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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)**

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INTRODUCTION

The first cycle of implementation of the Marine Strategy Framework Directive¹ (MSFD) – with its holistic and integrative approach, large implementation area and knowledge requirements – demonstrated to be challenging. The first ‘marine strategies’ developed by Member States are just finalised and the evidence base to evaluate their effectiveness is still scarce.

The first assessment of EU marine waters was reported by Member States in 2012-13 under Article 8(1). Decision 2010/477/EU provided for methodological standards and criteria for determining good environmental status. From that first reporting, it was not possible to build a coherent marine knowledge base across Europe due to, among other reasons, inconsistency on indicators reported per criterion, high heterogeneity of methodological approaches, inconsistencies and gaps in the reported information, and lack of data or adequate time-series to assess all MSFD criteria. The number of unknown or not assessed areas largely outnumbered the assessed ones (Figures 1 and 2). To improve that situation, the Commission adopted in 2017 the new Decision 2017/848/EU, repealing the abovementioned 2010 Decision, setting out a detailed framework of criteria and methodological standards as well as methodologies for monitoring and assessment. Member States are required to work at regional or EU wide level to set threshold values to determine the extent to which good environmental status is achieved across the various descriptors² of the Directive.

¹ Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (OJ L 164, 25.6.2008, p. 19).

² The 11 qualitative descriptors are defined in Annex I of the Marine Strategy Framework Directive and further specified in Commission Decision 2017/848/EU. They include D1- Biodiversity, D2- Non indigenous species, D3- Commercial fish and shellfish, D4- Food webs, D5- Eutrophication, D6- Sea-floor integrity, D7- Hydrographical changes, D8- Contaminants, D9- Contaminants in seafood, D10- Litter, D11- Energy, including underwater noise.

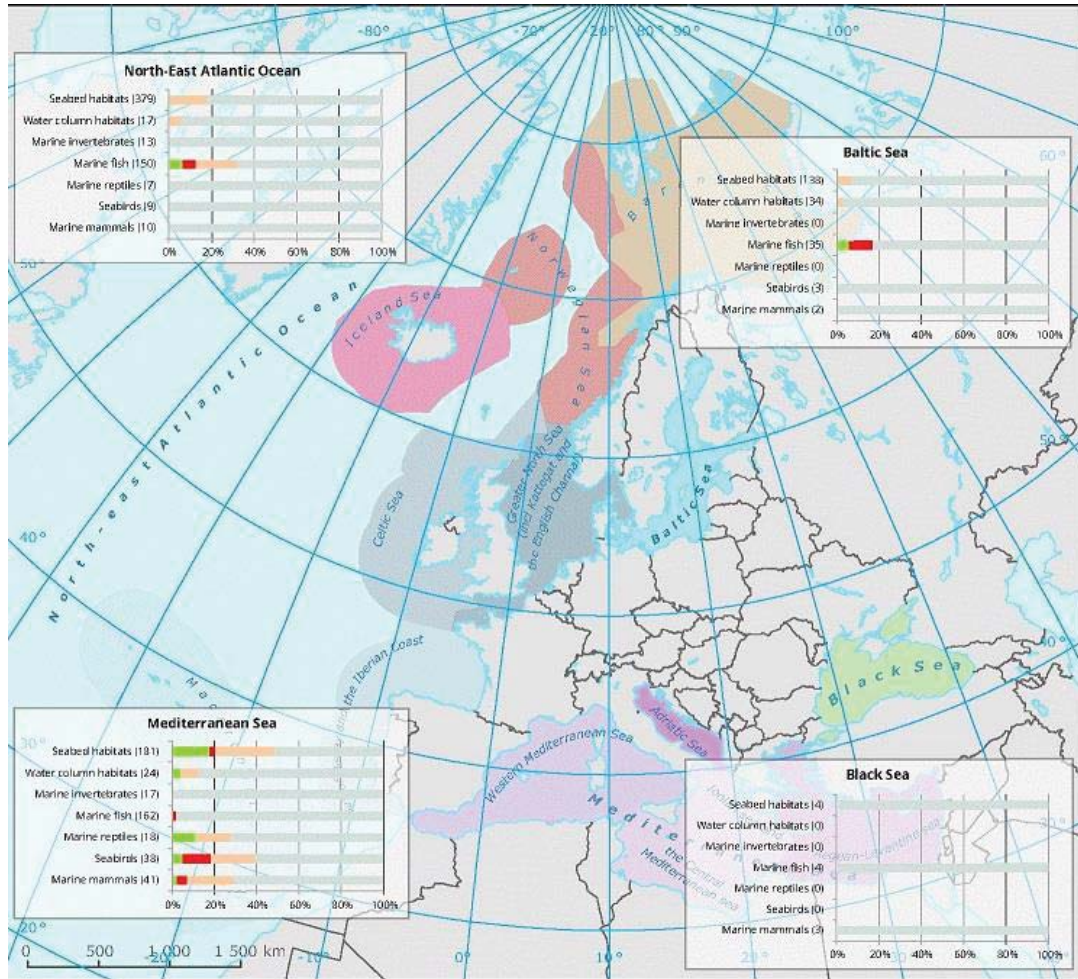


Figure 1: Status assessment of natural features reported by EU Member States under MSFD Article 8(1) in 2012-13 (<https://www.eea.europa.eu/data-and-maps/figures/status-assessment-of-natural-features-1>). Green=good, red=not good, beige=other, grey=unknown. The figures in parenthesis are the number of reported features by EU Member States. Disclaimers: the associated confidence rating of the information is rarely high; the numbers are not comparable across regions; there are no marine reptiles in the Baltic and the Black Seas.

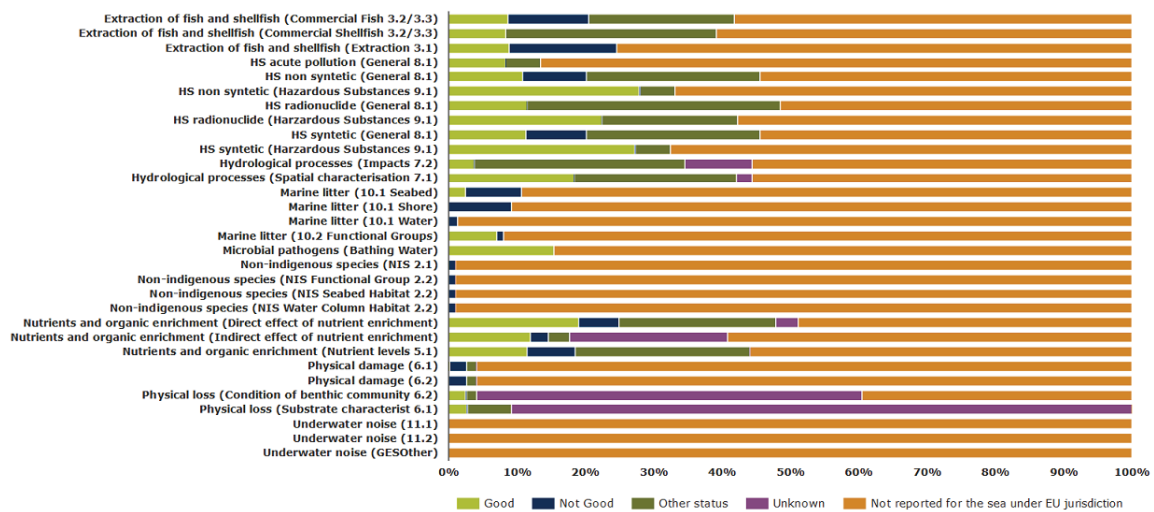


Figure 2: Status assessment of pressures reported by EU Member States under MSFD Article 8(1) in 2012-13 (https://www.eea.europa.eu/data-and-maps/daviz/percentage-of-area-with-different#tab-chart_1). The figure shows the percentage of area with different assessment status

with respect to the size of the MSFD marine regions. The “not reported” class (in orange) may be overestimated since not all pressures are relevant for all regions and Member States.

By October 2018, Member States had to update their initial assessments (as well as their determinations of good environmental status and their targets), as required by Article 17 of the MSFD. By October 2019, one year after the deadline, only 14 Member States had reported in paper format, of which only 10 had reported through the agreed electronic sheets. The aggregated information coming from those 10 electronic reports is shown at the beginning of each chapter of this Staff Working Document³. Table 1 shows the legend code used to illustrate the status assessments. For more updated information, see the online dashboards on the WISE-Marine website⁴.









	<i>Overall level: Good environmental status assessments provided per descriptor and feature</i>	<i>Criteria level: Criteria status assessments</i>
	GES achieved	Good
	GES expected to be achieved by 2020	Good, based on low risk
	GES expected to be achieved later than 2020, Article 14 exception reported	Not good
	GES expected to be achieved later than 2020, no Article 14 exception reported	
	Not relevant	
	Not assessed	Not assessed
	Unknown	Unknown
		Contributes to assessment of another criterion/element

Table 1: Colour legend of the status assessments reported under the MSFD. The available assessments will be illustrated under each descriptor’s section.

Given the lack of MSFD-reported information that could give a broad (geographical and temporal) overview of the status of the EU marine environment, this Staff Working Document complements the official data reported by Member States with assessments coming from a variety of non-MSFD sources, such as the most recent quality status reports coming from the Regional Sea Conventions⁵ or independent studies. The European Environmental Agency and the European Commission’s Joint Research Centre compiled the available information about the European marine regions and framed it to

³ A number of figures in this Staff Working Document represent the information recently reported by 10 Member States (Belgium, Denmark, Germany, Estonia, Spain, Latvia, Netherlands, Poland, Finland, Sweden) using the ART8_GES schema: <https://cdr.eionet.europa.eu/help/msfd/MSFD%20Schemas>. The figures show the percentage (vertical axis) and the total number of assessments (numbers on the bars) with conclusions at the “overall status level” and the “criteria level” (see Table 1). Not all Member States have reported on all the criteria or all the descriptors, therefore the percentages refer to the proportion out of the total number of assessments reported.

⁴ <https://water.europa.eu/marine>

⁵ Baltic Sea: HELCOM HOLAS II (<http://www.helcom.fi/helcom-at-work/projects/holas-ii>); North-east Atlantic Ocean: OSPAR Intermediate Assessment 2017 (<https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/introduction/ospar-and-intermediate-assessment-2017/>); Mediterranean Sea: UNEP/MAP Quality Status Report 2017 (<https://www.medqsr.org/>); Black Sea: Black Sea State of Environment Report 2009-2014/5, which was not available at the time of preparation of this report (<http://www.blacksea-commission.org/SoE2009-2014/SoE2009-2014.pdf>).

feed this report. Over time, MSFD-reported information is expected to be readily available and increasingly delivered according to defined methods and standards.

This Staff Working Document presents evidences or proxies of the status of EU marine ecosystems and the pressures acting on them through the 11 MSFD descriptors. The criteria are briefly introduced for each descriptor, allowing for a comparison between those used for the 2010 (reviewed and repealed by the following) and 2017 Commission Decision, respectively. This is followed by an overview of the (still incomplete) update of the status of marine waters by Member States, a scientific assessment of the available information (on status and/or pressures), an analysis of trends and impacts (if feasible), technical observations (regarding methodologies or knowledge gaps), and key messages (conclusions). Although understanding the consequences of cumulative impacts is intrinsic to the MSFD, the lack of systematic information prevents this review to tackle this important issue yet.

Descriptor 1: ‘Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions’

1. MSFD FRAMEWORK

COM DEC 2017/848/EU		COM DEC 2010/477/EU
D1 Biodiversity – species ⁶		
D1C1 Incidental by-catch rate	The mortality rate per species from incidental by-catch is below levels which threaten the species	
D1C2 Population abundance	The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured	1.2 Population size 1.2.1 Population abundance
D1C3 Population demographics	The population demographic characteristics of the species are indicative of a natural population which is not adversely affected due to anthropogenic pressures	1.3 Population condition 1.3.1 Population demographics
D1C4 Population distributional range and pattern	The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions	1.1 Species distribution 1.1.1 Species range 1.1.2 Species pattern
D1C5 Habitat for species	The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species	
		1.1.3 Area covered by species
		1.3.2 Population genetic structure
D1 Biodiversity – pelagic habitats		
D1C6 Pelagic habitat condition	The condition of the habitat type, including its biotic and abiotic structure and its functions is not adversely affected due to anthropogenic pressures	1.6 Habitat condition 1.6.1 Condition typical species 1.6.2 Relative abundance 1.6.3 Habitat condition

2. OBSERVED STATUS OF EU MARINE BIODIVERSITY

2.1. Ongoing reporting under the MSFD

⁶ Applicable to birds, mammals, reptiles, fish and cephalopods; taking into account the absence of cephalopods in the Black Sea and of reptiles in the Baltic Sea.

Mammals

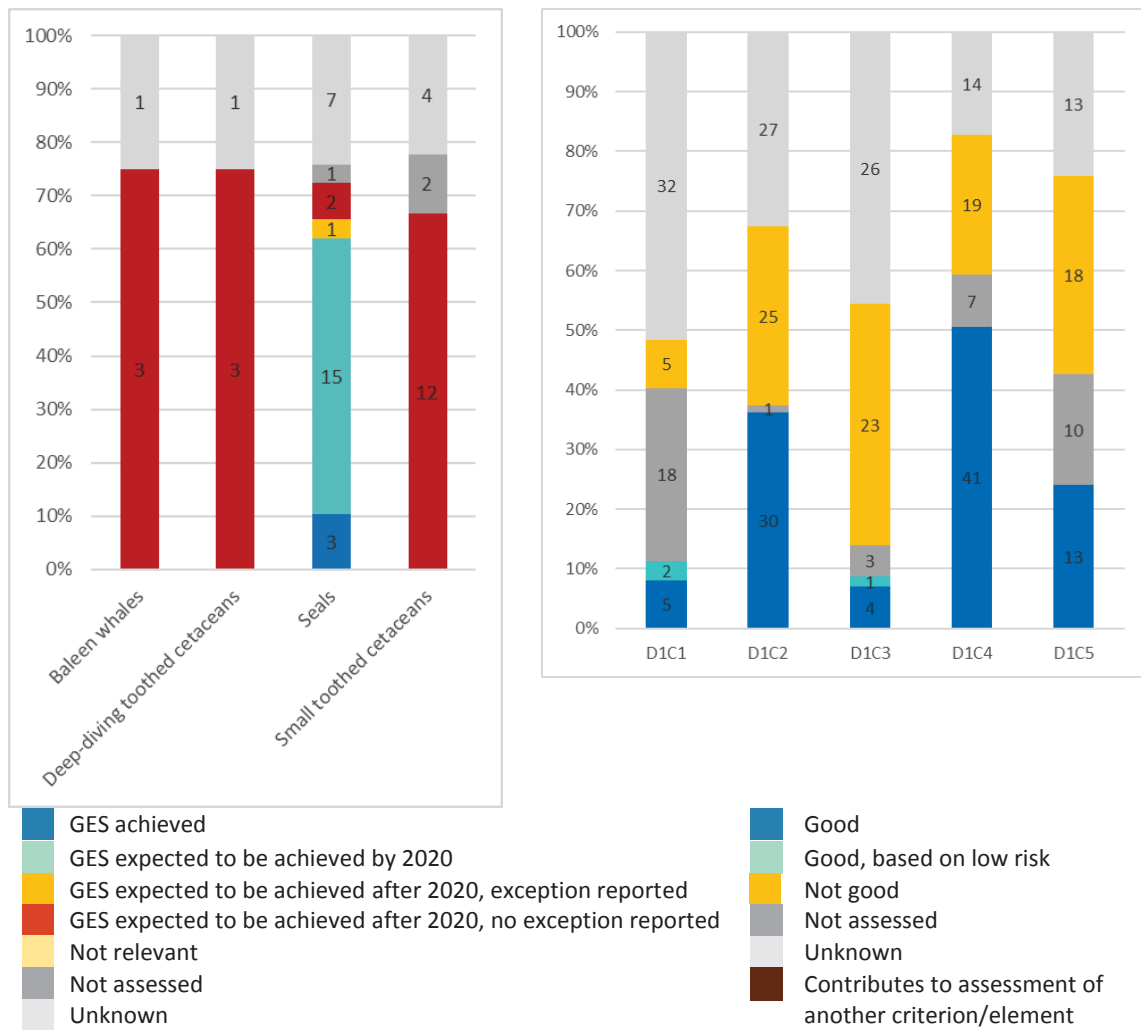


Figure 3: Latest MSFD assessments of good environmental status per species group (left) and per criteria (right) under Descriptor 1: Mammals. The information comes from 10 Member States' electronic reports.

Most of the assessments of marine mammals refer to seals and small toothed cetaceans. For seals, GES is achieved only in 3 assessments, but 15 assessments report that GES will be achieved by 2020. However, the situation of the small toothed cetaceans is more concerning. None of the reported assessments has resulted in an achievement of the GES, and, in almost 70% of the cases, GES will be achieved only later than 2020 without any exception having been reported under Article 14. In the case of baleen whales and deep-diving toothed cetaceans, in 3 out of the 4 assessments that have been reported for each group, GES will be achieved only later than 2020 without any exception having been reported under Article 14.

Most of the criteria of Descriptor 1 for mammals have been assessed and reported. For the population abundance (D1C2), the population distribution (D1C4) and the habitats condition for the species (D1C5), they have achieved the 'good' status in 30, 41 and 13 assessments respectively, although also a big number of assessments result in the criteria being 'not good' (25, 19 and 18 respectively). On the other hand, only 5 assessments on by-catch (D1C1) and 4 assessments on the demographic characteristics (D1C3) have been reported as 'good' while 5 and 23 respectively are 'not good'.

