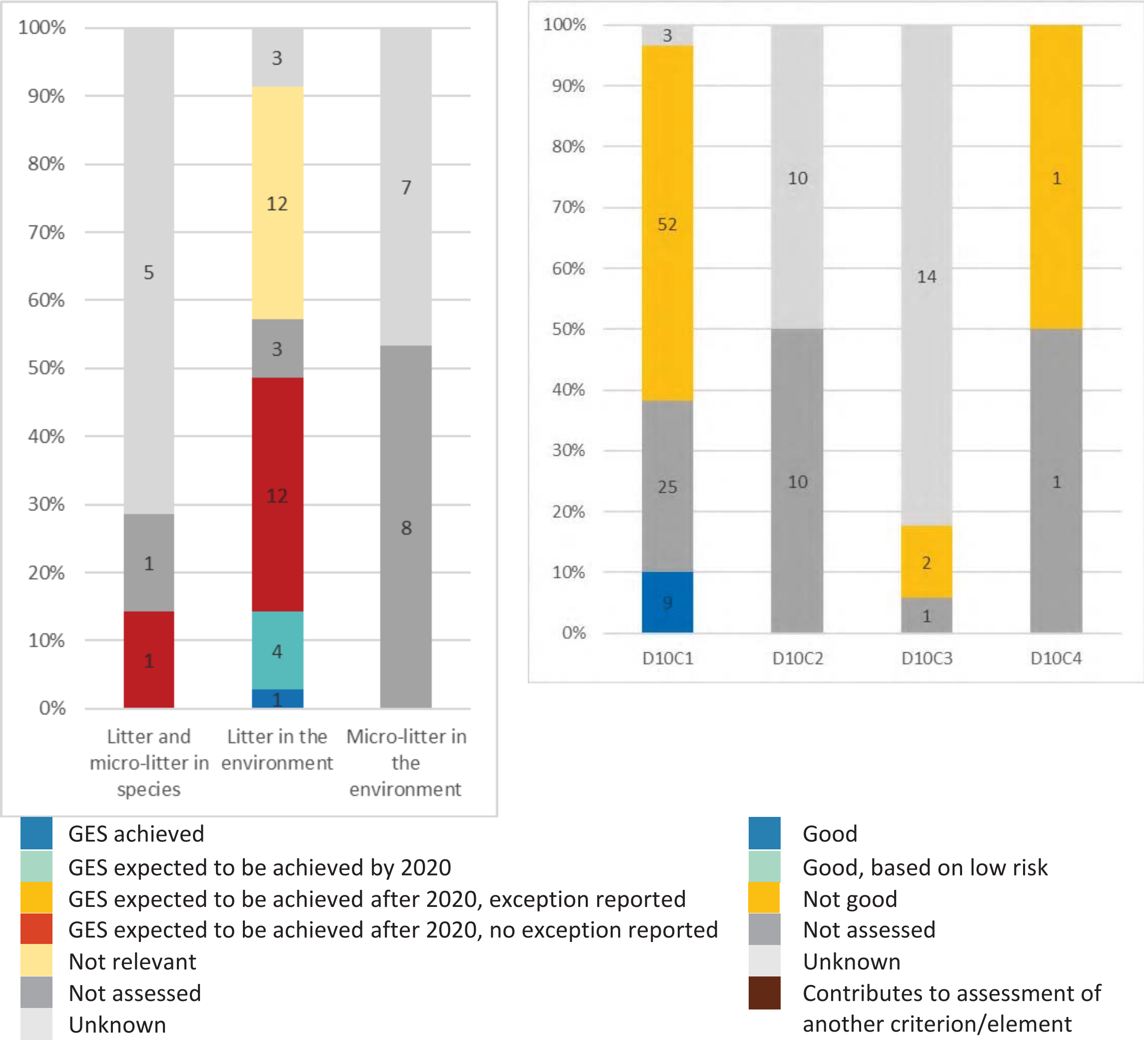


Figure 50: Latest MSFD assessments of good environmental status for marine litter per feature (left) and associated criteria (right) under Descriptor 10. The information comes from 10 Member States' electronic reports.

For litter in the environment, GES is achieved only in 1 of the assessments reported, while in 4 assessments GES will be achieved by 2020 and in 12 cases GES will be achieved only later than 2020 with no exceptions reported on this under Article 14. 12 assessments have reported the conclusion on GES as 'not relevant', therefore not concluding on the status of the feature.

Regarding litter and micro-litter in species, there have been few GES assessments reported. One of them states that GES will be achieved only later than 2020 and where no exception has been reported, and the others have been reported GES as 'not assessed' or 'unknown'. Litter and micro-litter in the environment is either 'not assessed' or 'unknown'.

The most reported criterion for marine litter assessment is litter in the environment (D10C1), while the micro-litter (D10C2), the litter ingested (D10C3) and the adverse effects of litter (D10C4) have been used in very few assessments. The criterion litter in the environment is assessed per category, and it has only achieved the ‘good’ status in 9 assessments, while it has been reported as ‘not good’ in 52 assessments.

2.2. MSFD and other assessments

Marine litter has been considered, in comparison to other pressures, only recently. The EU scale development and implementation of monitoring programmes was initiated only through MSFD provisions after its adoption in 2008. First reporting for initial MSFD assessment in 2012 revealed major shortcomings in the coverage and comparability of data (Palialexis et al., 2014). The MSFD Technical Group on Marine Litter (TG Litter) was therefore set-up on demand of Member States in order to provide collaborative harmonisation, guidance and provide support to the implementation of MSFD D10[30].

The assessment of the state of the marine environment regarding marine litter is limited by the temporal and spatial coverage of monitoring, method availability and comparability, and its data treatment and accessibility. While guidance has been provided (Galgani et al., 2013), large scale assessments of the marine environment are enabled only for few criteria elements.

The following information provide an overview on the status of Descriptor 10 based on reports by the MSFD TG Litter, the Regional Sea Conventions (on common regional parameters) and scientific projects and literature. Ongoing reporting by Member States is expected to enable a more complete and up-to-date overview on the state of the marine environment regarding marine litter.

2.2.1. Shoreline litter

The shores and beaches act as litter input interface through littering on the beaches, as source to the sea, and are impacted by litter washed ashore, then also acting as sentinel for floating coastal litter. Depending on beach location and use, their monitoring provides information on litter sources and, depending on local conditions, on litter being deposited by currents and wave action. Litter on shorelines can impact local wildlife and has adverse effects on humans, their wellbeing and commercial activities.

Monitoring of shoreline litter is done by observers who survey a beach area and report the found litter types in categories that have been agreed for harmonised data evaluation. Beach litter data from Member States have been collected on 331 beaches between 2012 and 2016 and treated (in close collaboration with EMODNET) in order to enable (sub)regional, national and EU scale baseline scenario analysis (Hanke et al., 2019, Figure 51). Data availability 2012-2016 allows the consideration of all EU regions, though with different coverage. All subregions, except for the Eastern Mediterranean Sea, can be evaluated.

[30] https://mcc.jrc.ec.europa.eu/main/dev.py?N=41&O=434&titre_chap=TG%2520Marine%2520Litter

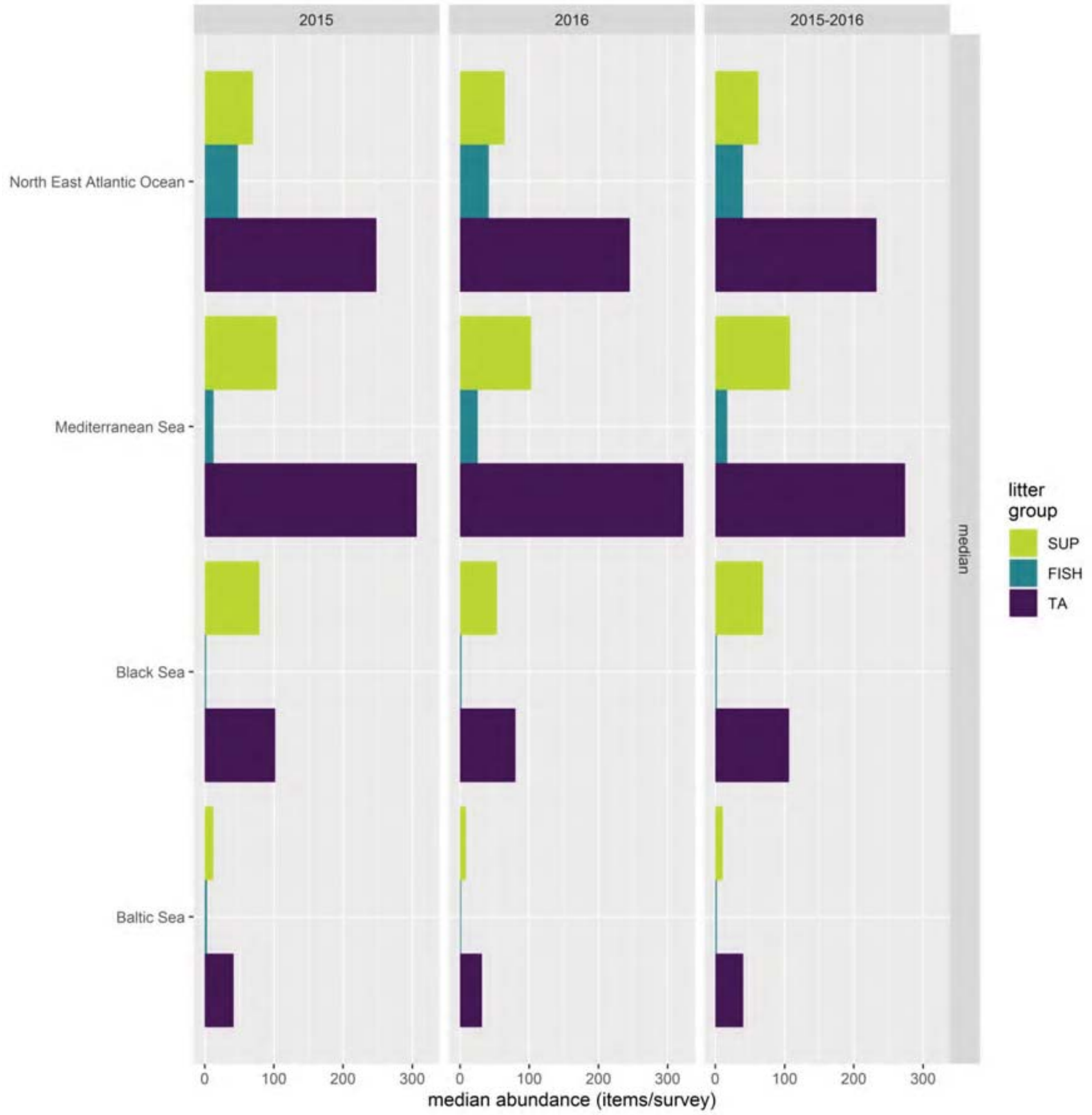


Figure 51: Beach litter abundance per category (SUP=single use plastics, FISH=fishery related items, TA=other litter items). Data have been aggregated as median values per region.

The mean total abundance of litter, i.e. the sum of single-use plastics, fishery-related and other litter in the North-east Atlantic Ocean amounted to 675 litter items per survey of 100 m, in the Mediterranean Sea 773 litter items, in the Black Sea 169 items and in the Baltic Sea 77 litter items (Hanke et al., 2019). Litter patterns are characterised by some high values of specific categories and beaches.

<u>*MSFD Top Beach Litter Items*</u>

A dedicated subset of data was analysed for identification of the most frequently occurring items (Addamo, 2018). Around 84 % of beach litter is consisting of plastic material (with a high percentage of artificial polymer materials), and around 50 % are related to single-use plastic items. The analysis provided a list of most abundant beach litter items as well as single use plastic items across Europe and enabled policy actions as part of the European Strategy for Plastics in a Circular Economy[31] and subsequent proposal for single-use plastics directive[32].

2.2.2. *Water column litter*

Once at sea, buoyant litter items and their fragments are a direct hazard for marine wildlife through entanglement and ingestion. Litter objects can become potential traps or being mistaken for food. Even buoyant litter objects can float subsurface, therefore a surface layer is proposed for monitoring. While the water column itself may contain litter, sinking or neutral-buoyant, it has due to the low occurrence density, not been recommended for routine monitoring.

Representative monitoring at sea requires the sampling of large surfaces, therefore ship or airplane based observations are being employed for monitoring. Due to differences in the methodologies (e.g. in the target size ranges) surveys may not be comparable and not all litter sizes are being considered. While some countries have performed monitoring of floating macro litter, there is no coordinated monitoring by Regional Sea Conventions. The main sources of information are therefore scientific publications. Harmonisation efforts at large scale have led to data becoming more comparable, though different size ranges and descriptions are still in use.