Birds

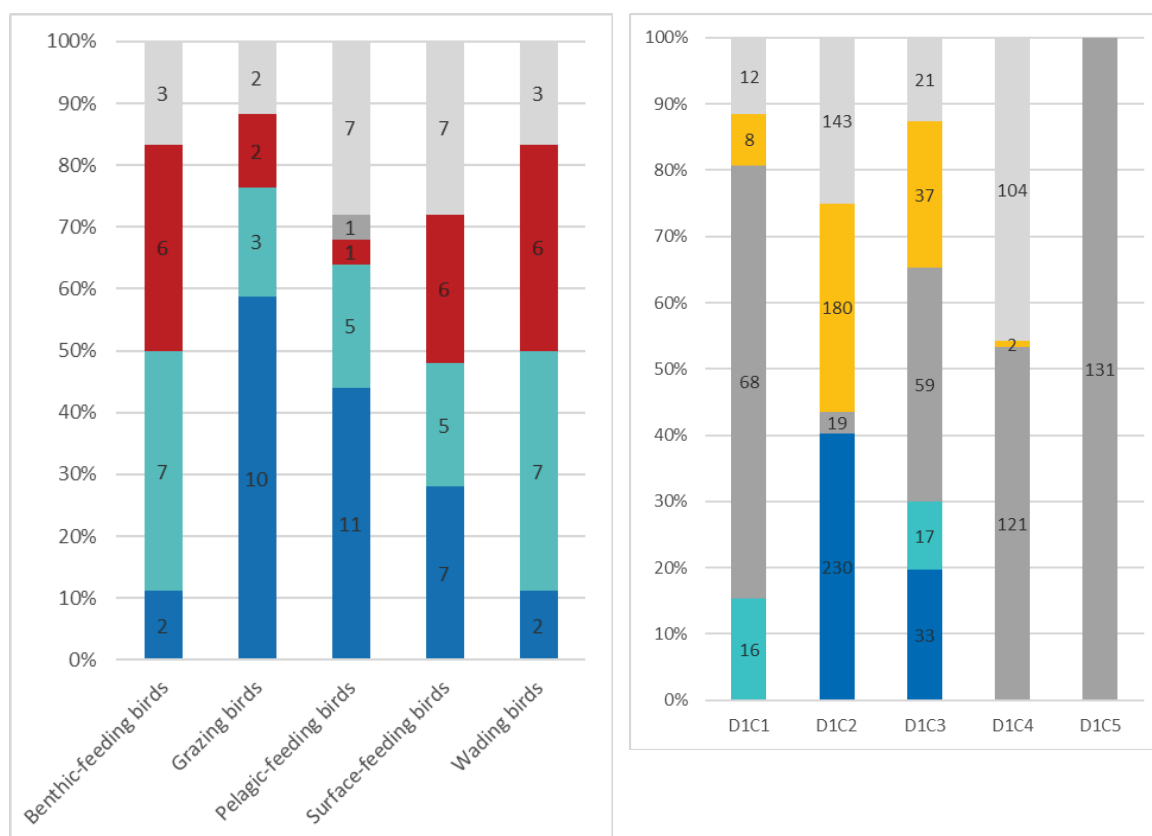


Figure 4: Latest MSFD assessments of good environmental status per species group (left) and per criteria (right) under Descriptor 1: Birds. The information comes from 10 Member State's electronic reports. See legend in Figure 3.

Except one report that has been done for all birds, the rest of the assessments have been reported per species groups. The status of the species groups is very diverse, the best one being the grazing birds (where almost 60% of assessments achieved GES), followed by the pelagic-feeding birds (where almost 50% of cases achieved GES) and the surface-feeding birds (around 30%).

On the other hand, the benthic-feeding birds and the wading birds seem not to be in good shape (in both cases there are only 2 assessments where GES is achieved). However, the reports show for these groups that Member States expect to achieve GES by 2020 at a great extent. Member States have not reported exceptions under Article 14 when GES is expected to be achieved later than 2020.

For the criterion on by-catch (D1C1), 16 assessments conclude that the status is 'good, based on low risk', while 68 cases have been reported as 'not assessed'. Similarly, both the population distribution (D1C4) and the habitats condition for the species (D1C5) have been reported as 'not assessed' or 'unknown' at a great extent.

The most frequently assessed criteria are the population abundance (D1C2) and the demographic characteristics (D1C3). In the first case, the status has been reported as 'good' in 230 assessments, and as 'not good' in 180 assessments. In the second case, there are 59 cases reported as 'not assessed', and 37 assessments resulting in 'not good', 33 in 'good' and 17 in 'good, based on low risk'.

Fish

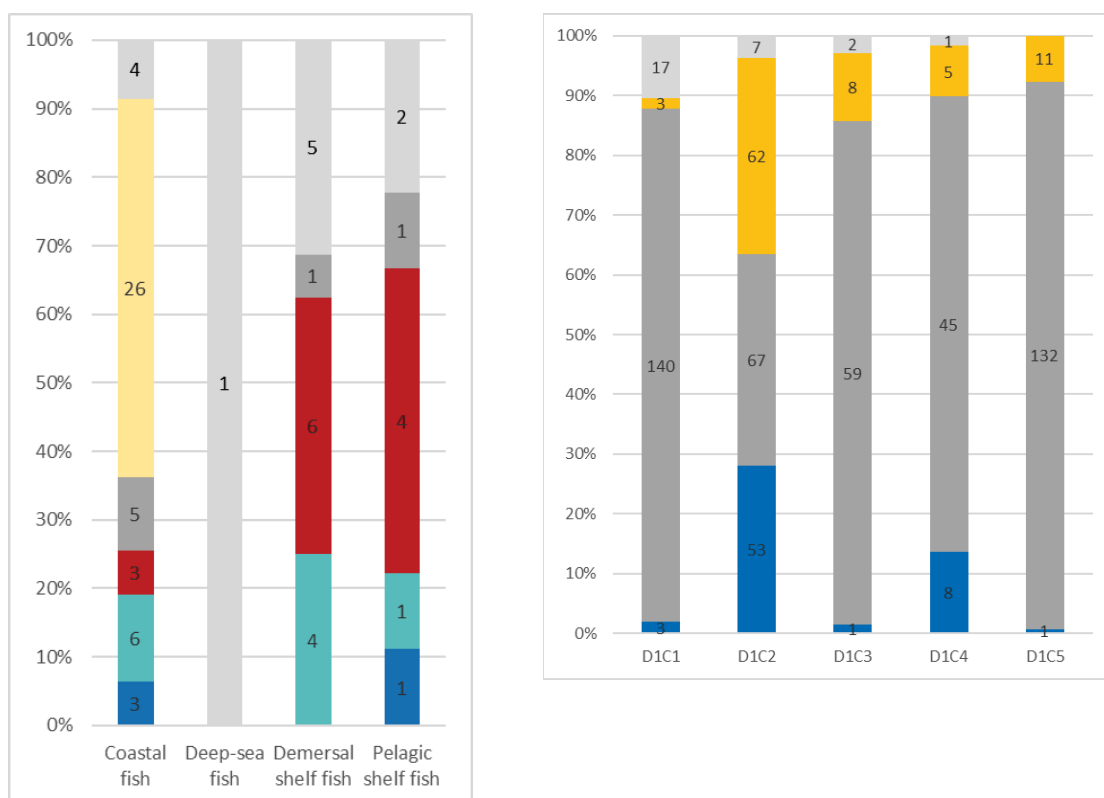


Figure 5: Latest MSFD assessments of good environmental status per species group (left) and per criteria (right) under Descriptor 1: Fish. The information comes from 10 Member State's electronic reports. See legend in Figure 3.

Except one report that was done for all fish, the rest of the assessments have been reported per species groups. GES is achieved in very few cases for coastal fish (in 2 assessments) and pelagic shelf fish (in 1 assessment), and no cases of GES achieved have been reported for demersal shelf fish nor for deep-sea fish (where only 1 assessment has been reported and is 'unknown'). It is worth noting that for coastal fish a significant number of assessments have been reported as 'not relevant', and a lot of cases in all the species groups have been reported as 'not assessed' or as 'unknown'.

The reports show that Member States expect to achieve GES by 2020 in some cases. Member States have not reported exceptions under Article 14 when GES is expected to be achieved later than 2020.

The majority of criteria assessments have been reported as 'not assessed', except for population abundance (D1C2), which has been assessed in almost 30% of the cases. For the abundance, 53 assessments have been reported as in 'good' status, while 62 conclude that the status of this criterion is 'not good'. In the case of the demographic characteristics (D1C3) and the habitats condition for the species (D1C5), only one assessment has been reported as 'good'. For the by-catch (D1C1) and the population distribution (D1C4) only 3 and 8 assessments respectively have been reported as 'good'.

To date, there has been almost no reports on cephalopods and reptiles. Hence, the corresponding figures have not been added to the present summary.

Habitats

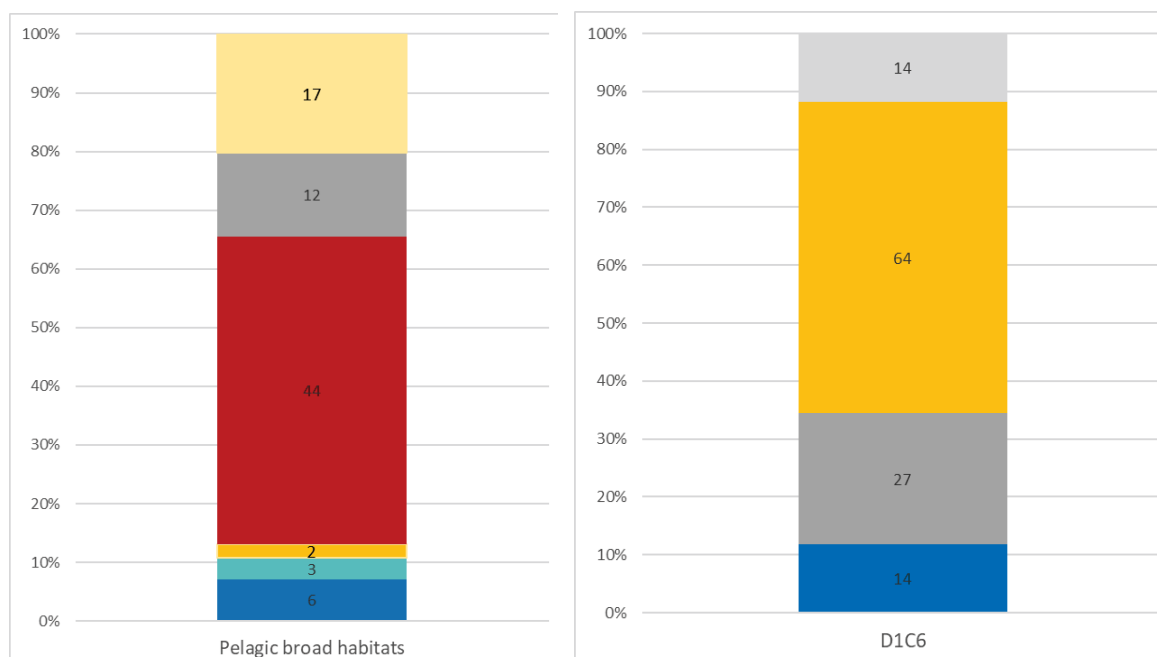


Figure 6: Latest MSFD assessments of good environmental status per ecosystem component (left) and per criteria (right) under Descriptors 1: Habitats (in this case only pelagic habitats, as benthic habitats are shown under Descriptor 6). The information comes from 10 Member State's electronic reports. See legend in Figure 3.

GES is achieved in very few cases for the pelagic habitats (only 6 assessments), 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. A significant number of assessments have been reported as 'not assessed' or 'not relevant'. The status of benthic habitats (although also linked to Descriptor 1) will be discussed under Descriptor 6.

The pelagic habitats do not seem to be in good shape. The habitat condition (D1C6) has only achieved the 'good' status in 14 cases, while 64 assessments have been reported as 'not good'.

2.2. Other assessments of marine biodiversity

The information presented in this section aims to shed light on the MSFD criteria and to contribute to the overall goal of Descriptor 1, i.e. to know whether species groups and habitat types are reaching a 'good environmental status'. The status categories used here (see Table 2) however do not refer to any established MSFD methodology, given the Directive only speaks of *good* environmental status. In the absence of most MSFD reporting under the second implementation cycle, the main sources of information are the quality status reports from the Regional Seas Conventions, additional knowledge from Red List assessments about special or threatened species and habitats, and information from the previous reporting of the Habitats Directive (i.e. the 2007-2012 period) (Table 2). Most of this information comes from ETC/ICM (2019a).

Ecosystem Component		North-east Atlantic Ocean by OSPAR	Baltic Sea by HELCOM	Mediterranean Sea by UNEP-MAP	European assessment by the Red List ⁷	European assessment based on the Habitats Directive
Species	Seals	Yellow	Yellow	Yellow	Orange	Orange
	Cetaceans	Grey	Orange	Orange	Orange	Grey
	Birds	Orange	Orange	Orange	Red	n/a
	Bony fish	Green	Yellow	Orange	Yellow	Grey
	Elasmobranchs	Orange	Orange	Grey	Red	n/a
	Cephalopods	Grey	Grey	Grey	Grey	n/a
	Reptiles	Grey	n/a	Grey	Red	Grey
Habitats	Benthic ⁸	Yellow	Yellow	Grey	Orange	Red
	Pelagic	Grey	Yellow	Grey	n/a	n/a

Table 2: Summary of the main marine biodiversity assessments found at regional or pan-European level. More detailed evidence is presented in the following tables. Green: positive trends or status. Yellow: mixed or no clear trends. Orange: negative trends or low status. Red: very negative trends or bad status. Grey: insufficient data.

The general EU picture is worrying, with many knowledge gaps and an overall status that ranges from bad to moderate.

2.2.1. Mammals

The abundance and condition of marine mammals, as top predators, can help indicate whether a marine ecosystem is in a good state or not. Seals and cetaceans (whales and dolphins) are assessed separately because they have different life histories and ecological requirements. Seals are also much easier to study and count because they come onto land to rest and to breed. Cetaceans range widely across Europe's seas, and are therefore more difficult to monitor and there are generally not enough long synoptic time series to accurately assess the status of their populations. During the first MSFD cycle, the Regional Sea Conventions have greatly aligned their assessment methodologies with the MSFD requirements. In many cases, the Regional Sea Conventions play a leading role in the development and implementation of harmonised methods to assess the status of species and habitats. On the contrary, the IUCN criteria are not well aligned with the MSFD criteria, as they have been developed to determine the extinction risk of species, rather than their population status. Table 3 summarises all available assessments.

IUCN	In Red List assessments of status and trends in European seal populations, most species are of Least Concern, except for the Mediterranean monk seal (Temple and Terry, 2007). Still, many trends are unknown (see Table 10).
Habitats Directive	While the Habitats Directive includes seven seals in its Annexes, three of them are vagrant in the EU waters and only four can be assessed: grey seal, Mediterranean monk seal, ringed seal and common or harbour seal. Only the monk seal populations in the Mediterranean and Macaronesia regions were

⁷ The European Red List is funded by the European Commission and compiled by IUCN's Global Species Programme. It assesses all vertebrates (mammals, amphibians, reptiles, birds and fishes). The status is based on percentage of species.

⁸ Even if benthic habitats are described under Descriptor 6, they were also included in this table to allow for the comparison of all ecosystem components.

	reported in 2013 under Article 17 of the Habitats Directive where four member states reported unfavourable status, and one reported the status as unknown (EEA, 2013a).
OSPAR	In the non-Arctic OSPAR region grey seal populations are generally stable or increasing in most assessed areas although some harbour seal populations are declining (OSPAR, 2017a).
HELCOM	In the Baltic Sea, grey seal populations are increasing but their nutritional and reproductive states are not good. Harbour seals are only in a good state in one sub-region and the state of the ringed seal population is critical with less than 100 animals (HELCOM, 2018a).
UNEP-MAP	The distribution of monk seal in the Mediterranean remains stable or expanding though it is still endangered and systematic monitoring is needed to assess overall status (UNEP-MAP, 2018)

Table 3: Conclusions from different assessments about the status of seals' populations in the European seas.

IUCN	Of the 20 cetacean species present in European waters (excluding those with marginal occurrences), 60% were assessed as data deficient. 3 species were regarded as threatened (Atlantic right whale, Sei whale and Blue whale) while 2 species, harbour porpoises and sperm whales, were regarded as Near Threatened (Temple and Terry, 2007).
Habitats Directive	In the 2013 reporting of the Habitats Directive for cetaceans in Annexes I, III and IV, the status was generally reported as 'unknown' (73% at European level, with 18% 'unfavourable' and 9% 'favourable'). These proportions differed in the Black Sea (67% 'unfavourable', 3 cetaceans) and the Baltic Sea (100% 'unfavourable', 1 species <i>Phocoena phocoena</i>).
OSPAR	In the OSPAR region, there is no evidence of changes in abundance for white-beaked dolphin, minke whale and harbour porpoise since 1994 (OSPAR, 2017a). There is insufficient evidence for other species except for some coastal bottlenose dolphin populations which have remained low but stable. An assessment of killer whales, another top predator in the North-east Atlantic Ocean, could only be performed as a pilot exercise due to lack of data. However, the potential impacts from accumulation of pollutants were noted as these could have led to a reduction in numbers due to reproductive failure (OSPAR, 2017b). Recent scientific studies of populations of killer whales 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 around the UK and around the Strait of Gibraltar (Desforges et al., 2018).
HELCOM	A particular concern is the local population of harbour porpoise in the Baltic Proper, with a population size recently estimated at around 500 animals (HELCOM, 2018a).
UNEP-MAP	In the Mediterranean Sea, there is some evidence of declining numbers of fin whales and common dolphins (UNEP-MAP, 2018). Fin whale abundance in the Western Mediterranean was estimated as 3,500 in the mid-1990s (Forcada, 2011), but more recent estimates in 2017 suggested 460 individuals. The first estimate, however, includes individuals entering the Mediterranean from the Atlantic Ocean, while the second estimate refers only to the Mediterranean residents.