In the Black Sea, the EMBLAS-Plus project has performed large scale monitoring of floating litter. Visual surveys from ships found much variability and high concentrations in areas of the Black Sea (Figure 52). Concentrations of litter larger than 2.5 cm ranged from few ten to several hundred items per km², with elevated concentrations in the eastern basin.

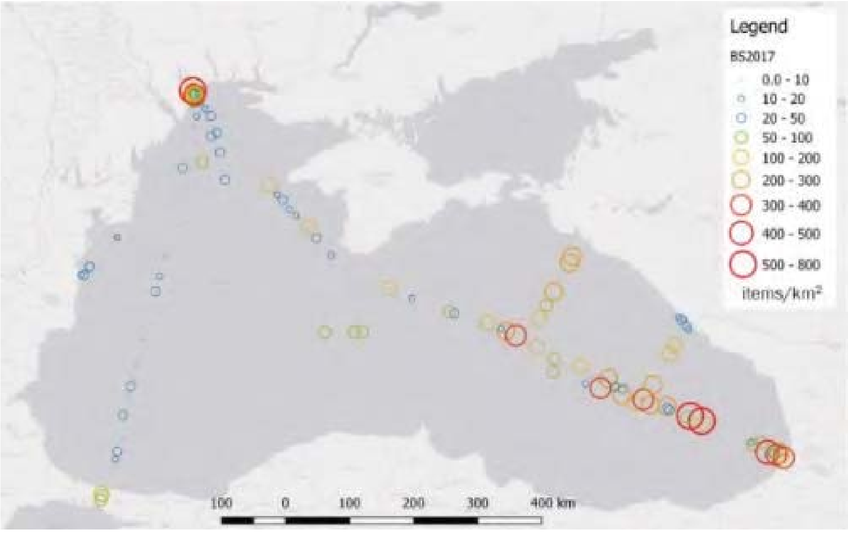


Figure 52: EMBLAS joint Black Sea survey of macro litter, 2016-2017 (Pogojeva et al., 2019).

Surveys in the eastern Mediterranean Sea found densities of floating litter, above 2.5 cm size, between 18 and 1593 items/km² (average 232 +/- 325 items/km²). Small plastic debris accounted for > 90% of the items surveyed (Constantino, 2019).

[31] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1516265440535&uri=COM:2018:28:FIN

[32] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018PC0340

Another study based on observations from ferries in the Mediterranean Sea found an average amount of macro-litter (above 20 cm size in its largest dimension) in the range of 2-5 items/km², with the highest concentrations observed in the Adriatic Sea (Arcangeli et al., 2018) (Figure 53).

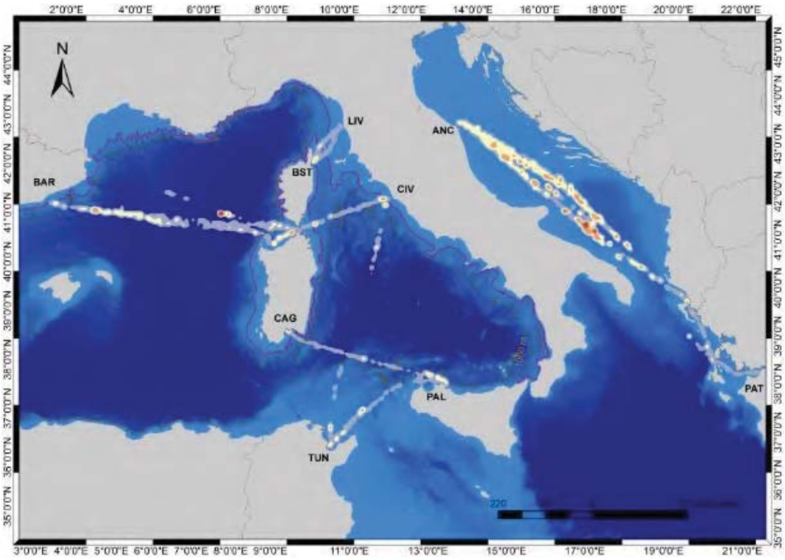


Figure 53: MEDSEALITTER floating macro litter observations from ferry lines in the Mediterranean Sea. From Arcangeli et al. (2018).

2.2.3. *Seafloor macro litter*

Litter entering the sea through different pathways is assumed to end-up mostly on the seafloor. While this is obvious for litter with a higher density than seawater, also less dense litter sinks over time due to biofouling and subsequent buoyancy change.

Most seafloor litter monitoring is performed by bottom trawling during fishery surveys, with very few investigations by scientific surveys in areas where trawling cannot be done.

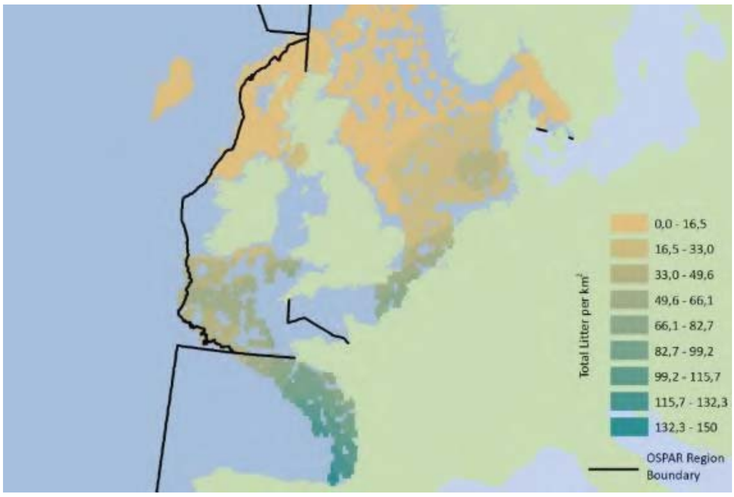


Figure 54: Seafloor litter distribution in the North Sea and other North-east Atlantic areas (OSPAR, 2017g). Note that not all results are directly comparable as different trawling gear were employed.

Some fishery-related surveys like the International Bottom Trawl Survey (in the North-east Atlantic Ocean), the Baltic International Trawl Survey and the Mediterranean International Trawl Survey provided the following results from bottom trawling litter bycatch:

- *Baltic Sea*: Over half (58 %) of the 1599 Baltic Sea hauls reported in 2012-2016 contained marine litter items. The average number of items was clearly highest in the Western Gotland Basin. Plastic was the most common litter material category at the Baltic Sea scale, constituting on average around 30 % of the number of items and 16% of the weight. A weak but statistically significant increase in seafloor litter representing non-natural materials was seen over the studied time period (HELCOM, 2018c).