Table 4: Conclusions from different assessments about the status of cetaceans' populations in the European seas.

2.2.2. Birds

There are around 150-200 species of birds in Europe that, at some point in their annual life cycle, are reliant on coastal and/or offshore marine areas (IUCN and BirdLife International, 2014). These include waders and waterbirds, such as ducks, geese, swans, divers and grebes; as well as birds that are usually referred to as seabirds: petrels, shearwaters, gannets, cormorants, skuas, gulls, terns and auks. The assessments below were based on monitoring data from breeding populations and/or non-breeding populations during migration or over the winter, depending on the species, primarily for the OSPAR and HELCOM areas. Similar long-term trend data within the Mediterranean and Black Sea regions are rare.

IUCN	Birds associated with marine habitats in Europe have a relatively high proportion of threatened species (20%), which reflect the prevalence of human pressures such as habitat disturbance, bycatch and pollution, but also predation at colony sites often by invasive species (IUCN and BirdLife International, 2014) This is the case for the Critically Endangered Balearic Shearwater.
OSPAR	Since the mid-2000s, the breeding abundance of more than a quarter of the marine bird species which breed in the OSPAR Maritime Area has been below the 1992 baseline, indicating that the populations are not healthy (Figure 8) (OSPAR, 2017c). A similar pattern was found in the non-breeding abundance of species that visit the Arctic Waters and Celtic Seas during migration and/or during winter. In contrast, non-breeding populations in the Greater North Sea are doing much better, and with 75% or more of species meeting assessment values in every year since 1993 are considered healthy (OSPAR, 2017c). Within the breeding birds, populations of water column feeders (e.g. gannets) were healthier than those in feeding at the surface, indicating changes in availability of small surface dwelling fish. This was also reflected in widespread breeding failure in surface-feeding species (OSPAR, 2017c).
HELCOM	A similar pattern of decline is suggested in the Baltic Sea where open sea species are considered to have strongly declining trends, though the formal assessment covered primarily coastal-dwelling species. Here, 31% of waterbirds in the breeding season have declined, compared to 18% of over-wintering species. The pattern of status for feeding groups differs in the HELCOM assessment from the OSPAR region, as in the Baltic Sea, surface and pelagic feeders have a good status (HELCOM, 2018a).
UNEP-MAP	Status of birds from the Mediterranean Sea is unclear with most of the data coming from North-western areas. Trends in the critically endangered Balearic shearwater suggest marked declines (UNEP-MAP, 2018) primarily from predation by introduced land carnivores and from fisheries by-catch (IUCN and BirdLife International, 2014). Of the 16 bird species regarded as Endangered or Vulnerable in the IUCN Red List assessment, all are marine species (IUCN and BirdLife International, 2014).

Table 5: Conclusions from different assessments about the status of marine birds' populations in the European seas.

2.2.3. Fish

There are over 1200 fish species in the North-east Atlantic Ocean and Mediterranean Sea (Nieto et al., 2015), which includes both commercial and non-marketable species. 15% of these are endemic to the region. The areas with the highest diversity of fish species are the coast of Portugal, the archipelagos in Macaronesia and the western Mediterranean Sea which are also the areas with the highest number of threatened species (Nieto et al.,

2015; EEA, 2019a). While fish populations appear to be recovering in the North-east Atlantic Ocean, populations in the Black and Mediterranean seas are under continuing downward pressures. This conclusion refers to commercial fish species and to fisheries subjected to several management measures, especially in the North-east Atlantic.

IUCN	<p>85 fish species (7 % of the total of European marine fish species) and 11 of the endemic species are either Threatened or Near Threatened under the IUCN Red List classification.</p> <p>Among the bony fish, only <3 % of the species are classified threatened, but with the uncertainties related to the smaller species this share may theoretically extend up to 23 % if all data deficient species were threatened.</p>
OSPAR	<p>The OSPAR assessment showed that there has been an improvement in the proportion of large demersal fish at least in the Greater North Sea, leading to recovery by 2022 but only if current trends continue (OSPAR, 2017d). More sensitive demersal species have shown a recovery in the Celtic Seas at least and typical lengths are increasing, suggesting higher proportion of mature individuals since 2010 in the Greater North Sea and Celtic Seas. The pelagic fish assemblage shows no long-term change in much of the OSPAR maritime area (OSPAR, 2017d).</p>
HELCOM	<p>HELCOM has two indicators for the species that can be allocated under Descriptor 1: (1) abundance of key coastal fish species, and (2) abundance of coastal fish key functional groups (HELCOM, 2018a). For the first indicator, good status is achieved in 13 out of the 21 coastal HELCOM assessment units that were assessed. Generally, good status is more often reached in the Northern and Eastern parts of the Baltic Sea where perch is the key species, while in the Western and Southern areas, where flounder is the key species, the status is more often not good. For the second indicator, good status is achieved in 13 coastal HELCOM assessment units out of the 16 that were evaluated for piscivores, and in 7 of the 16 evaluated assessment units for cyprinids/mesopredators.</p>
UNEP-MAP	<p>Around 85% of the analysed stocks in the Mediterranean and the Black sea have been overfished. The situation is particularly alarming for demersal fish that experience higher mortality rates than the target. For example, hake, a charismatic and economically important species in the Mediterranean, shows the highest fishing mortality with a rate that is on average 5 times higher than the target and reaches up to 12 times higher for some stocks. On the other hand, small pelagic fish show moderate fishing mortality rates close to the target or even below the target for some specific species. Data expressed through Spawning Stock Biomass indicates that up to 42% of the stocks assessed in the Mediterranean show a low biomass (UNEP-MAP, 2018).</p>

Table 6: Conclusions from different assessments about the status of teleost (ray-finned fish) in the European seas.

Cartilaginous fish (sharks, skates and rays) is less fished in Europe than in previous times, but by-catch is still a significant problem, both for demersal and pelagic species (European Commission, 2016).

IUCN	<p>Sharks, rays and skates cover two thirds (56 species) of all the threatened species. Many of these chondrichthyans are poorly known and of the 204 Data Deficient species many were benthic sharks.</p> <p>In the Mediterranean Sea, sharks, skates and rays are particularly threatened with almost 40% of species facing a declining population trend (FAO, 2012; Nieto et al., 2015). The increased extinction risk of many of these species can be linked fishing practices in the Mediterranean Sea, where their status has worsened (Cavanagh and</p>
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	Gibson, 2007; Nieto et al., 2015).
OSPAR	OSPAR has included 11 chondrichthyan species on the OSPAR list of Threatened and Declining species, covering species at most risk (OSPAR, 2019a). Long-term trend assessment indicated population decline particularly in larger species (spurdog and common skate) where commercial fisheries existed (Sguotti et al., 2016). Catches has been highly variable and declining until 2010.
HELCOM	HELCOM's Red List assessment also included two shark species (porbeagle and spurdog) that have suffered dramatic reduction in populations.

Table 7: Conclusions from different assessments about the status of elasmobranchs (cartilaginous fish) in the European seas.

2.2.4. Reptiles

IUCN	In the North-east Atlantic Ocean and the Mediterranean Sea, both OSPAR and the Barcelona Convention list the loggerhead and leatherback turtles as threatened and/or declining species (OSPAR, 2019a; UNEP-MAP, 2018). Marine turtles are very rare visitors in the Black Sea, while they have not been observed in the Baltic Sea. The Mediterranean poses the highest average threats to marine turtles out of all global ocean basins (Wallace et al., 2011).
Habitats Directive	The Habitats Directive Annex IV includes the following species: <i>Caretta caretta</i> , <i>Chelonia mydas</i> , <i>Dermochelys coriacea</i> , <i>Eretmochelys imbricate</i> , <i>Lepidochelys kempii</i> . However, only the two first species are assessed in the Mediterranean and the North-east Atlantic. There are no data or established populations for the other species. Overall, the conservation status of marine reptiles was unknown in 67% of the reports, with 33% in unfavourable status. However, for the marine Mediterranean region, 60% of the reports were unfavourable, compared to 40% unknown (EEA, 2013a) (Figure 7).
UNEP-MAP	At present, knowledge on sea turtle abundance and demography is patchy at best for each component and that effort needs to be placed on filling existing gaps in order to predict with any certainty the future viability of sea turtle populations in the Mediterranean (UNEP-MAP, 2018)

Table 8: Conclusions from different assessments about the status of reptiles (in this case, sea turtles) in the European seas.

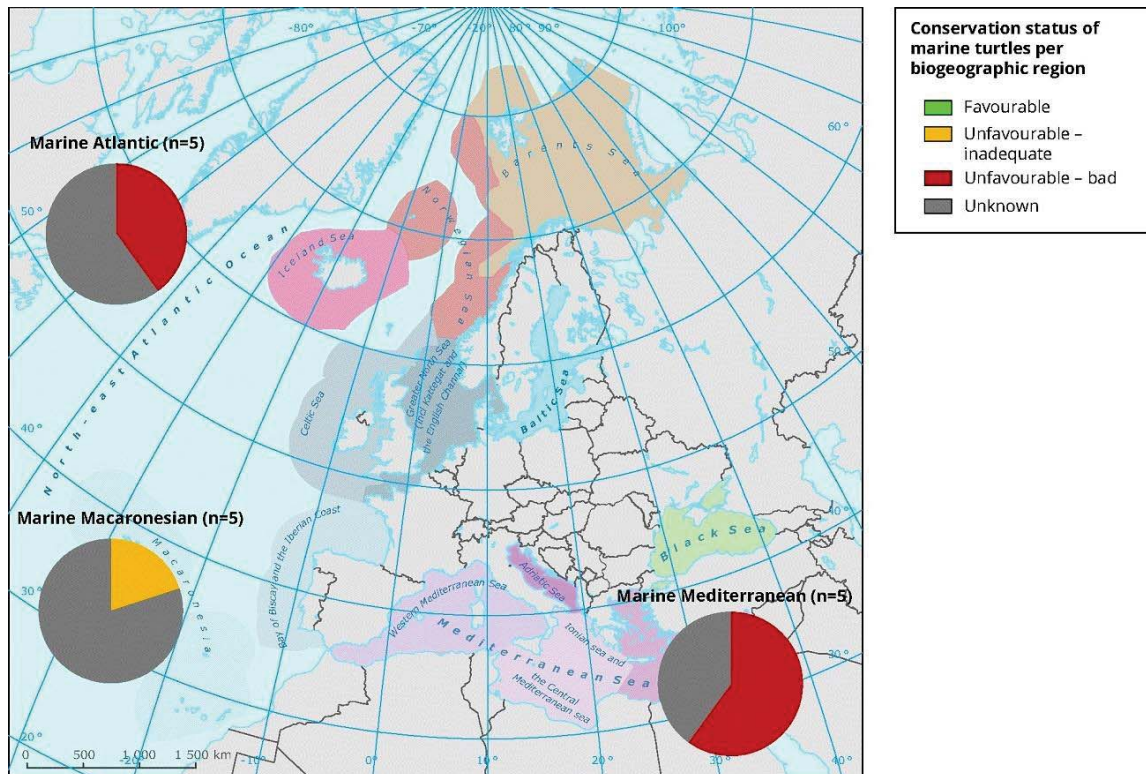


Figure 7: Conservation status of marine turtles per sea region. Source: EEA (2013b). Based upon the previous reporting round of the Habitats Directive 2007-2012, none of the five species normally occurring in European waters were in 'favourable conservation status'. Of these, two species breed in European waters: the green turtle (*Chelonia mydas*) which breeds in the south-eastern portion of the Mediterranean Sea and the loggerhead turtle (*Caretta caretta*) which breeds in the southern part of the same basin.

2.2.5. Pelagic habitats

HELCOM	Using indicators for phytoplankton and zooplankton, HELCOM reported good status for pelagic habitats is achieved in the Kattegat, but not in any other open sea sub-basin during 2011-2016. 20% of the coastal areas achieve good integrated status.
OSPAR	In the OSPAR region, local and large-scale changes in phytoplankton biomass and zooplankton abundance were observed from 1958 to 2002. Since 2004, plankton communities experienced significant changes in relative abundance, indicating alterations to key aspects of ecosystem functioning. The inference is that those changes are linked to prevailing environmental conditions such as climate change, nutrient enrichment or other factors (OSPAR, 2017e).

Table 9: Conclusions from different assessments about the status of pelagic habitats in the European seas.

3. SOME OBSERVED TRENDS

There are not consistent metrics of trends to evaluate marine biodiversity as a whole, but the following tables and figures show some examples of specific regional-scale studies.

	World	Europe	Baltic Sea	North-east Atlantic Ocean	Mediterranean Sea
Ringed seal	?	↑ LC	↑ ↓		

Grey seal	↑ LC	↑ LC	↑ LC	↑
Harbour seal	?	? LC	↑ ↓	↑ ↓
Harp seal	↑ LC	?		↑ ↓
Monk seal	↑ EN	↑ EN		↑ EN
Hooded seal	? VU	?		
Bearded seal	? LC	?		

Table 10: Population trends of seven seal species globally, in Europe, and in three marine regions. Red List status: EN-Endangered, VU-Vulnerable, NT-Not threatened, LC-Least concern. Arrows represent upward/downward trends while question marks are unknown trends.

Several seal populations in Europe start showing positive trends, although their evolution is still unmonitored or endangered in many cases.

	World	Europe	Baltic Sea	North-east Atlantic	Mediterranean	Black Sea
Improving	3 spp	1 sp	1 pop	6 spp		
Stable	1 sp	3 spp		3 spp		
Declining	1 sp	2 sp	1 pop	3 spp	5 spp	3 spp
Unknown	27 spp	27 spp		13 spp	6 spp	

Table 11: Population trends of 41 cetacean species globally, in Europe and in four marine regions. Source: Temple and Terry, 2007; OSPAR, 2017a; HELCOM, 2018a.

With the only possible exception of the North-east Atlantic Ocean, there are very few examples of an improving situation for cetaceans in European waters. The percentage of unknown trends is very high.



Figure 8: OSPAR marine bird abundance assessment. Change in the annual proportion of species exceeding assessment values for the relative breeding (left figure) and non-breeding (right figure) abundance of marine birds in the Norwegian part of the Arctic waters, Celtic Seas

and in the Greater North Sea. The black line denotes the multi-species assessment value of 75%. Source: OSPAR (2017c).

Overall, the abundance of marine bird species in the OSPAR area seems to have decreased during the last 15 years. See also Table 5.

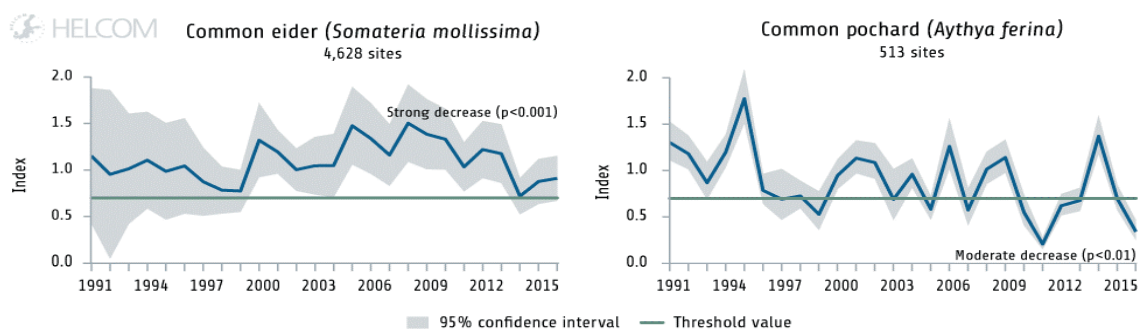


Figure 9: Population trends of two bird benthic feeders in the Baltic Sea. The trends show common eider (*Somateria mollissima*) in the breeding season and common pochard (*Aythya ferina*) in the wintering season at the whole Baltic Sea scale. Based on abundance index values during 1991-2016. The green line shows the index value of 0.7 which is the threshold to determine whether the populations have reached a good status or not. Source: HELCOM (2018a).

In the case of elasmobranchs, catches of sharks in the Mediterranean Sea and Black Sea have declined at least for the larger species as a result of increased fishing pressure especially since the 1960's (FAO, 2012). Similar findings were found in the North Sea (Sguotti et al., 2016) where two species, common skate and angelshark became locally extirpated. However, changes in overall distribution, particularly of smaller non-commercial elasmobranch species, could also be linked to climate change and habitat degradation as well as fishing pressure (Sguotti et al., 2016). The HELCOM Red List assessment found the common skate (*Dipturus batis*) to be already regionally extinct in the Baltic Sea.

4. TECHNICAL OBSERVATIONS

The MSFD, Habitats Directive and other scientific assessment and monitoring programmes have helped understanding the ranges, distribution and condition of individual ecosystem components. Still, many habitats and species groups are not systematically monitored and high mobile species are not well covered. Also, the understanding of how whole ecosystems functions is still very low. This means that it is not always possible to clearly state if trends are indicative of improving or worsening levels of human pressure, as changes in other biological components may also be an influential factor.

Europe's biological ocean observation capability needs to be more integrated (across different countries and purposes), harmonised and strengthened. Support is needed in taxonomic expertise and in the use of new emerging technologies, data science and management. Supporting technological innovation can bring cost-effective automated monitoring of biological variables; and supporting 'citizen science' can improve observation capacity, increase public confidence in science and the public's emotional connectedness with the marine environment (from EMB, 2018).

Some contrasting conclusions coming from different assessments of species and habitats must be due to the use of different threshold values and classification criteria. The harmonisation of the methods and criteria to set threshold values for the status assessment of species and habitats under the MSFD will greatly facilitate the management and policy decision-making process.

5. KEY MESSAGES

- Thanks to the MSFD, progress has been made on understanding biodiversity elements and the relative intensity of human pressures. This knowledge aims at underpinning management measures and policy objectives.
- Assessment of the status is inadequate for most assessed species and habitats. Still, the available information point to the following conclusions:
 - Marine mammals, being the top mobile predator, are exposed to multiple pressures across their distributional range and not well monitored. Existing measures have contributed to stable or increasing abundance for some species of seals (e.g. some populations of grey and harbour seals in the Baltic Sea and in the North Sea) and joint regional programmes have been launched recently. The population status and trends of cetaceans are mostly unknown, with the only possible exception of the North-east Atlantic Ocean, in slight decline.
 - Assessments for marine birds in the Baltic Sea and the North-east Atlantic show a diverse assessment status. Over 20% in seabird populations have declined in the last 25 years for more than a quarter of the species assessed in the North-east Atlantic. In the Baltic Sea, 31% of breeding water bird populations have declined, while in general surface and pelagic feeders have a good status. The level of harmonisation in the assessments' methods among regions should improve.
 - Elasmobranchs comprise most of the classified threatened species (both in continental and regional Red Lists), although most of them are very poorly monitored. For example, in the Mediterranean Sea 40% of sharks, skates and rays are facing a declining population trend.
 - Cephalopods and reptiles are too poorly monitored (e.g. 33% of the reports on marine turtles under the Habitats Directive were in unfavourable conservation status and 67% unknown).
- There are relatively few cases with unambiguous improvements in trends of populations, species or groups of species. These include commercially exploited fish in the North-east Atlantic Ocean and Baltic Sea, grey seals in general, harbour seals in the Kattegat, monk seal in the Mediterranean, white-tailed eagle in Baltic Sea and the Mediterranean bluefin tuna. These positive effects are normally the result of joint efforts that managed to reduce selected pressures in the regional seas during the last one or two decades.
- Despite these examples, halting marine biodiversity loss remains a challenge. Some marine populations and groups of species are still at threat, including some seal populations (e.g. monk seals, harbour seals and ringed seals), some seabirds,

commercially exploited fish in Mediterranean and Black seas, reptiles, sharks and rays, and killer whales.

- We can therefore conclude that biodiversity loss was not halted in Europe's seas during the first MSFD cycle. Overall, marine life is still under threat across Europe's seas with multiple pressures affecting individual species and habitats. Of particular concern are the hotspots of biodiversity, places where endemism is high and/or rare species are present in significant numbers. These tend to be in areas already under significant human pressure or where the monitoring or management measures are still being developed such as the Mediterranean Sea or Macaronesia.

Descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems

1. MSFD FRAMEWORK

COM DEC 2017/848/EU		COM DEC 2010/477/EU
D2 Non-indigenous species		
D2C1 Newly-introduced non-indigenous species	The number of non-indigenous marine species which are newly introduced into a given EU marine region via human activities is minimised and, where possible, reduced to zero.	
D2C2 Established non-indigenous species	Abundance and spatial distribution of established non-indigenous species, particularly of invasive species, contributing significantly to adverse effects on particular species groups or broad habitat types.	2.1 Abundance/state of non-indigenous species 2.1.1 Trends in abundance of non-indigenous species
D2C3 Adverse effects of non-indigenous species	Proportion of the species group or spatial extent of the broad habitat type which is adversely altered due to non-indigenous species, particularly invasive non-indigenous species.	2.2 Impacts of invasive non-indigenous species 2.2.1 Ratio invasive to native species 2.2.2 Impacts of non-indigenous species

Non-indigenous, or alien, species refers to any live specimen of a species, subspecies or lower taxon of animals, plants, algae, fungi or micro-organisms introduced outside its natural range. It includes any part (e.g. gametes, seeds, eggs or propagules) of such species as well as any hybrids, varieties or breeds that might survive and subsequently reproduce (modified from the EU Regulation [1143/2014](#) on Invasive Alien Species⁹).

⁹ Regulation (EU) No [1143/2014](#) of the European Parliament and of the Council on the prevention and management of the introduction and spread of invasive alien species. Official Journal of the European Union (L315), pp. 35-55.

2. PRESENCE OF NON-INDIGENOUS SPECIES IN EU MARINE WATERS

2.1. Ongoing reporting under the MSFD

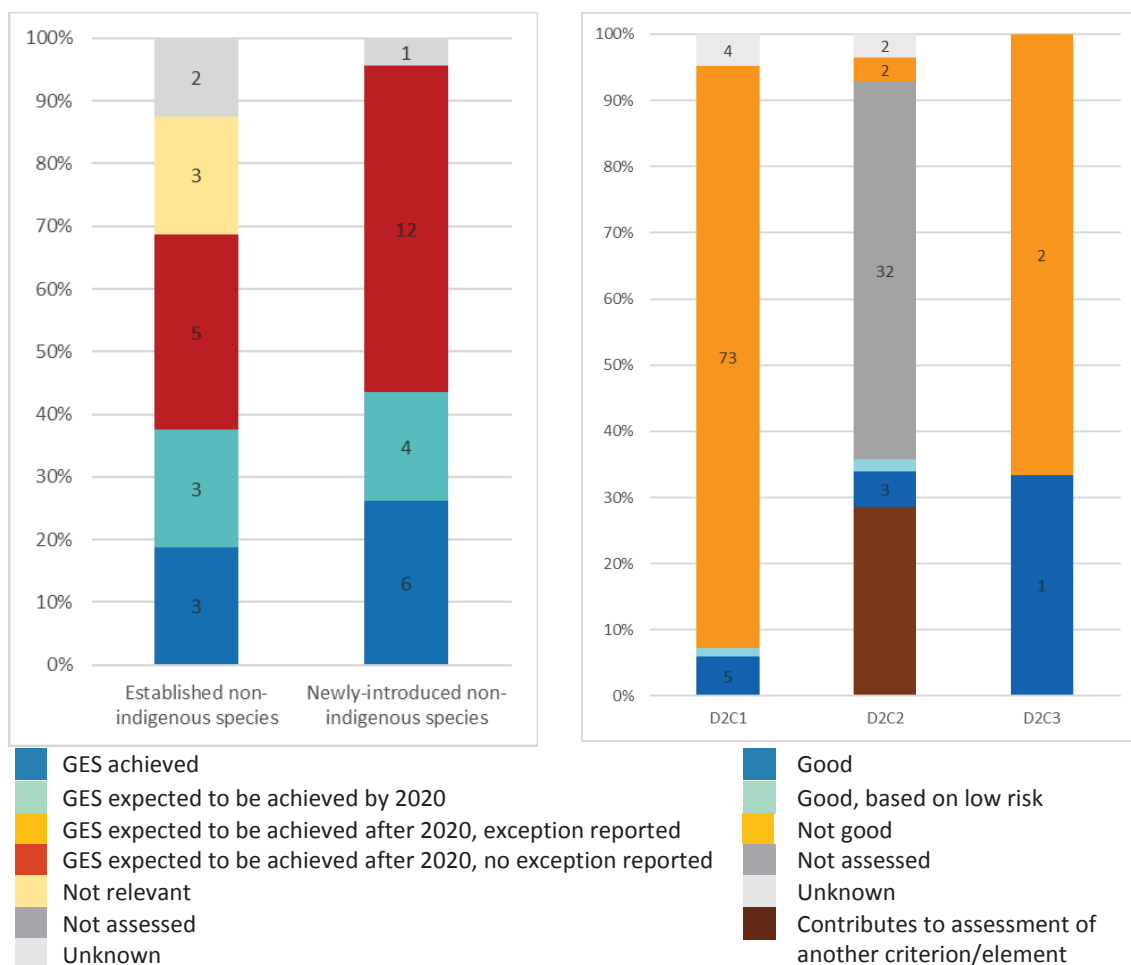


Figure 10: Latest MSFD assessments of good environmental status related to non-indigenous species and corresponding criteria under Descriptor 2. The information comes from 10 Member States' electronic reports.

The analysis of newly introduced non-indigenous species conclude that GES has been achieved only in 6 assessments (around 25% of the cases), while other 6 assessments have concluded that it will be achieved by 2020. More than 50% of the results have been reported as 'GES expected to be achieved later than 2020 and where no Article 14 exception has been reported'.

A number of assessments have been reported on the established non-indigenous species, where in almost 40% have either achieved GES or will achieve it by 2020. 3 assessments have been reported as 'not relevant', therefore not concluding on the status of those species.

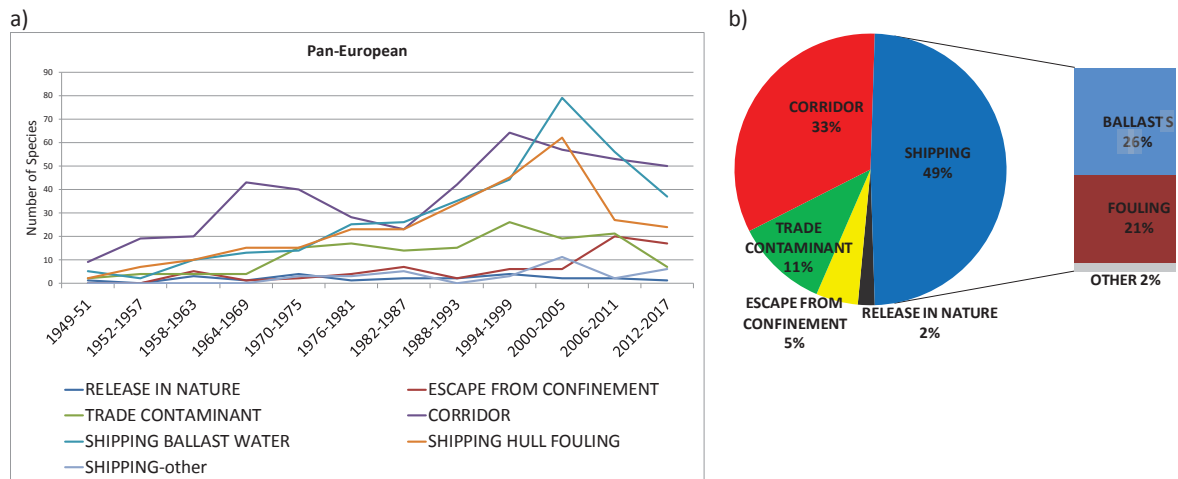
A large proportion of assessments of the criteria about the number of newly introduced non-indigenous species (D2C1) and the adverse effects of those species on other ecosystem components (D2C3) are reported in 'not good' status. The majority of asse The abundance and distribution of established non-indigenous species (D2C2) is mostly 'not assessed' or used for other criterion/element.

2.2. Other assessments

2.2.1. Pathways of introduction of non-indigenous species

Increased trade and tourism and the related maritime transport as well as the development of aquaculture and fisheries have provided pathways for the introduction and spread of marine alien species across Europe's seas. In addition, many non-indigenous species already introduced in the marine waters of a country have significantly expanded their distribution range (ETC/ICM, 2019b). Full eradication is no longer a suitable solution for management once an alien species has established a viable population, although controlling species population might be achieved, for instance capturing the species and commercialising them as seafood. There is a wide international consensus that pathways-based preventive management is of absolute priority in effectively combating marine alien species (Ojaveer et al., 2018).

The main pathways for introductions of marine non-indigenous species in Europe's seas (Figure 11) are shipping (49%) and marine and inland corridors (33 %, notably the Suez Canal). However, the contribution of these two pathways is widely different across the EU marine regions. Shipping contribution ranges from 45% in the Eastern Mediterranean Sea to approximately 82 % in the Black Sea. Among the marine alien species transferred by shipping, most species have been possibly transferred in ballast water (346 species), while the introduction of 287 species is tentatively attributed to boat hull fouling (EEA, 2019b). Marine and inland corridors are main pathways of introductions in the Eastern Mediterranean Sea (>46% of all marine introductions are via the Suez Canal) and in the Baltic Sea (15 % via inland canals). Additionally, important pathways of introduction are the unintentional movement of live organisms (11%) (i.e. by aquaculture activities), and escapes from aquaria and aquaculture (5%). Aquaculture (directly related to oyster culture) is responsible for more than 30% of marine introductions in the North-east Atlantic (Celtic, Iberian, Icelandic and North seas) (EEA, 2019b). Intentional releases in nature account for around 2%.



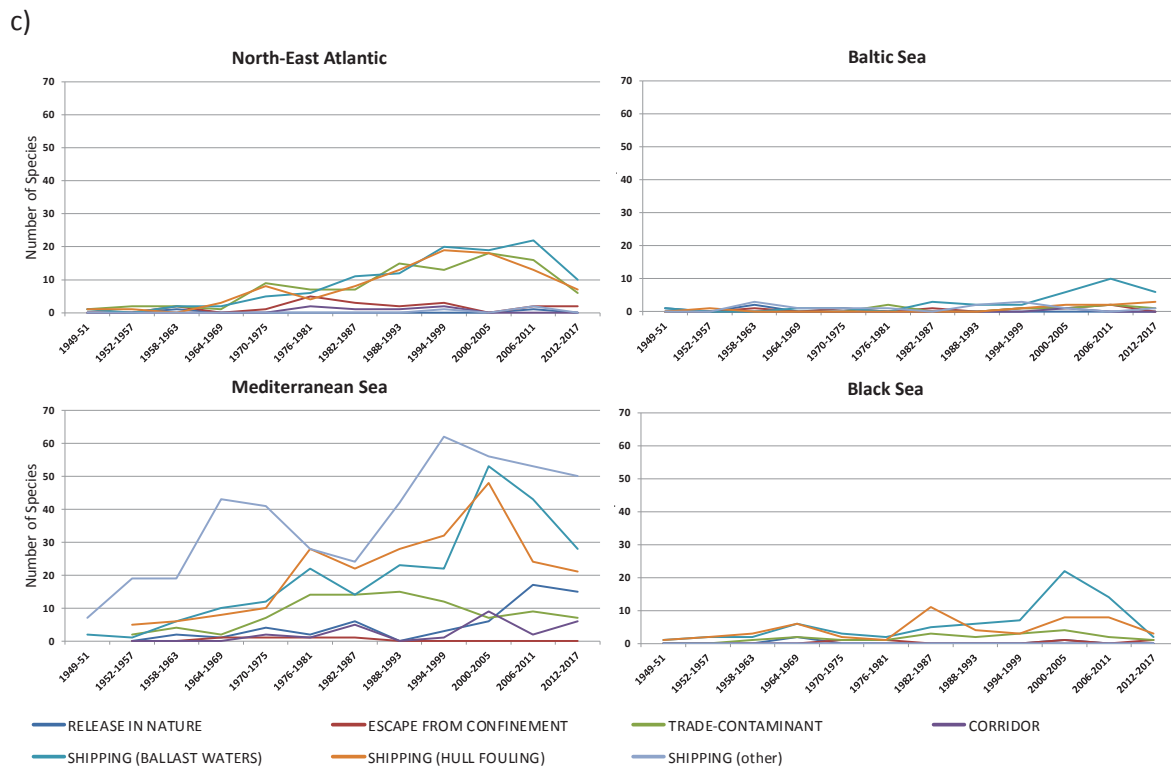


Figure 11: a) Trends in introductions of new non-indigenous species in European marine regions since 1949 per pathway. b) Relative importance of the pathways of introduction of non-indigenous species in EU marine regions since 1949. c) Trends in introductions of new non-indigenous species in each EU marine region since 1949 per pathway (EEA, 2019b).

2.2.2. The native distribution range of non-indigenous species

The vast majority of the European marine non-indigenous species originate in the Western and Central Indo Pacific, being mostly associated with introductions into the Mediterranean Sea through the Suez Canal (Tsiamis et al., 2018). However, a more detailed analysis reveals various patterns of the dominating native distributions introduced in Europe, depending on the European marine subregions where they have been initially introduced (Figure 12).