- *North-east Atlantic Ocean*: The most recent assessment of seabed litter was undertaken in 2017 as part of OSPAR's Intermediate Assessment of the state of the marine environment. This showed that litter is widespread on the seafloor across the areas assessed, with plastic being the predominant material encountered. Larger amounts of litter and plastic were found in the eastern Bay of Biscay, southern Celtic Sea and English Channel than in the northern Greater North Sea and Celtic Seas (OSPAR, 2017g) (Figure 54). This could be due to larger anthropogenic inputs, rivers, prevailing winds and/or currents. Previous studies have shown that the Bay of Biscay receives large amounts of litter from local rivers and sea currents that may result from large-scale circulation in the sub-region as a whole. In general, floating and sinking litter follow different pathways and gather in different hotspots, which do not necessarily overlap.

- *Mediterranean Sea*: The abundance and composition of seabed litter in the Northern and Central Adriatic Sea were investigated at 67 stations with bottom trawl nets within the SoleMon project. Average litter density observed was 913 ± 80 items/km^2, ranking the Adriatic as one of the most polluted basins worldwide. The study showed that plastics were the dominant material in terms of quantity (80%) and in terms of weight (62%). Plastics were mainly bags, sheets and mussel nets. Higher quantities of litter were found in coastal areas, especially in front river mouths, coastal cities and mussel farms. In deep waters, litter hotspots were associated with most congested shipping lanes, indicating an additional litter input to the basin. Litter composition resulted to be largely driven by the vicinity to local sources, i.e. mussel farming installations and most congested shipping routes (Pasquini et al., 2016).

Available data from scientific publications is being collected for facilitated data accessibility[33] (Tekman, 2018). Reports on very high seafloor litter densities in accumulation areas, above 1 item/m of linear observation path in the Messina channel (Pierdomenico, 2019), confirm the need to expand the range of monitoring methodologies and coverage. Due to the scarce spatial coverage, no large scale assessments on seafloor can currently be made, while different quantification and reporting methods hinder data comparison.

Derelict fishing gear is a particular threat, due to the continuous acting of lost or discarded fishing gear as trap and obstructing of habitats. There is no quantitative overview available, though local assessments and clean-up activities have been made and

[33] https://litterbase.awi.de/

find high amounts, such as 362 items on 21 km² seafloor in the northern Adriatic Sea (Moscino, 2019).

2.2.4. Micro-litter

Litter particles, including microplastics, smaller than 5 mm require different monitoring techniques. The water surface and sediments are main monitoring matrices. There are still challenges in relation to quality assurance and control, e.g. the need to avoid contamination during sampling/analysis and for verified identification of litter material. To date, large scale comparable assessments are still not possible, due to different reporting units and non-harmonized monitoring approaches.

Floating micro-litter

Floating micro-litter is sampled through a surface town net (Manta net), collecting particulate material in a surface layer with a mesh size of 333 µm. Due to the limited sampled area, the method does not provide representative sampling for larger objects. While few countries report these results, some scientific publications and reports provide insights on the encountered levels of floating micro-litter.

- *Baltic Sea*: Microlitter has been sampled for a few years in the Baltic Sea and a number of different methods and sampling devices have been used. Although coordinated, regular monitoring is under development. As one example of results, 0.3-2.1 particles/m³ were noted in the Gulf of Finland and 0.04-0.09 particles/m³ were recorded in the South Funen Archipelago and Belt Sea, both studies using Manta trawls with mesh sizes over 333 micrometres (HELCOM, 2018c).

- *Mediterranean Sea*: Concentrations of micro-litter in the Mediterranean Sea are high, different surveys report concentrations above 10^5 particles/km², up to $4x10^5$ particles/km² (Cincinelli, 2019).

- *Black Sea*: A study on microplastics in zooplankton samples taken during two cruises along the south-eastern coast of the Black Sea, in November of 2014 and February of 2015, found microplastics (0.2-5 mm) in 92% of the samples. Concentrations of micro-litter in November ($1.2 \pm 1.1x10^3$ particles/m³) were higher than in February ($0.6 \pm 0.55x10^3$ particles/m³). This relatively high microplastic concentrations suggest that the Black Sea is a hotspot for microplastic pollution and that it is urgent to understand their origins, transportation, and effects on marine life (Aytan, 2016).

Overall, monitoring results are not comparable and besides the different sampling tools and reporting units, sample contamination and other aspects of quality assurance and control (e.g. the lack of reference materials) are challenging. Efforts are underway in order to improve that situation through agreed guidance, joint data management tools, such as EMODNET, and the set-up of a quality assurance and control framework under the MSFD.

Large scale micro-litter assessments in other matrices, such as beach, sediment and seafloor are not yet available.

Through the European Commission Scientific Advice Mechanism, current information on potential impacts of microplastics have been evaluated and confirmed the need for quantitative assessments and the limitation of microplastic quantities in the environment (SAM, 2019).

3. Litter impacts

Impacts of marine litter are harming marine ecosystems mainly through litter ingestion, entanglement, enhancing the spread of non-native species, and potential toxicity of released chemicals from plastic. Population level effects are still unknown.

A large number of species is known to be impacted by marine litter (Werner et al., 2016). Quantitative assessments are challenging as impacted animals may be often perished and lost at sea. Monitoring is therefore mostly based on the occasional finding of dead or impacted animals.

Ingestion

Marine wildlife ingests litter which it mistakes for food or ingests by accident. As elements for assessments under MSFD D10C3, regional specific species have been identified for monitoring of litter ingestion.

In the North-east Atlantic Ocean, the fulmar bird is used as sentinel species for the ingestion of litter. Over a five-year period 2010–2014, across all 525 fulmar stomachs analysed over this period, 58% contained more than 0.1 g of plastic, whereas OSPAR's long-term goal is to reduce this to less than 10%. Of all birds analysed, 93% had some ingested plastic, and average values per bird were 33 particles and 0.31 g. There has been no significant change in the amount of plastic in fulmar stomachs over the past ten years (OSPAR, 2017g). On the Irish coast within 30 months, 121 birds comprising 16 different species were collected and examined for the presence of litter. Of these, 27.3% comprising 12 different species were found to ingest litter, mainly plastics. The average mass of ingested litter was 0.141 g. Among 14 sampled Northern fulmars, 13 (93%) had ingested plastic litter, all of them over the 0.1 g threshold used in OSPAR and MSFD policy target definition (Acampora et al., 2016).

In the Mediterranean, from 2012-2014, 85% of the turtles considered (n = 120) collected on the Italian coast were found to have ingested an average of 1.3 ± 0.2 g of litter (dry mass) or 16 ± 3 items (Matiddi et al., 2017). Within the MSFD TG Litter and through the INDICIT project[34], a methodology for the assessment of litter by turtles has been developed. The use of other species for assessment of ingestion is under development.

Entanglement

While there are recurrent incidents and reports of marine wildlife across many different species being entangled (Werner, 2016), there is no monitoring that would allow a large scale assessment. An evaluation of research literature considering seabirds analysed reports on wildlife-litter interactions, finding more species interacting through ingestion (n=164 species, 79.6%) than species interacting through entanglement (n=117; 56.8%) or incorporation of litter in nests. For 75 species (36.4%), evidence for both the interactions with ingestion and entanglement was found (Battisti et al., 2019), confirming the impact through the different interaction types.

[34] https://indicit-europa.eu/

Understanding litter pathways

Based on the incoming environmental litter occurrence data, modelling approaches can be employed to improve the understanding of litter pathways, thus identifying spatial litter sources and enabling targeted actions. This is of particular importance as marine litter is a transboundary problem and measures may be required far from the impact areas.

4. TECHNICAL OBSERVATIONS

- Harmonised monitoring methodologies and monitoring efforts should be improved in order to provide better assessments on the abundance and effects of the marine litter. Monitoring in most areas started recently, therefore the estimation of long-term trends is still not possible.

- In the EU, there are important data and assessment gaps regarding litter on seabed, on the water column, micro-litter and effects on marine species (especially entanglement).

- MSFD GES thresholds values for litter are being developed.

5. KEY MESSAGES

Marine litter, linked also to the occurrence of litter in the terrestrial and riverine environment, has received substantial attention and, helped by the assessments made through the MSFD, has led to a swift preparation of legislative actions at EU level against plastics, single use plastics and fishery related litter[35]. Specific actions at EU level under the Circular Economy Action Plan are also taken against intentionally added micro-plastics. Regional action plans against marine litter have identified a large number of management options that are being implemented. Furthermore, there are substantial national efforts. Still, litter quantity assessments and understanding of pathways are under development. Quantitative comparable assessments are needed to monitor progress in litter reduction. There are major gaps in knowledge and monitoring.

- Beach litter data from Member States between 2012 and 2016 resulted in a mean abundance of litter of more than 600 items/survey.

- Around 84 % of beach litter is consisting of plastic material and around 50 % are single-use plastic items. Fishing gear containing plastics accounts for another 27% of marine litter items found on European beaches.

- Rivers play an important role in transporting litter items from the terrestrial to the marine environment.

[35] For example the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A European Strategy for Plastics in a Circular Economy (COM/2018/028 final) or the Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (OJ L 155, 12.6.2019, p. 1).

- The presence of litter has been confirmed in all compartments of the marine environment (shoreline, water column and seafloor). Plastic items are the most abundant component of marine litter. Some studies and projects provide quantitative observations, but their temporal and spatial scale rarely allow for wider regional assessments.

- Litter is widespread on the seafloor across the areas assessed (e.g. it is present more than half of the area surveyed in the Baltic Sea, it is relatively high in the Bay of Biscay, and seems to be extremely high in the Adriatic Sea), with plastic being the predominant material encountered.

- Although there is no regular regional monitoring and results are not comparable, all scientific studies indicate the existence of considerable amounts of micro-litter in seawater.

- Ingestion of plastic by marine species is widespread in the European seas. A study from the North-east Atlantic (mostly focused on the North Sea) showed that 93% of all fulmar birds analysed had some ingested plastic. Levels of plastic ingestion by fulmars appear to have stabilised at around 60% of individuals exceeding the 0.1 g level of plastic ingestion. Another study from the Mediterranean Sea (focused in Italy) showed that 85% of the assessed turtles had ingested litter.

- There is no information to produce quantitative analyses of entanglement at large scale, but some preliminary findings suggest that interaction between birds and litter is less frequent through entanglement than through ingestion.