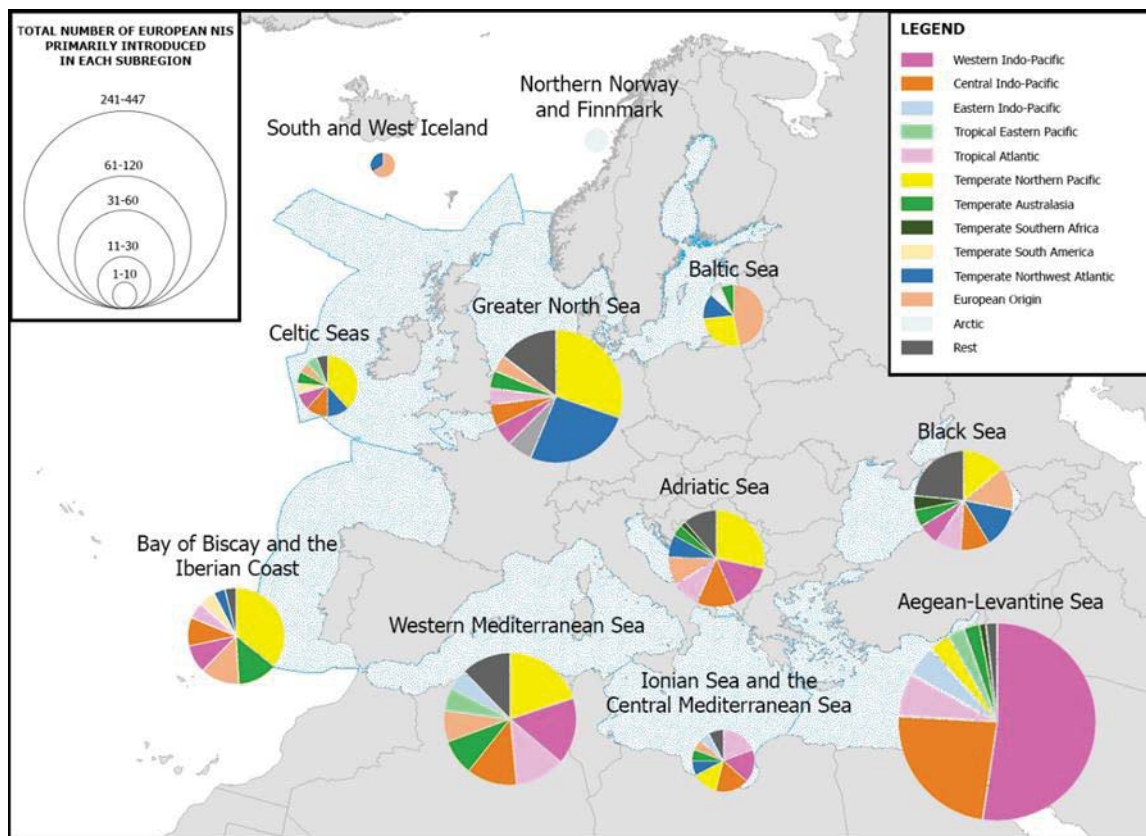


Figure 12: Proportion of the major native distribution ranges of established European marine non-indigenous species, associated with their first introduction events in Europe, depicted per marine sub-regions following the MSFD and Spalding et al. (2007). The size of each pie chart represents the total number of non-indigenous species primarily introduced in a subregion (the subregion of the initial arrival at European scale). The species of European origin have been counted in the subregion of first introduction within their alien European range. Non-indigenous species associated with “European Origin” are those with native distribution in at least one European Sea but with alien range into other(s). Source: © 2018 REABIC, Tsiamis et al. (2018).

3. OBSERVED TRENDS

The number of newly introduced non-indigenous species shows both temporal and spatial variation when looking across Europe’s seas since the early fifties. Available data show that around 1 223 non-indigenous species are present in the Europe’s seas, of which almost 81% (1 039) were recorded in the period 1949-2017 (EEA, 2019c).

When considering the four EU marine regions altogether as well as each individual region, there is a decreasing trend of new introductions observed during the last decade (Figure 13), and this is most significant in the Black Sea, Greater North Sea and Celtic Seas. However, the abrupt increase in monitoring efforts during the 1990s and 2000s could have given an inflated increased peak for newly introduced species during that period, resulting in the subsequent “decreasing trend” observed during the 2010s.

According to an ICES¹⁰ evaluation of the period 2012-2017, at the national level, the number of non-indigenous species introduced via human activity has been reduced to zero in the marine waters of Belgium, Denmark, Estonia, Finland, Germany, Ireland,

¹⁰ International Council for the Exploration of the Seas

Latvia, Lithuania, Netherlands, Poland, Sweden and United Kingdom (ICES, 2018a). However, this could be related to the insufficiency of monitoring programmes; thus, these data should be considered with caution.

In a recent work led by the Joint Research Centre, refined baseline inventories of non-indigenous species were set per Member State in the context of the MSFD Descriptor 2 (Tsiamis et al., 2019). The inventories were based on the initial assessment of the MSFD of 2012 and the updated data of the European Alien Species Information Network (EASIN), in collaboration with experts appointed by the Member States¹¹. The analysis revealed that a large number of non-indigenous species was omitted from the initial assessments. Moreover, several species initially listed are currently considered as native in Europe or were proven to be historical misreporting. The refined baseline inventories constitute a milestone for the MSFD Descriptor 2 implementation, providing an improved basis for reporting new introductions of non-indigenous species by the Member States (Figure 14). In addition, the inventories can help Member States in the establishment of monitoring systems of targeted species, and foster cooperation on monitoring alien species across or within shared marine subregions.

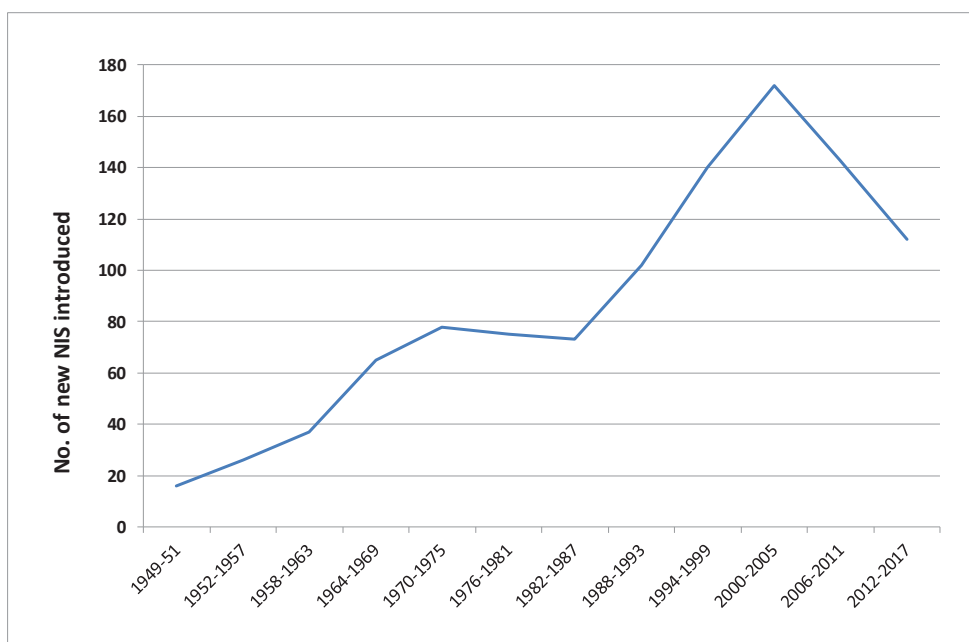


Figure 13: Introductions of new non-indigenous species in Europe's seas since the 50s (EEA, 2019c).

¹¹ AquaNIS (2018), which is routinely updated by the ICES Working Group of Introduction and Transfers of Marine Organisms, substantially contributed to the Baltic Sea and several North-east Atlantic countries.

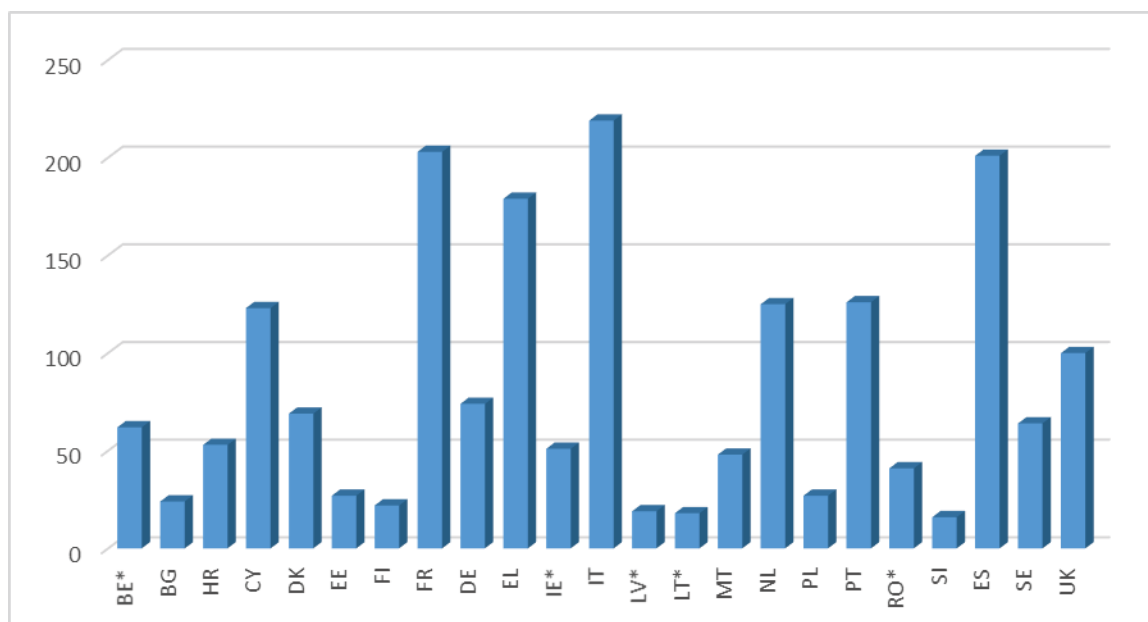


Figure 14: Refined total number of non-indigenous species up to 31.12.2011 per EU Member State. For Member States with an * data are exclusively based on the comparison assessment between the initial reporting lists of non-indigenous species and EASIN. Source: © 2019 Marine Pollution Bulletin, Tsiamis et al. (2019).

Data sources

Georeferenced data for the selected non-indigenous species were provided by:

- AquaNIS, Information system on Aquatic Non-Indigenous and Cryptogenic Species. World Wide Web electronic publication. www.corpi.ku.lt/databases/aquanis Version 2.36+
- EASIN, JRC European Alien Species Information Network. <https://easin.jrc.ec.europa.eu/>; last assessed 03.08.2018
- ELNAIS: <https://services.ath.hcmr.gr/>
- EPPO: http://www.eppo.org/INVASIVE_PLANTS/ias_plants.htm
- ESENIAS: <http://www.esenias.org/>
- EurOBIS, <http://www.eurobis.org/> citation: data assessed on 17.05.2017
- GISIN, Global Invasive Species Information Network: <http://www.gisinet.org/>
- HCMR, additional information: HCMR and EEA offline database for the Mediterranean (last update from July 2018);
- ICES/IMO/IOC WGBOSV and WGITMO reports 2002-2018: <http://www.ices.dk/community/groups/Pages/WGITMO.aspx> and <http://www.ices.dk/community/groups/Pages/WGBOSV.aspx>
- MAMIAS, UNEP-MAP-RAC/SPA, 2018. Marine Mediterranean Invasive Alien Species: <http://www.mamias.org/>
- NOBANIS, European Network on Invasive Alien Species: <http://www.nobanis.org/>
- REABIC, Regional Euro-Asian Biological Invasions Centre: <http://www.reabic.net/>

4. MAIN IMPACTS

Introductions of non-indigenous species are widely perceived as one of the main threats to biological diversity. Of particular importance are the invasive alien species, namely

those non-indigenous species that, once established, spread rapidly and impact the native biological diversity in various ways. Their impacts can range from reduced genetic variation, eroded gene pools, through to altered habitats and ecosystems functioning, to the extinction of endemic species (Katsanevakis et al., 2014). Some examples of marine invasive alien species include the alien comb jelly *Mnemiopsis leidyi* in the Black and Caspian seas (Dumont et al., 2004) and the Lessepsian fish *Siganus luridus* in the Eastern Mediterranean Sea (Azzurro et al., 2016) (Figure 15).



Figure 15: Left: *Mnemiopsis leidyi*; photo author Karl Van Ginderdeuren. Right: *Siganus luridus*, photo author Roberto Pillon. These photos are under a Creative Commons Attribution-Noncommercial-Share Alike 4.0 License (downloaded from the World Register of Marine Species).

The cumulative impact of invasive alien species in the European seas is maximum in a restricted coastal area. The total area of Europe's marine and coastal ecosystems *invaded* by invasive alien species is 8%. Out of this, the total area *impacted* by invasive alien is slightly lower, at 7%, which corresponds to approximately 421 231 km² (ETC/ICM, 2019b). However, these numbers should be considered with caution in the absence of related information regarding the impact of numerous marine non-indigenous species and due to the knowledge gaps on the species distribution, especially when it comes to the offshore areas.

5. TECHNICAL OBSERVATIONS

- As already recommended in previous Commission reports under the MSFD, joint monitoring approaches spanning whole EU marine regions could close knowledge gaps in terms of new introductions of non-indigenous species.
- There is a need to investigate the impacts of non-indigenous species on the native communities, ecosystems and the services they provide.
- Measures would need to better address the main pathways of introduction in order to minimise new introductions, and would, thus, differ from region to region. In terms of preventing the impacts from such introductions, measures would need to focus on increasing the resilience of Europe's seas ecosystems and minimising the conditions that can promote non-indigenous species to become invasive. Such conditions include the existence of 'empty niches' in the food web because of the reductions of certain native species resulting from human

activities, such as the loss of top predators caused by fisheries, or climate change impacts reflected in an increased sea surface temperature.

- The implementation of current global and EU legislative instruments and policies, such as the MSFD, the Invasive Alien Species Regulation, and the Ballast Water Management Convention¹², should be monitored in terms of their efficiency in decreasing the risk of new introductions of alien species.

6. KEY MESSAGES

- There are over 1200 marine non-indigenous species in Europe's seas. The cumulative number of non-indigenous species is still increasing, since they are still introduced into Europe's seas. However, the rate of new introductions seems to be decelerating.
- The main pathways for introductions of alien species in Europe's seas seem to be shipping (49%) and marine and inland corridors (33 %).
- The vast majority of the European marine non-indigenous species have their native distribution in the Western and Central Indo Pacific. However, there are various patterns of the dominating native distributions of the introduced species in Europe, depending on the European marine subregions where they have been initially introduced.
- Some non-indigenous species already introduced have significantly expanded their distribution range in some areas. However, it is difficult to assess the proportion of marine species and habitats that have been adversely affected.
- New refined baseline inventories of non-indigenous species per Member State show discrepancies with the initial assessments reported under the MSFD. Italy, France, Spain and Greece had the largest numbers of non-indigenous species back in 2011 (more than 150 species each). These baselines provide an improved basis for reporting new introductions and for establishing of monitoring systems.
- More than 80 non-indigenous species correspond to invasive alien species. Their impacts may be scored and mapped, their impacts are obvious in coastal areas but not offshore. The total area of Europe's marine and coastal ecosystems impacted by invasive alien species is 7%. However, this is most likely an underestimation due to the knowledge gaps regarding their actual distribution and impacts.

¹² The International Convention for the Control and Management of Ships' Ballast Water and Sediments adopted by the International Maritime Organization (IMO) in February 2004 in order to halt invasive aquatic species.



Brussels, 25.6.2020
SWD(2020) 61 final

PART 2/3

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 3: Populations of all commercially-exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock

1. MSFD AND BROADER LEGAL FRAMEWORK

COM DEC 2017/848/EU		COM DEC 2010/477/EU
D3 Commercial fish and shellfish		
D3C1 Fishing mortality rate (F)	The Fishing mortality rate of populations of commercially-exploited species is at or below levels which can produce the maximum sustainable yield (MSY). Appropriate scientific bodies shall be consulted in accordance with Article 26 of Regulation (EU) No 1380/2013.	3.1 Level of fishing pressure 3.1.1 Fishing mortality 3.1.2 Fish catch/biomass ratio
D3C2 Spawning stock biomass (SSB) ¹	The Spawning Stock Biomass of populations of commercially-exploited species are above biomass levels capable of producing maximum sustainable yield. Appropriate scientific bodies shall be consulted in accordance with Article 26 of Regulation (EU) No 1380/2013.	3.2 Reproductive capacity of stock 3.2.1 Spawning stock biomass 3.2.2 Biomass indices
D3C3 Population age/size distribution ²	The age and size distribution of individuals in the populations ³ of commercially-exploited species is indicative of a healthy population. This shall include a high proportion of old/large individuals and limited adverse effects of exploitation on genetic diversity.	3.3 Population age/size distribution 3.3.1 Proportion of larger fish 3.3.3 Fish length distribution 3.3.4 Fish size at maturation
		3.3.2 Maximum length of fish

Descriptor 3 deals with the state of all commercially exploited fish and shellfish. Commercially exploited populations applies to all marine biological resources targeted for economic profit, including the bony fish (teleosts), sharks and rays (elasmobranchs), crustaceans such as lobsters and shrimps, and molluscs (including bivalves and cephalopods). The scope of the MSFD concerning Descriptor 3 is particularly broad. It encompasses the precautionary principle, the ecosystem approach and exploitation levels that correspond to the maximum sustainable yield (MSY)⁴.

¹ SSB is an estimate of the mass of the fish of a particular stock that reproduces at a defined time, including both males and females and fish that reproduce viviparously.

² Commission Decision 2017/848/EU acknowledges that D3C3 may not be available for use for the 2018 review of the initial assessment and determination of good environmental status under Article 17(2)(a) of the MSFD, reflecting ongoing discussions on relevant indicators and lack of reference points.

³ The term ‘populations’ shall be understood as the term ‘stocks’ within the meaning of Regulation (EU) No 1380/2013

⁴ MSY means the highest theoretical equilibrium yield that can be continuously taken on average from a stock under existing average environmental conditions without significantly affecting the reproduction process

The EU has an exclusive competence in the area of the conservation of marine biological resources under the Common Fisheries Policy (Article 3 of Treaty on the Functioning of the EU, TFEU) for capture fisheries in EU waters and for fisheries outside EU waters conducted by EU vessels. Under the MSFD, measures relating to fisheries management can be taken in the context of the Common Fisheries Policy. Under the Common Fisheries Policy, the fishing pressure on stocks concerned should be aligned as soon as possible, and by 2020 at the latest, to the objective of restoring and maintaining stocks to levels that can produce MSY. Exploiting fish stocks at or below the exploitation levels which is associated with MSY allows them to be maintained or allows them to recover to healthy levels, and providing food for consumers while contributing to important ecosystem and marine food web functions. Achieving this objective will also contribute to achieving good environmental status in European seas by 2020, as required by the MSFD, and to reducing the negative impact of fishing activities on marine ecosystems.