Descriptor 11: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment

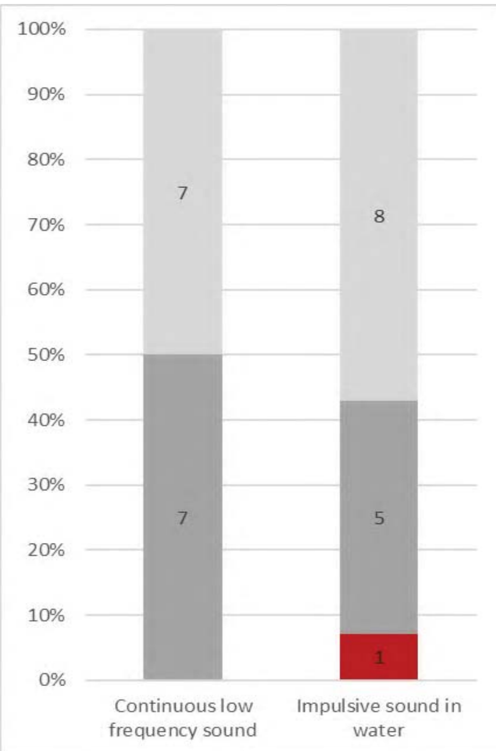
1. MSFD FRAMEWORK

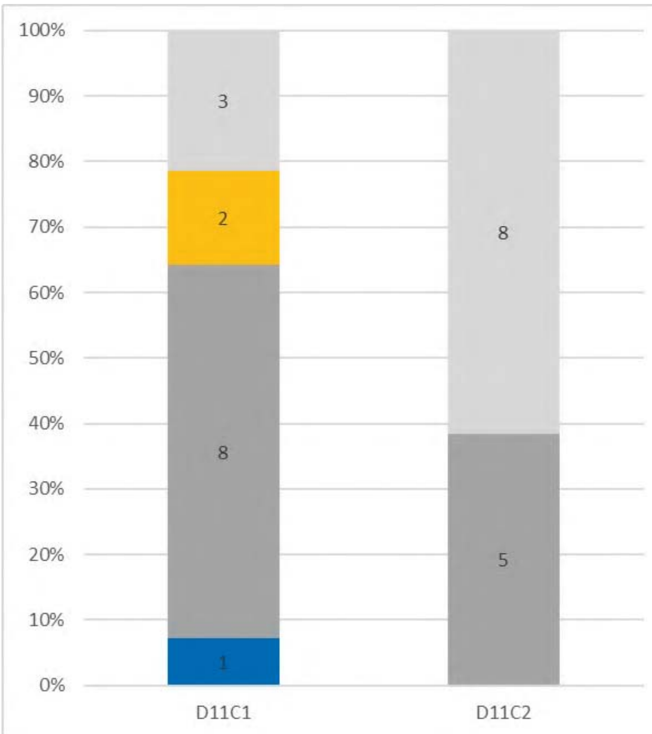
COM DEC 2017/848/EU		COM DEC 2010/477/EU
D11 Energy, including underwater noise		
D11C1 Anthropogenic impulsive sound	The spatial distribution, temporal extent, and levels of anthropogenic impulsive sound sources do not exceed levels that adversely affect populations of marine animals.	11.1 Distribution of impulsive sounds 11.1.1 Days with loud sound levels
D11C2 Anthropogenic continuous low-frequency sound	The spatial distribution, temporal extent and levels of anthropogenic continuous low-frequency sound do not exceed levels that adversely affect populations of marine animals.	11.2 Continuous low frequency sound 11.2.1 Ambient noise

Criteria relating to other forms of energy input (including thermal energy, electromagnetic fields and light) and criteria relating to the environmental impacts of noise are still subject to further development.

2. UNDERWATER NOISE IN THE EU MARINE ENVIRONMENT

2.1. Ongoing reporting under the MSFD





GES achieved
GES expected to be achieved by 2020
GES expected to be achieved after 2020, exception reported
GES expected to be achieved after 2020, no exception reported
Not relevant
Not assessed
Unknown

Good
Good, based on low risk
Not good
Not assessed
Unknown
Contributes to assessment of another criterion/element

Figure 55: Latest MSFD status assessments of underwater noise at overall level (left) and at criteria level (right) under Descriptor 11. The information comes from 10 Member States' electronic reports.

Under Descriptor 11, only one conclusion on GES has been reported for impulsive sound, where GES will be achieved later than 2020 with no exceptions reported on this under Article 14. All the rest of overall assessments are either 'not assessed' or 'unknown'.

The only criterion with some conclusion reported (by only two countries) is anthropogenic impulsive sound (D11C1), with 1 assessment in 'good' status and 2 in 'not good'. Most of the reported information, including all reports of anthropogenic continuous low-frequency sound (D11C2), are 'not assessed' or 'unknown'.

2.2. MSFD efforts to address underwater noise

Human activities at sea introduce additional energy into marine ecosystems, and this is a form of pollution. This energy includes underwater sound, magnetic and electromagnetic radiation, heat and (artificial) light. Currently, only underwater noise caused by anthropogenic sound inputs is directly addressed by the MSFD criteria under Descriptor 11, although the different forms of energy should be included. Underwater noise is the most widespread and pervasive form of energy in the marine environment (Van der Graaf et al., 2012). Human-induced underwater sound is divided into two categories – continuous and impulsive sound. Sound becomes 'noise' when it is of anthropogenic origin and has the potential to cause negative effects on marine animals over a short time-scale (acute effects) or a long time-scale (chronic effects) (Tasker et al., 2010, Van der Graaf, 2012).

Sources of continuous underwater noise are shipping; the operation of human-made structures or installations, in particular for energy production (e.g. offshore wind energy); and other offshore and coastal industrial activities (e.g. continued drilling and dredging). Sources of impulsive noise are seismic surveys (e.g. using air guns for oil and gas exploration); explosions (e.g. naval operations, mining, removal of munitions); pile driving (e.g. for the deployment of windmills); the construction of offshore structures or installations; or sonar sources (e.g. military practices). The loudness of a sound and its propagation in the ocean depends on its acoustic frequency and the physical properties of the ocean; impacts of sound/noise will, thus, depend on the exposure area, sound level, duration, distance and frequency.

EU-level efforts have focused on identifying the spatial distribution and sources of underwater noise as a first step into its assessment because such information is relevant to characterise the potential exposure of marine ecosystems to this pressure. Monitoring of continuous underwater noise has been deployed in many EU countries following the MSFD requirements and recommendations (Dekeling at al., 2014a; 2014b; 2014c), but the approach to data analysis and assessment is still under development. Therefore, monitoring (and related assessment) of underwater noise was reported by Member States as one of the areas where there is significant lack of monitoring data and, thus, of knowledge[36], and this includes both the characteristics and impacts of underwater noise across the EU level.

In 2011, a Technical Group on Underwater Noise (TG Noise) was set up under the MSFD. In 2012, the group provided a report clarifying the purpose, use and limitation of the indicators in the 2010 GES Decision and described methodology that would be "unambiguous, effective and practicable". In 2013, the main focus of TG Noise was on developing a practical guidance for monitoring and noise registration for Member States. In 2014, TG Noise provided further advice on the actual progress of monitoring and recommendations on priorities for the review of the Commission Decision. Since 2015, TG Noise has been working on the upcoming MSFD assessments of the status of marine environment and target setting; the aim is to support Member States to make an improved assessment of their progress towards achieving GES, in particular for the Mediterranean Sea and Black Sea regions.

Under the 2016-2019 CIS work programme, TG Noise has been tasked to delivered advice on methodology and options to set threshold values. A common methodology to assess potential impacts of impulsive anthropogenic sound has been delivered as a first step to setting thresholds. Next key deliverables of the group will include:

- a proposal for a common methodology for assessment of the effects of continuous anthropogenic sound,

- options for setting thresholds for both impulsive and continuous sound (starting in 2020).

2.3. Other assessments

A register of impulsive underwater noise where Member States report its spatial distribution, intensity and temporal frequency, measured by pulse block days was established by OSPAR and HELCOM, and is managed by ICES[37]. This ICES register currently only includes northern European data for the period 2008-2017. Regional Sea Conventions are joining efforts and developing guidance (e.g. HELCOM, 2019, OSPAR, 2019b). Mediterranean Sea and Black Sea data is hosted by ACCOBAMS (the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area). Data from these registers was assessed by ETC/ICM (2019b) in order to illustrate the level of potential pressure from impulsive noise.