The tools available under the Common Fisheries Policy for achieving sustainability include Total Allowable Catches, effort control and access restrictions. These measures can be packaged in multi-annual plans in order to allow some stability of the industry, whilst continuing to ensure the sustainability of the fisheries. Furthermore, the EU introduced an obligation for all catches of species subject to a catch limit to be landed, as well as all catches subject to a minimum catching size in the Mediterranean Sea⁵. Implemented this obligation is expected to lead to a decreased fisheries pressure on juveniles, as fish previously banned from being landed now have to be landed and are counted towards the Total Allowable Catches. The vast majority of Member States reported some of these fisheries management measures as part of their MSFD programme of measures.

⁵ Article 15 of Regulation (EU) No. 1380 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. O.J. L 354 , 28.12.2013, p.22.

2. OBSERVED STATUS OF THE EU'S COMMERCIAL FISH AND SHELLFISH

2.1. Ongoing reporting under the MSFD

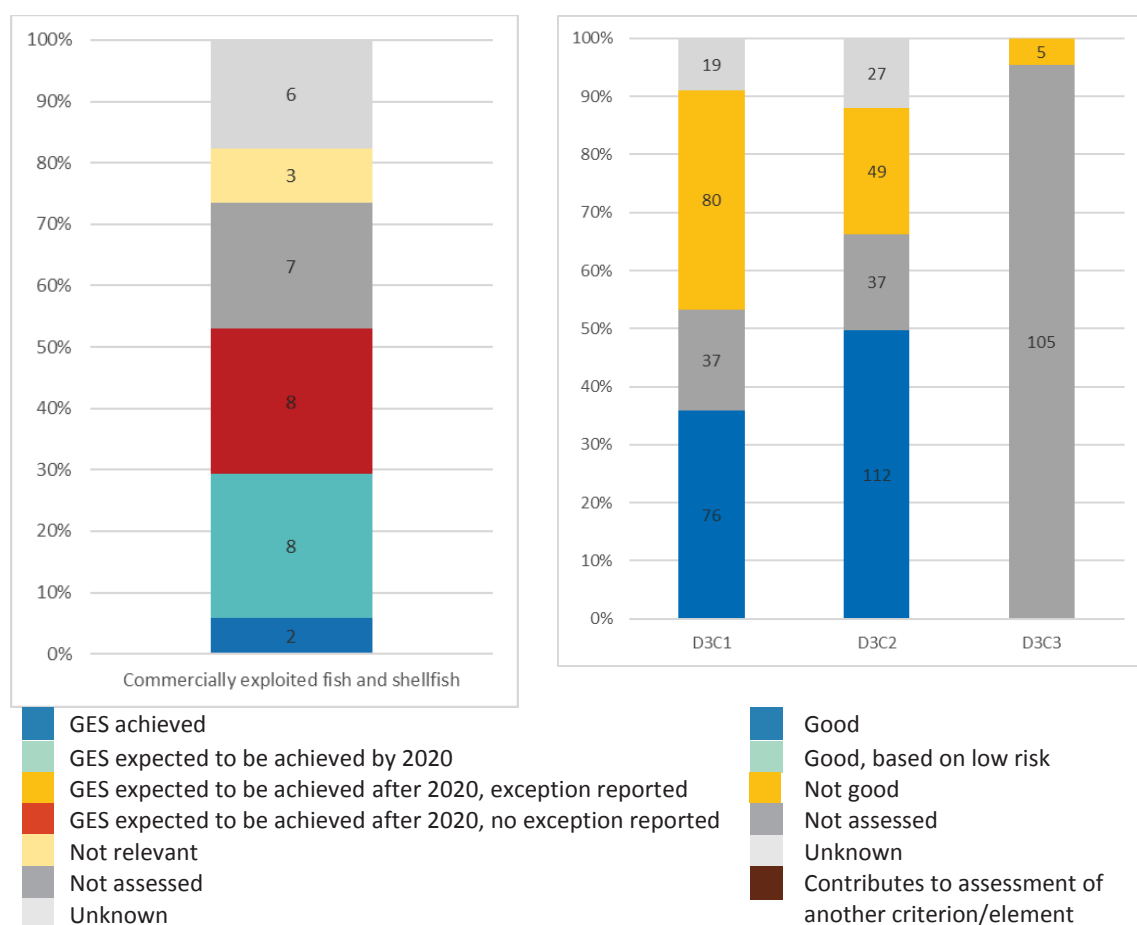


Figure 16: Latest MSFD status assessments per feature (left) and per criteria (right) under Descriptor 3. The information comes from 10 Member States' electronic reports.

Only in 2 of the reported assessments for commercially exploited fish and shellfish GES is achieved, while in 8 cases GES will be achieved by 2020 and in 8 it will be achieved only later than 2020 and no Article 14 exception has been reported. Almost 50% of the assessments have been reported with no conclusion.

The most reported criteria for fish stocks assessments are the fishing mortality rate (D3C1) and the spawning stock biomass (D3C2). For fishing mortality, around 35% of the assessments are reported in 'good' status and another 35% as 'not good'. For spawning stock biomass, 50% of the assessments conclude that the status of the stocks is 'good'. There are still a number of assessments without conclusion in these two criteria, but the proportion of 'not assessed' is much higher (over 95%) for the criterion related to the population age/size distribution (D3C3). The few reported assessment of this criterion resulted in 'not good'.

2.2. Other assessments

The capture fisheries or wild fisheries in the EU are usually classified into two areas under the Common Fisheries Policy: the Atlantic waters (including the MSFD North-east Atlantic Ocean and Baltic Sea regions) and the Mediterranean Sea and Black Sea regions together. The present assessment is based on the same selection of stocks that are used by

the Common Fisheries Policy monitoring report: stocks in the North-east Atlantic Ocean are included if they are managed by total allowable catches, whereas the advisory committee (STECF) decided on a list of stocks in for the Mediterranean area (STECF, 2019). Still, it must be noted that such analysis may cover less than half of the commercially exploited fish/shellfish stocks landed across Europe's seas (EEA, 2019g - table 4.1). The results presented in this chapter (see the selection criteria in the next paragraph) seem to cover over one third of the commercial fish/shellfish stocks in the North-east Atlantic Ocean and Baltic Sea regions and around half of the stocks in the Mediterranean Sea and Black Sea regions (based on EEA, 2019d and STECF, 2019).

The number of stocks inside/outside biological limits (Figure 17) corresponds to indicators 3.3 and 3.4 of the annual Common Fisheries Policy monitoring report (Annex 1 of STECF, 2019)⁶. The safe biological limit (SBL) is defined as the fishing mortality (F) being below the precautionary reference exploitation level (F_{pa}) and the spawning stock biomass being above the precautionary biomass level (B_{pa})⁷. However, as data from the Mediterranean or Black Sea stocks are not enough to perform the analysis adequately (i.e. having available estimates for fishing mortality, biomass, and point for both), it was decided to use only the fishing mortality estimates and comparing them to the fishing mortality that produces the maximum sustainable yield (F_{msy}) as a reference point. A similar analysis is presented in EEA (2019d).

None of these assessments include the third MSFD D3 criterion on age and size structure of the populations as this cannot be assessed at present. Hence, an overall conclusion about the 'good environmental status' of fish/shellfish stocks cannot be reached at the moment according to the MSFD standards.

Currently, 41% of the assessed fish and shellfish stocks in the North-east Atlantic Ocean and Baltic Sea regions are within safe biological limits⁸. The situation is worst in the Mediterranean and Black Sea regions where only 13% of the stocks⁹ considered in this analysis are not overfished and 87% are overfished¹⁰. The Central Mediterranean Sea is the worst performing ecoregion in terms of percentage of overfishing. Given this context, the 2020 objective of having healthy commercial fish and shellfish populations seems unlikely to be met in all Europe's seas and further collective action is required¹¹.

⁶ The precise methodology for SBL and trends analyses as well as the corresponding data sources are explained in detail in the Annex of STECF (2019).

⁷ Note that these precautionary reference values are different, usually less strict, than the MSY levels although they allow to make a more comprehensive analysis of safe biological limits. This is driven by data availability.

⁸ This is based on an analysis of 70 stocks with data and reference points available (see figure 17 and STECF, 2019) while the total commercially exploited stocks in the area can exceed 200 stocks (EEA, 2019d).

⁹ Or 7.5% of the stocks (3 out of 40) according to EEA (2019d).

¹⁰ This is based on an analysis of 47 stocks that can represent half of the total commercially exploited stocks in the area.

¹¹ An alternative estimation (EEA, 2019d) shows that around 45 % of the assessed commercially exploited fish and shellfish stocks in Europe's seas are not in GES based on both fishing mortality and reproductive capacity criteria, or in cases where only one criteria was available and not in GES. The other 55 % of the stocks met at least one of the criteria for GES. This assessment does not include the third GES criterion on age and size structure of the populations as this cannot be assessed at present.

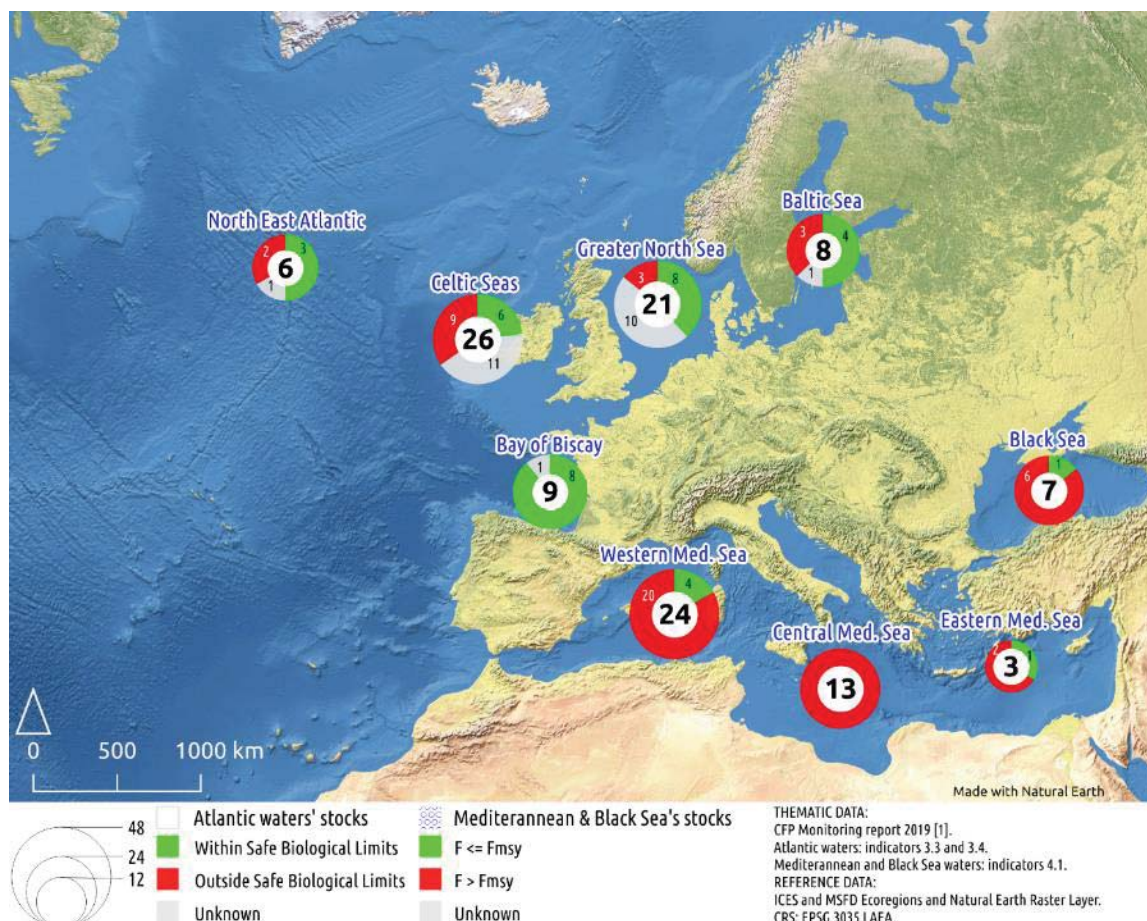


Figure 17: European waters' fish stocks analyses based on indicators from the Common Fisheries Policy monitoring report 2019. The number of stocks are a subsample of all stocks following the same selection procedure as the Common Fisheries Policy monitoring report. The total number of stocks is displayed using proportional circles with labels in the middle; parts of the total are displayed using a doughnut diagram with labels reporting absolute number of stocks in each category. © European Union, reproduced with permission, STECF (2019).

As a reflection of data availability and quality, Figure 18 shows commercial European fish landings by MSFD regions in 2017 (EEA, 2019d). Within this figure, fish landings are divided into three categories, namely (1) landings for assessed stocks for which adequate information is available to determine fishing pressure and reproductive capacity (covering MSFD criteria D3C1 and D3C2), (2) landings for assessed stocks for which insufficient information is available to determine one of those criteria, and (3) landings for assessed stocks for which information on both criteria is insufficient to determine GES. While the information base continues to improve, knowledge gaps remain. For the EU waters, about a third of the landings (34%) are from stocks for which their status could be assessed against at least one GES criterion. However, there are distinct regional differences. Figure 18 shows that an assessment of status is only possible for 6.5% of total landings from the Mediterranean Sea and the Black Sea, compared with 36% of those from the North-east Atlantic Ocean and Baltic Sea. Therefore, the EU still faces the need to assess more stocks to obtain better information to inform GES assessments specially for many of the smaller and less commercially stocks which often lack information upon which to base an assessment of GES.

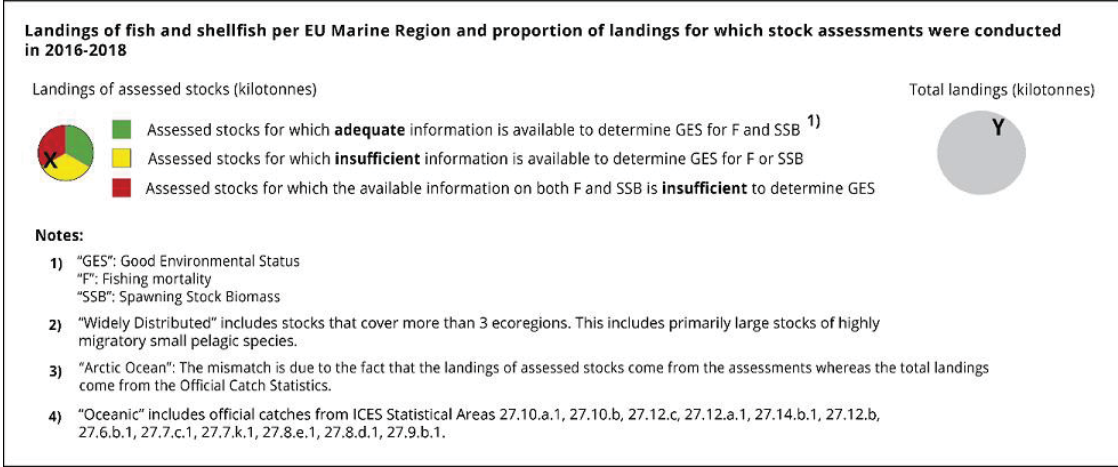
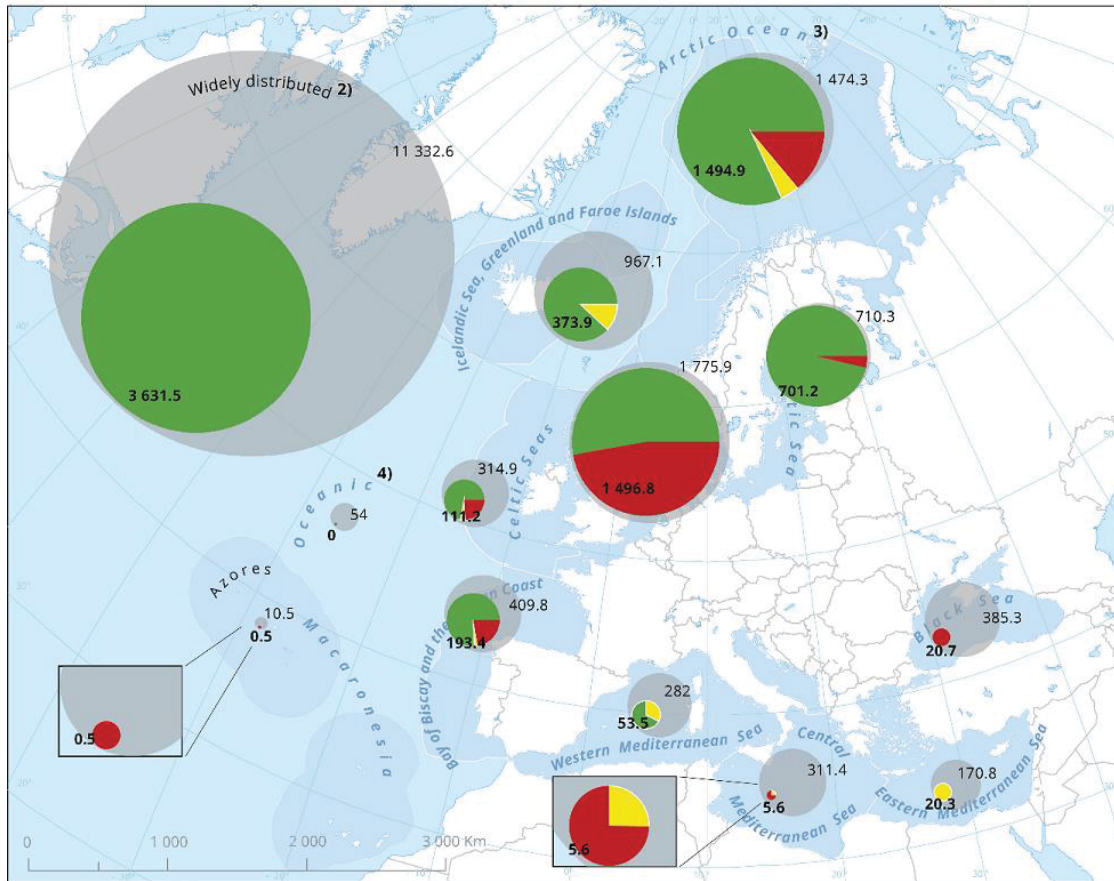


Figure 18: Landings of commercial fish and shellfish per regional sea, and proportion of landings for which stock assessments are available (EEA, 2019d).

3. OBSERVED TRENDS

Fishing mortality

Trends in F with respect to the F_{msy} reference point corresponds to indicator 3.7 of the Common Fisheries Policy report (Annex 1 of STECF, 2019). A value greater than 1 ($F > F_{msy}$) indicates exploitation exceeds the level that would produce the maximum yield, and is likely less sustainable in the long term.

In the Atlantic waters (covering the MSFD North-east Atlantic Ocean and Baltic Sea regions), the average fishing mortality has decreased since 2003 towards the F_{msy} reference point. All Atlantic sub-regions (or ‘ecoregions’ as referred to in the Common Fisheries Policy) mirror this trend with the exception of the Baltic Sea where the average fishing mortality has slightly increased over the past few years. The other ecoregions have an average fishing mortality that is below or very close to the average F_{msy} (Figure 19). In order to fulfil the Common Fisheries Policy requirements completely, the management-by- F_{msy} -coverage of the stocks needs to increase to all stocks.

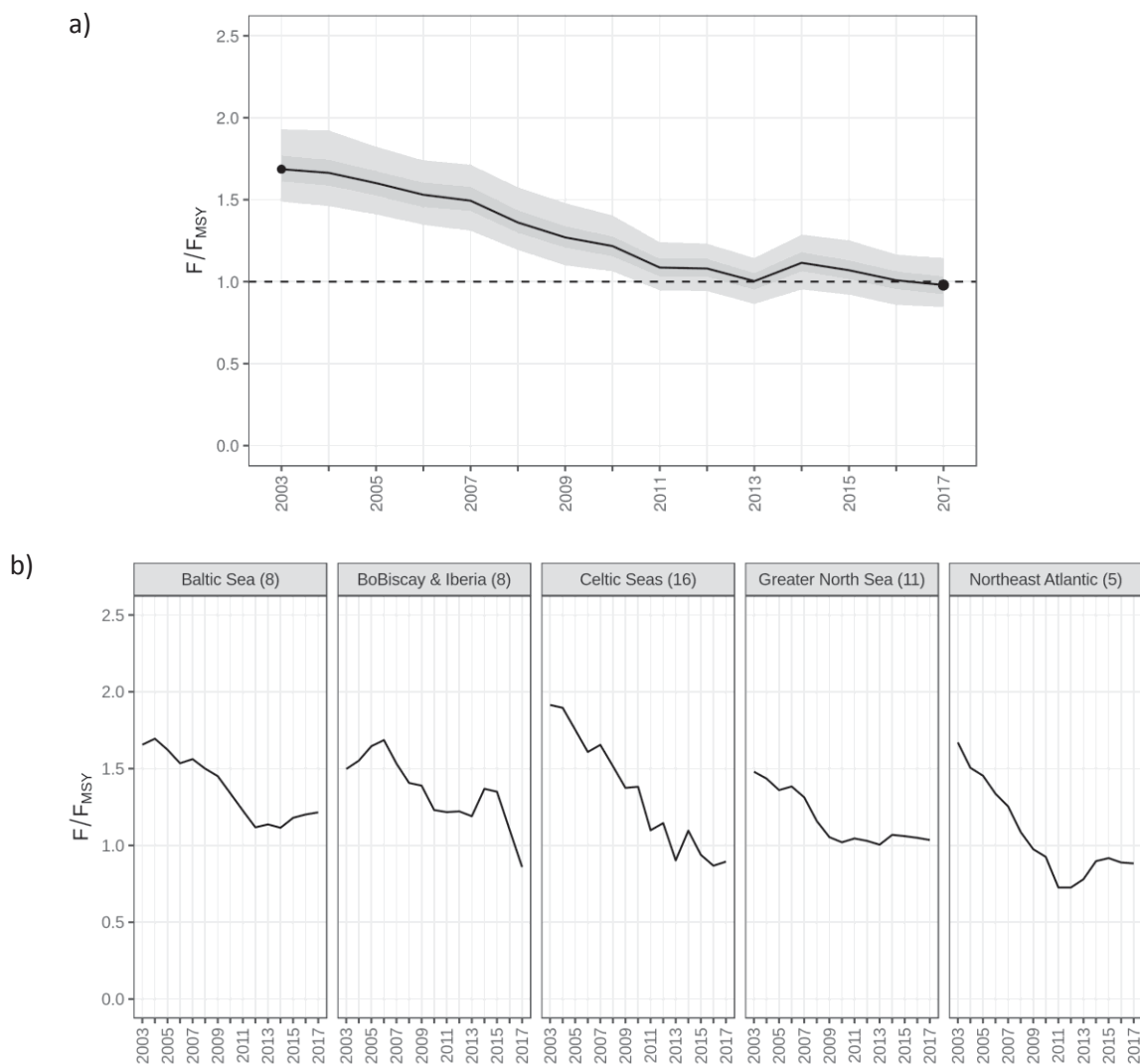


Figure 19: Trend in F/F_{msy} in a) Atlantic waters as a whole (based just on 48 stocks) and b) by ecoregion (number of stocks are in parenthesis). No uncertainty envelopes were calculated due to the low number of stocks available within each region. The confidence intervals shown are 50% (dark grey) and 95% (light grey). STECF (2019) © European Union.

The fishing mortality in the Mediterranean and Black Sea has remained virtually unchanged since 2003. It remains extremely high, indicating that most selected stocks are severely overfished. In recent years, a small decrease in average fishing mortality is encouraging, but not enough to fulfil the Common Fisheries Policy requirement to fish at F_{msy} levels by 2020. Regional trends mirror the overall trend with the exception of the Eastern Mediterranean, where a severe drop in fishing mortality has been observed. This drop can be explained in part through the low number of stocks in this region used by this analysis and its persistence into the future cannot be taken for granted (Figure 20).

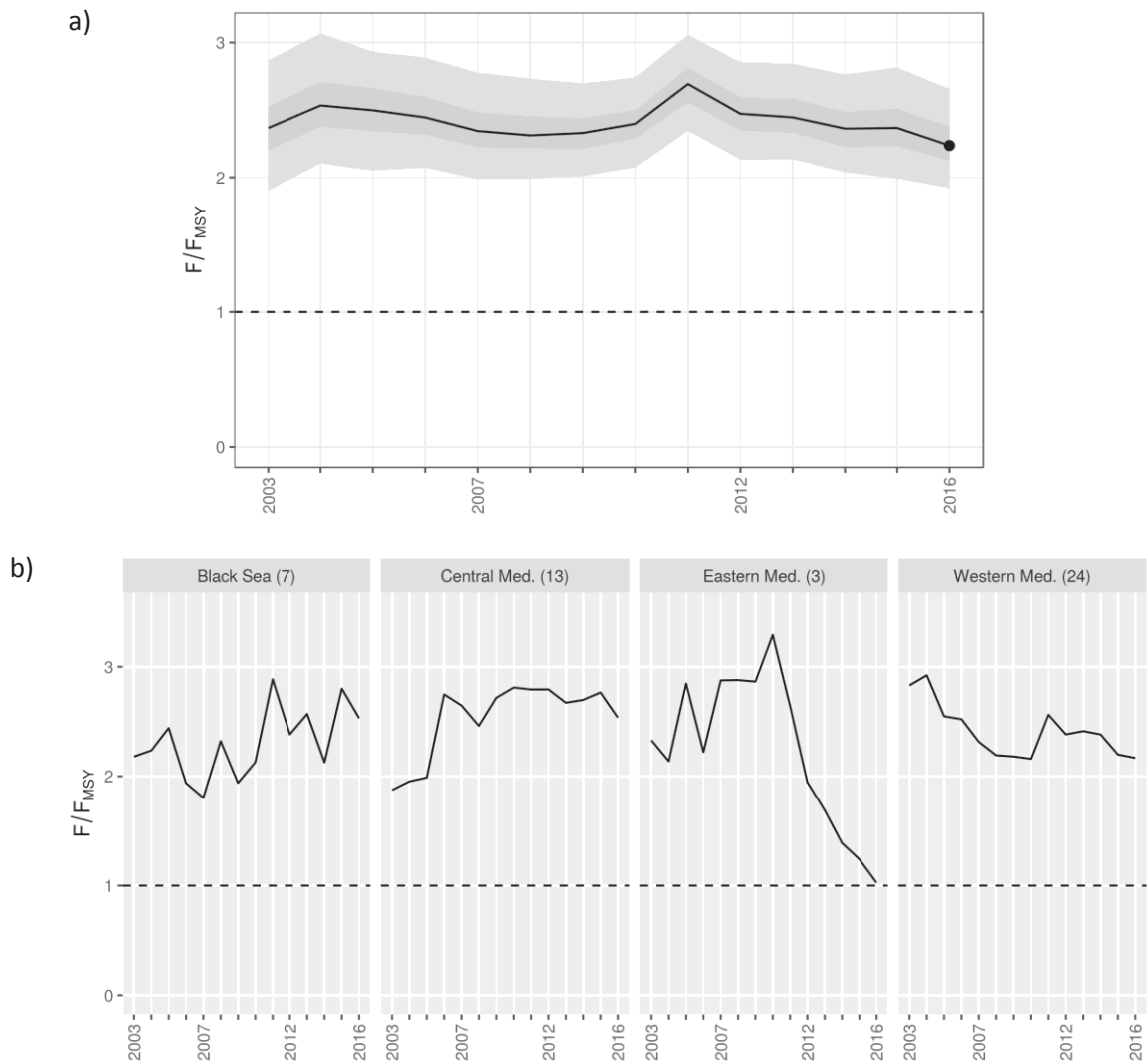


Figure 20: Trend in F/F_{msy} in a) the Mediterranean and Black Seas (based on 47 stocks) and b) the individual ecoregions (number of stocks are in paranthesis). No uncertainty envelops were calculated due to the low number of stocks available within each region. The confidence intervals shown are 50% (dark grey) and 95% (light grey). STECF (2019) © European Union.

Although only the trend analysis since 2003 is consistent in methods and the suite of assessed stocks, longer-term indicators have been estimated for the period 1947-2017¹². Such indicators show that fishing mortality in the North-east Atlantic Ocean and Baltic Sea increased over time from approximately sustainable levels ($F = 1$) in the 1950s to a maximum of more than twice the sustainable level, reached in the late 1990s. This was followed by a constant decline towards sustainable levels, and reached $F < F_{MSY}$ in 2017. Some of these trends may have been caused by newly assessed stocks being introduced into the analysis. As not all stocks are assessed every year, spurious trends can be introduced by chance in years when more heavily-fished stocks or more lightly-fished stocks may be chosen for assessment.

Despite recent improvements in the North-east Atlantic Ocean region, Nimmo and Cappell (2017) considered that a major step change was required to reduce both the

¹² Trend in the status of stocks assessment and the progress made in GES assessment in the North-east Atlantic Ocean and Baltic Sea since 1945, <https://www.eea.europa.eu/data-and-maps/figures/trend-in-the-status-of>

proportion of Total Allowable Catches set above scientific recommendations and the number of Total Allowable Catches set without scientific recommendations, since this contravenes opportunities for earlier stock recovery.

Spawning stock biomass

Trends in spawning stock biomass with respect to the spawning stock biomass in 2003, fitted using a generalised linear model. This indicator corresponds to indicator 3.8 of the Common Fisheries Policy report (Annex 1, STECF, 2019). A value greater than 1 ($B > B_{2003}$) means that spawning stock biomass is above the 2003 levels indicating that the reproductive capacity of stocks is improving.

The spawning stock biomass has slightly increased since 2003. The biggest relative increase is observed in the stocks of the Bay of Biscay and the North-east Atlantic Ocean. The trend over the recent years is upwards in most ecoregions. Trends in recruitment have started to increase after a decline (compared to 2003) that lasted from 2003 until 2014 in some areas. An exception to the average trend is the Celtic Sea region, which has seen no consistent decline in that period (Figure 21).

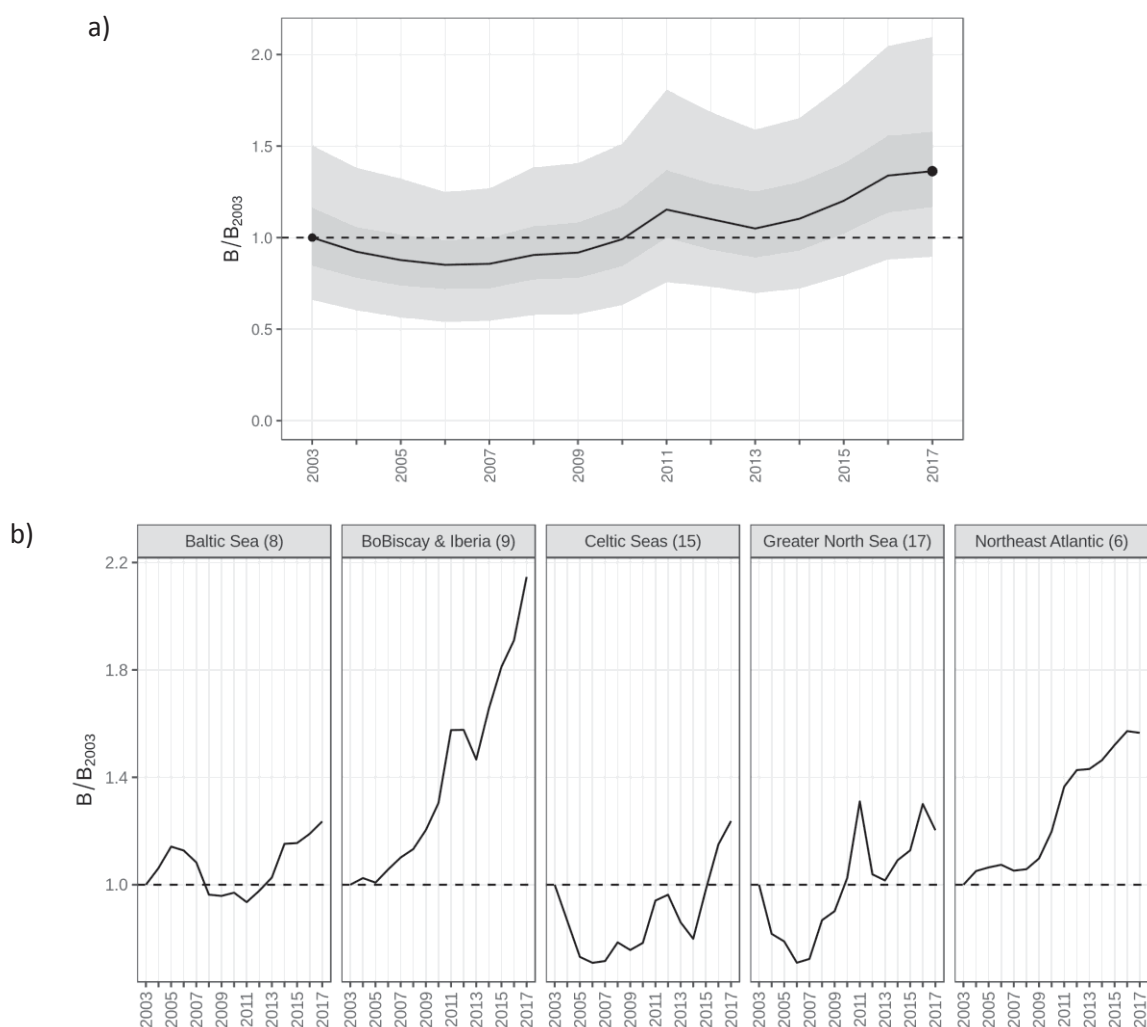


Figure 21: Trend in spawning stock biomass with respect to the 2003 level in a) Atlantic waters (based on 55 stocks) and b) by ecoregion (number of stocks are in parenthesis). The confidence intervals shown are 50% (dark grey) and 95% (light grey). STECF (2019) © European Union, reproduced with permission.

Similarly to the F_{msy} trend, the biomass trend in the Mediterranean and the Black Seas shows no statistically significant change since 2003. The average biomass has slightly increased in the last 2 years, which has been driven by the increase in spawning stock biomass in the Central and Eastern Mediterranean Sea. The ecoregions exhibit a large variation in trends and in number of stocks, which makes it difficult to make any assertions (Figure 22).