Several research projects are in place to assure fast progress towards the standardization of ambient underwater noise monitoring and assessment of impulsive noise (e.g. Heinis et al., 2015; Tasker, 2016; Heinis, 2017; Merchant et al., 2018), but an EU-level assessment of underwater noise is currently not possible. For that reason, the analysis of human activities as a pressure proxy was used to obtain information about potential exposure of marine ecosystems to underwater noise from both continuous - from shipping and port activities - and impulsive noise, using data from the ICES register and ACCOBAMS (ETC/ICM, 2019b).

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[36] Report from the Commission to the European Parliament and the Council assessing Member States' monitoring programmes under the Marine Strategy Framework Directive COM(2017) 3.

[37] See http://www.ices.dk/marine-data/data-portals/Pages/underwater-noise.aspx and http://underwaternoise.ices.dk/map.aspx

Continuous underwater noise

Mapping of human activities related to shipping and ports provides a spatial overview of areas where continuous sound potentially occurs (Figure 56). Shipping is widely distributed in all EU marine regions and intensity is highest along shipping corridors and near ports. These places are considered as the most exposed to continuous underwater noise. Based on shipping density, the Mediterranean Sea has the widest area of very high traffic (27 % of area), followed by the Baltic Sea (19 % of the sea area) (Figure 56). Only 9 % of the area of Europe's seas does not have shipping traffic. The North-east Atlantic Ocean has the widest not-trafficked area (14 % of the area), whilst the Mediterranean Sea has only 1% of area not trafficked.

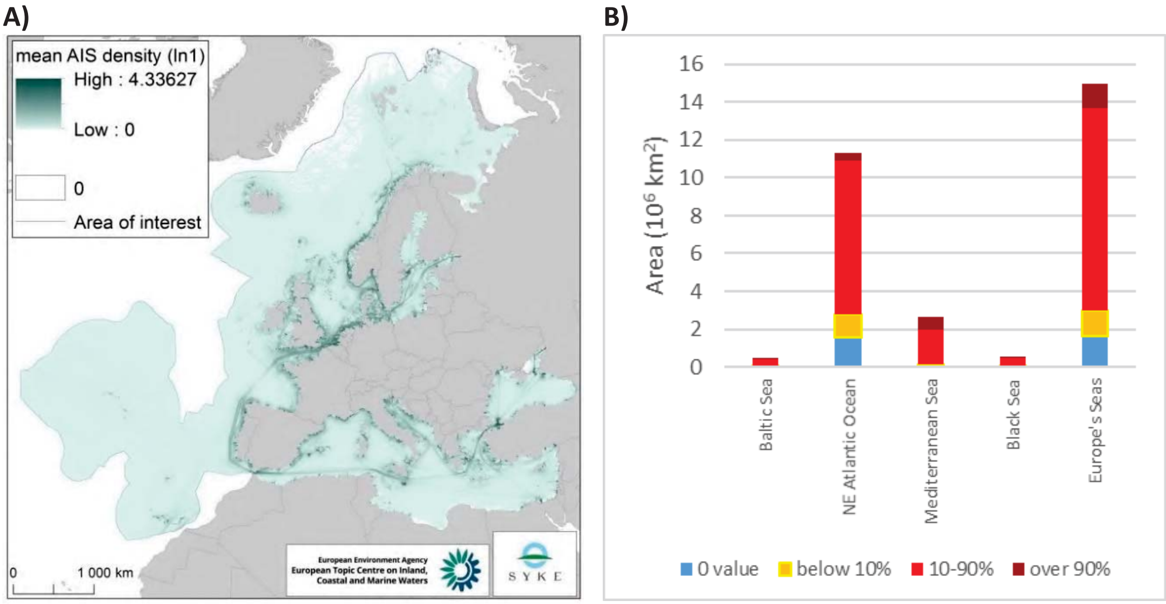

Figure 56: A) Distribution of maritime traffic across Europe's seas over the period 2011-2016 (from ETC/ICM, 2019b). B) Overall area of Europe's seas covered by shipping and proportion of each EU marine region were shipping takes place (from ETC/ICM, 2019b). Colours show four categories according to the percentage of area used by shipping in the area assessed.

Regarding trends in continuous underwater noise, European maritime freight traffic is expected to increase by 74-82 % between 2010-2030 and container port capacity will follow closely with a 42-50 % increase (OECD, 2016). However, the number of vessels in the main European ports may not increase so fast as the predicted maritime freight traffic because, overall, ship size is continuously increasing (UNCTAD, 2016). Studies indicate that larger and faster vessels emit higher values of underwater noise (e.g. McKenna et al., 2013). Thus, the current pressure trend is expected to increase unless it is offset or minimized by effective technical measures limiting emissions from ships and other sources of continuous underwater noise (ETC/ICM, 2019b).

Impulsive underwater noise

Pressure from impulsive noise likely occurs in 8 % of EU's sea area, including over large parts of the Baltic Sea, Central Mediterranean and Levantine Sea, North Sea, Celtic Seas, Balearic Sea and Adriatic Sea (Figure 57). However, spatial data coverage is not yet complete and it only indicates the spatial distribution of the main activities that can give rise to this type of underwater noise, not the actual noise level. Across the four EU marine regions, less than 1-32 % of the area assessed is under pressure from impulsive underwater noise. The largest area where relevant activities occur and, thus, likely affected by this pressure, is in the North-east Atlantic Ocean, but in the Baltic Sea the pressure coverage is widest in relation to the sea area (Figure 57).

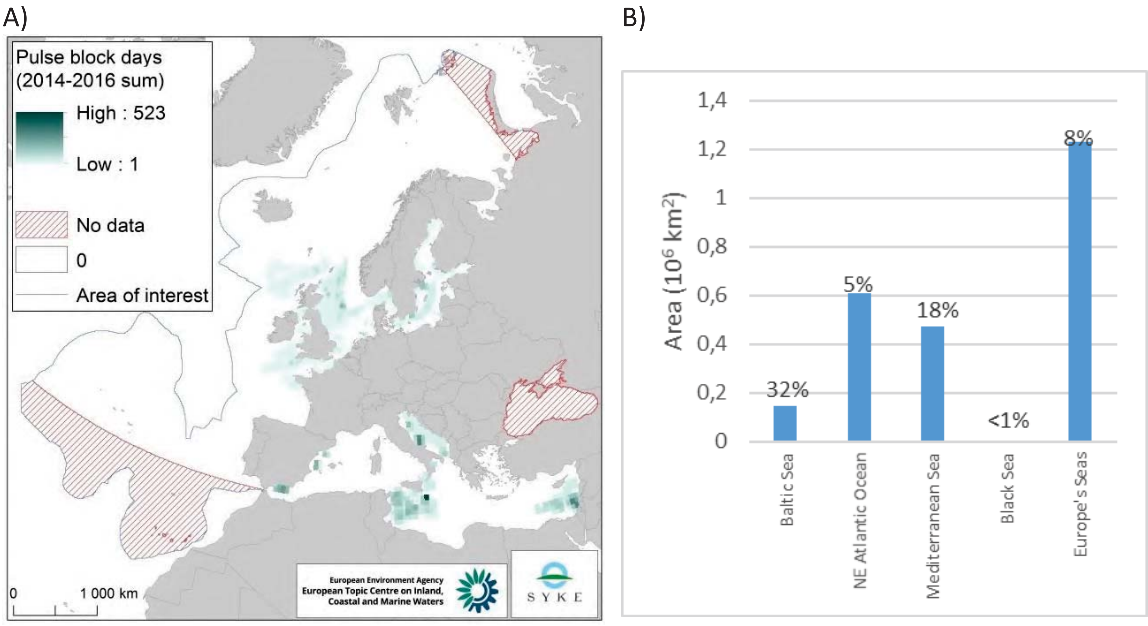

Figure 57: A) Distribution of activities causing impulsive underwater noise across Europe's seas over 2011-2016 (from ETC/ICM, 2019b). B) Overall area of Europe's seas covered by activities causing impulsive underwater noise and proportion of each EU marine region under the effect of relevant activities (from ETC/ICM, 2019b).

The trend in pressure from impulsive underwater noise can be assessed based on its driver, i.e. the development of the main human activities liable to cause this type of noise. Off-shore wind energy construction is one of main drivers of impulsive noise because the main building technique is pile-driving. This sector has experienced exponential growth across Europe's seas since 2000 and is expected to keep on growing (WindEurope, 2018), which is likely to increase pressure from impulsive underwater noise. Wind farms are also expected to be constructed in deeper waters and at larger distances from the shore, which would then also spatially extend the pressure. However, all these increases could be offset or minimized by using alternative construction methods or certain mitigation measures (Koschinski and Lüdemann, 2013).

3. Effects of underwater noise

For most marine animals, sound is important for short and long-range navigation and communication as well as for identifying prey, peers and predators. Human activities can change normal underwater sound levels, turning the sound to noise, and/or interfere with natural sound, which has the potential to impact these animals. Scientific investigations have documented various adverse physiological effects, including death, and disrupted behavioural responses of marine animal species to human induced changes in underwater sound levels (SBSTTA, 2012; Wright et al., 2016).

Criteria for the monitoring and assessment of the adverse effects of underwater noise are still under development (e.g. the thresholds determining what are 'adverse effects') and so there is no EU-level assessment of its impacts on marine life. However, based on the scientific literature, exposure to underwater noise can cause several types of adverse effects on marine animals, ranging from changes of behaviour to their death:

- Continuous underwater noise is likely to induce chronic (adverse) effects on marine animals, such as masking of communication and stress (Brumm, 2013).

- Both continuous and impulsive underwater noise can result in changes in behaviour. Stress and other types of harm to species of marine mammals, fish, shellfish (e.g. crabs) and sea turtles have been documented for decades from both types of underwater noise (e.g. Banner and Hyatt, 1973; Pickering, 1993; Engås et al., 1996; Samuel et al., 2005; Wysocki et al., 2006; Codarin et al., 2009; Popper et al., 2009; Brumm, 2013).

- Low and mid frequency impulsive underwater noise are likely to cause disturbance of marine animals even at low levels; where high levels of impulsive underwater noise induce acute (adverse) effects, including temporary or permanent injury to auditory systems, stranding of species to shore (Brumm, 2013), damage of tissue, or death (Popper and Hastings, 2009; Slabbekoorn et al., 2010).

Some mitigation measures are known for many sources of impulsive noise and are already included in Member State programmes of measures under the MSFD, as well as by OSPAR and HELCOM.

4. Technical observations

- The assessment of underwater noise across the EU is at an early stage and focuses on identifying and characterising sources and the (likely) spatial distribution of this pressure. There is a significant lack of monitoring programmes and data. While some underwater noise maps are available, status assessments of underwater noise are not yet available neither by Regional Seas Conventions nor by Member States under the MSFD.

- The spatial distribution of underwater noise is assumed to be based on the spatial distribution of the human activities introducing sound into marine ecosystems. Such a pressure analysis allows to conclude that elevated underwater noise, related to sound emissions from these activities, is widely distributed. However, the current pressure analysis does not consider noise propagation, intensity and characteristics.

5. Key messages

- EU-level efforts have currently focused on identifying the spatial distribution and sources of underwater noise as a first step into its assessment because such information is relevant to characterise the potential exposure of marine ecosystems to this pressure. The MSFD TG Noise has provided valuable technical guidance to assess underwater noise and will delivered advice on common methodologies and on options to set threshold values.

- A register of impulsive noise sources was established and currently includes northern European data (as it is centralised by ICES[38]), where Mediterranean and

[38] ICES is the International Council for the Exploration of the Sea, https://www.ices.dk/Pages/default.aspx

Black Sea data are hosted by ACCOBAMS[39]. Still, there are large gaps in monitoring and knowledge.

- Maritime traffic is the main source of continuous underwater noise and, thus, shipping and port activity can be used as a proxy for continuous underwater noise. The Mediterranean Sea has the widest area of very high traffic in the EU (27% of area), followed by the Baltic Sea (19 % of the area). In contrast, only 9% of EU's sea area has no shipping traffic.

- Impulsive underwater noise is spatially restricted (likely occurs in 8 % of EU's sea area) but still likely present in large areas of the Baltic Sea, Central Mediterranean and Levantine Sea, North Sea, Celtic Seas, Balearic Sea and Adriatic Sea.

- Given that most activities likely to cause continuous and impulsive underwater noise are expected to increase in the near future, it is highly probable that the trend in pressure from underwater noise will also increase. Some mitigation measures have already been put in place by Member States under the MSFD. In order to minimise the impact, limiting or offsetting underwater noise emissions should be considered at an early stage when planning to deploy the relevant technology or industrial activity (e.g. shipping corridors, wind farms).

- The impacts from current underwater noise levels on marine life cannot be assessed across Europe's seas. However, research activities demonstrate that exposure to underwater noise can cause several types of adverse effects on marine animals, ranging from changes of behaviour to their death.

[39] ACCOBAMS is the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area, http://www.accobams.org/

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