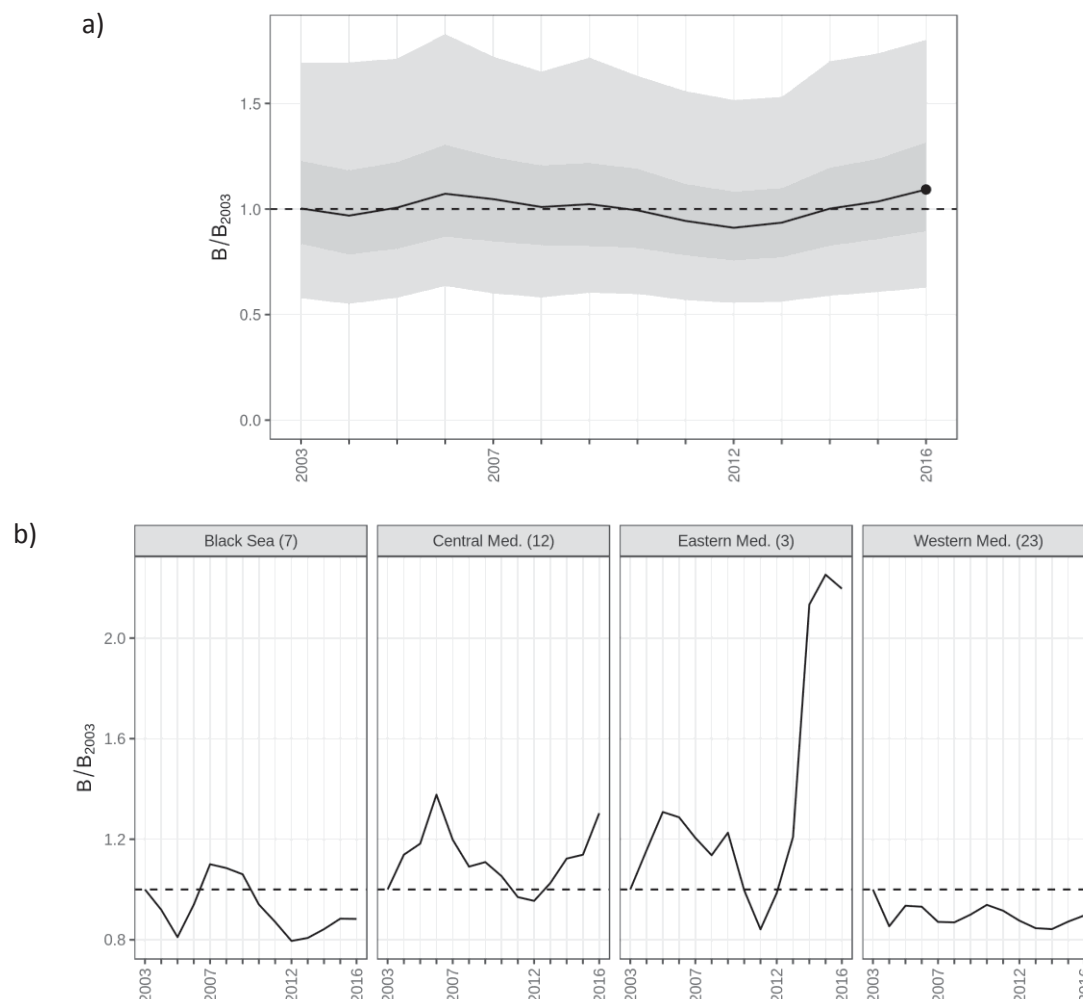


Figure 22: Trend in spawning stock biomass with respect to the 2003 level in a) the Mediterranean and Black sea regions based on the selected stocks, and b) by ecoregion (number of stocks are in parenthesis). The confidence intervals shown are 50% (dark grey) and 95% (light grey). STECF (2019) © European Union, reproduced with permission.

4. TECHNICAL OBSERVATIONS

Since 2010, an increasing proportion of EU Total Allowable Catches have been set in line with MSY advice¹³, climbing from 6% in 2005 to 71% in 2018 and 79% in 2020. Still, strong management decisions and transparent decision-making processes continue to be required if Total Allowable Catches are to be brought fully in line with scientific advice.

¹³ Table 4 of Commission staff working document accompanying the document Communication from the Commission on the state of play of the Common Fisheries Policy and consultation on the Fishing Opportunities for 2019. SWD(2019) 205 final.

It is urgent to improve data collection and perform regular and more stock assessments in particular in the Mediterranean Sea, Black Sea and Macaronesia. It is particularly important to develop and implement management arrangements for bringing the operation of fishing fleets in line with MSY parameters.

5. KEY MESSAGES

Although further improvements are still necessary, the trend analysis shows important signs of improvement in the North-east Atlantic Ocean and Baltic Sea. Since the early 2000s, better management measures have contributed to a decrease in fishing pressure on commercially exploited fish and shellfish stocks in these two regional seas, and signs of recovery in their reproductive capacity have started to appear. Currently, 41% of the assessed fish and shellfish stocks in the North-east Atlantic Ocean and Baltic Sea regions are within safe biological limits; although the assessed stocks cover around one third of the total commercial fish/shellfish stocks in the area. The spawning stock biomass has increased in these areas and it is now 36% higher than in 2003 and the number of assessed stocks inside safe biological limits has almost doubled from 2003 to 2017¹⁴. If management and implementation efforts are sustained, fishing pressure and reproductive capacity should continue to improve in the North-east Atlantic Ocean and Baltic Sea, although the progress is not enough to meet the relevant common fisheries policy objectives yet.

In contrast, in the Mediterranean Sea and the Black Sea the situation remains worrying with 87% of the assessed stocks overfished (based on the analysis of half of the total commercial fish/shellfish stocks in the area) and insufficient information about reproductive capacity to estimate safe biological limits. Both the trends in fishing mortality and the biomass trend in the Mediterranean and the Black Seas show no statistically significant change since 2003.

The figures indicate that further concerted efforts are required to achieve the 2020 objective of having healthy commercial fish and shellfish populations. Success will depend on the availability and quality of information and the commitment to implement the scientific advice and adequate uptake of management measures. Many stocks remain overfished and/or outside safe biological limits and it is clear that efforts by all actors will need to be intensified to meet CFP and MSFD objectives, considering in particular that 2020 is the first year when all stocks with an F_{msy} assessment should be managed at F_{msy} .

¹⁴ Communication from the Commission on the state of play of the Common Fisheries Policy and consultation on the Fishing Opportunities for 2020 (COM(2019) 274 final).

Descriptor 4: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity

1. MSFD FRAMEWORK

COM DEC 2017/848/EU		COM DEC 2010/477/EU
D4 Food webs / D1 Biodiversity - ecosystems		
D4C1 Trophic guild species diversity	Are anthropogenic pressures adversely affecting the diversity of the trophic guilds?	1.7 Ecosystem structure 1.7.1 Composition ecosystem
D4C2 Abundance across trophic guilds	Is the balance of total abundance between the trophic guilds adversely affected by anthropogenic pressures?	1.7 Ecosystem structure 1.7.1 Composition ecosystem 4.3 Abundance of trophic groups or species 4.3.1 Abundance of groups or species
D4C3 Trophic guild size distribution	Are anthropogenic pressures adversely affecting the distribution of individuals across the trophic guild?	4.2 Proportion of species at top of food webs 4.2.1 Large fish by weight
D4C4 Trophic guild productivity	Is the productivity of the trophic guild adversely affected due to anthropogenic pressures?	4.1 Productivity of species or trophic groups 4.1.1 Productivity of key predators

2. STATUS AND TRENDS OF MARINE FOOD WEBS IN EU WATERS

2.1. Ongoing reporting under the MSFD

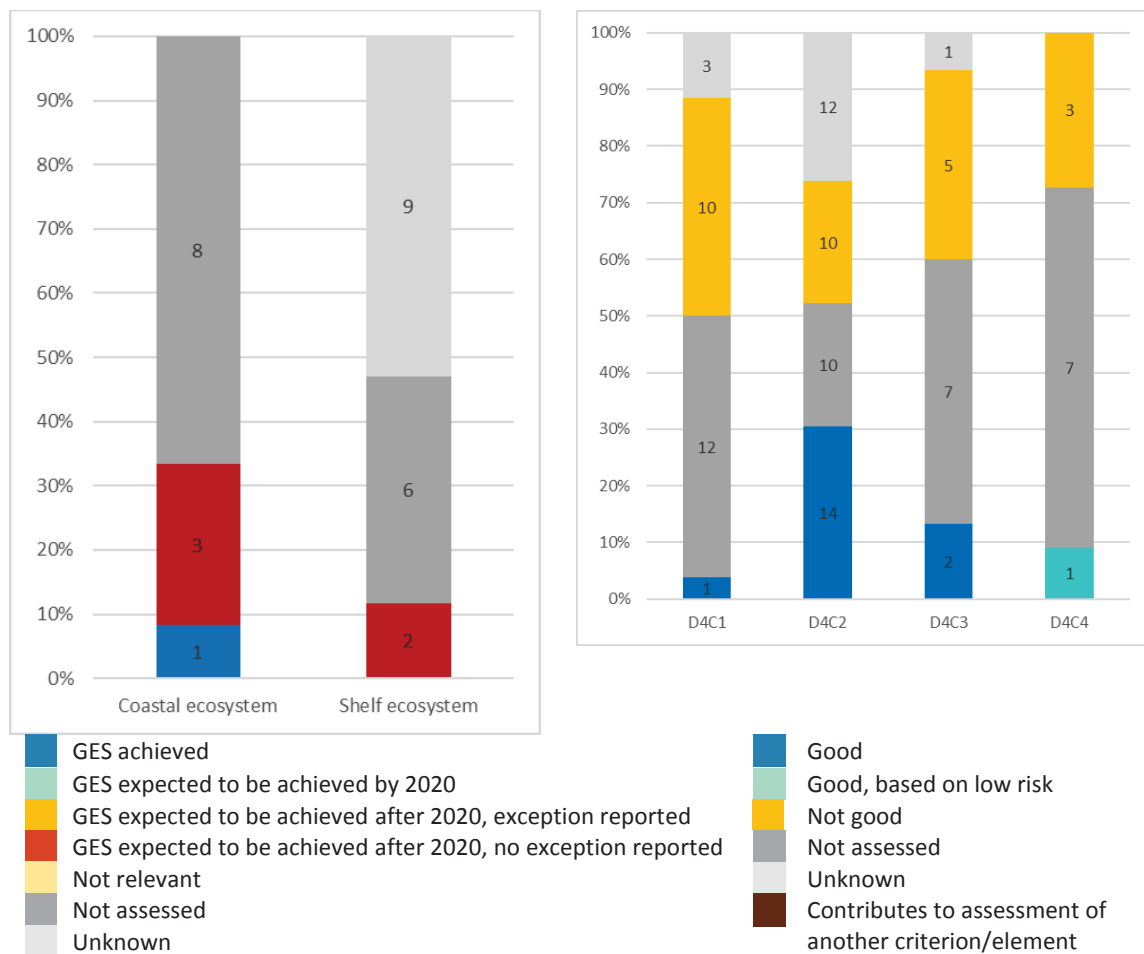


Figure 23: Latest MSFD assessments of good environmental status of marine food webs per feature (left) and associated criteria (right) under Descriptor 4 (closely linked to Descriptor 1). The information comes from 10 Member States' electronic reports.

Under Descriptor 4, there is only available information for coastal and shelf ecosystems. For the coastal ecosystems, GES is achieved in 1 case, and 3 assessments conclude that GES will be achieved later than 2020 and where no Article 14 exception has been reported. In more than 60% of the cases, the coastal ecosystem are 'not assessed'. For the shelf ecosystems, 2 assessments conclude that GES will be achieved later than 2020 and where no Article 14 exception has been reported, while the rest of assessments (almost 90%) are either 'not assessed' or 'unknown'.

The most reported criterion on the assessment of the status of food webs is the abundance across trophic guilds (D4C2), for which 14 assessments result in 'good', 10 in 'not good', and 10 and 12 have been reported as 'not assessed' or 'unknown' respectively.

The criteria on trophic guild species diversity (D4C1), trophic guild size distribution (D4C3) and trophic guild productivity (D4C4) have a similar distribution. A few assessments result in 'good' status (or 'good, based on low risk'), a larger number of assessments are in 'not good' status, and more than half of the assessments do not reach any conclusion.

2.2. Setting the scene for the analysis of food webs

Descriptor 4 of the MSFD represents one of the most complex and unknown aspects of marine ecosystems. There are still very few assessments and reports under the Directive, and they are hardly comparable. The Regional Sea Conventions are also struggling with making assessments of food webs.

Food chains describe biological communities in terms of their predator-prey relationships and are often referred to in terms of their structure (e.g. diversity, trophic levels), dynamics (e.g. robustness, resilience) and function (e.g. physicochemical and biological processes) (Rooney and McCann, 2012). Food chains are pathways that transfer energy and matter between feeding levels or trophic levels (i.e. guilds) and their natural interconnections form complex networks called food webs.

Human activities cause direct, indirect, diffuse and emergent changes in food webs (Layman et al., 2005). Overexploitation, pollution, eutrophication, habitat destruction, species invasions and climate change, all pose potential threats to the structure and dynamics of food webs, acting at variable spatial scales and affecting food webs in different ways (Moloney et al., 2010). Nutrient enrichment, for example, can drive bottom-up effects propagating up food webs from lower trophic levels (Davis et al., 2010), whereas the removal of top-predators (e.g. overfishing) can initiate top-down cascade effects through to basal trophic levels (Cury et al., 2003). All these changes can lead to abrupt, large and long-lasting reorganisations of the food web. These reorganisations, often referred to as ecological regime shifts, can bring forward undesirable effects on both the wider marine ecosystem and people (EEA, 2015).

Regime shifts are particularly undesirable notably because they may be very costly or impossible to reverse and often have considerable impacts on the economy and society (Biggs et al., 2009). This is because they affect the flow of marine ecosystem services and associated benefits to people (Rocha et al., 2014). Nevertheless, even without such extremes, existing food web impacts have already economic and management implications such as for fisheries management and viability. For example, the relatively small pelagic fish (e.g. sprat, anchovy and horse mackerel) have increased in recent decades in the Greater North Sea due to seawater warming as a result of climate change; whereas the larger species cod and plaice have decreased at their southern distribution limit (Perry, 2005). This change may have important socio-economic consequences as the stocks moving out tend to have a higher value than the stocks moving in (EEA, 2019a). Other implications of such distributional changes include the greater distances that must be travelled by fishing boats to reach certain target species increasing fuel cost and time at sea (Rijnsdorp et al., 2010).

The relationships between food webs and anthropogenic pressures, though, are highly complex and mostly indirect. In fact, given the complexity of marine food webs and the numerous interactions between marine ecosystems and human activities, it is difficult to clearly link visible signs of degradation of trophic guilds with specific anthropogenic causes (ICES, 2015).

Despite these difficulties, different approaches are currently used to investigate food web properties. For example, whilst data-based approaches are applied to reveal natural processes, modelling techniques are used to provide a more integrative image of the structure, functioning and dynamics of systems under different environmental and human pressures (Schewe et al., 2019, Liqueste et al., 2016). Unfortunately, the application of food web models to derive indicators and assess ecosystem status, in general, is often

constrained by the extensive data requirements needed to perform the analysis (Piroddi et al., 2015).

Also, while an ecosystem-based approach is increasingly used in fisheries management to study ecosystem responses to fishing pressure and to assure sustainable use of resources, similar holistic approaches to evaluate the combined influences of other anthropogenic stressors on food webs has received less attention to date.

2.3. Results from other assessments

Due to the complexity to analyse the state of marine food webs and, in most cases, the lack of data/knowledge of cause-effect relationships in Europe's seas, this section aims at showing few examples of food web degradation or recovery through the use of food web indicators, rather than a comprehensive assessment (Tam et al., 2017) that reflect all pressure-state relations within food webs.

The various examples of food web indicators come from national assessments or models. They show as major trends either (1) signs of long-term impact on a range of biodiversity features pointing towards a deteriorating state of food webs, or (2) food web recovery, which can be attributed to the implementation of key EU and other policies.

(Type of) indicator	Case study	Key observations
Large Fish Indicator	North Sea and Celtic Sea	Different multiannual trends, mostly degrading with some positive trends in the North sea
Primary productivity	OSPAR area	Very variable behaviour in different areas, e.g. stable in Liverpool bay, decreasing in Skagerrak
Zooplankton composition, Continuous Plankton Recorder	OSPAR area (esp. Celtic and North seas)	Changes in the proportion of zooplankton species affect fish and bird communities
Zooplankton abundance	HELCOM area	Copepods' abundance correlate with the fish condition and weight
Biomass of several trophic guilds	Central Baltic Sea	Regime shift
Keystone index and transfer efficiency	Black Sea	Regime shift
Biomass of selected functional groups	Mediterranean Sea	Decrease of forage fish and demersal fish, increase of invertebrates, 41% drop of top predators
Biomass of selected functional groups + trophic level indices	Multiple areas around the European seas	Different trends in marine ecosystems, mostly degrading but with some positive trends

Table 12: Summary of the examples presented in this section.

Among these indicators, size-based indicators have been widely used to demonstrate the effects of fishing on fish community structure, and the Large Fish Indicator (LFI), in particular, has been specifically developed to support the OSPAR ecosystem approach to marine management (Greenstreet et al., 2011; Shephard et al., 2013). The LFI describes the proportion of fish biomass contributed by large individuals in the demersal fish community and is defined as the ratio between the biomass of demersal fish above a length threshold over the total fish biomass.

This indicator has been widely used to assess demersal stocks impacted by fisheries in the North and Celtic seas. In fact, in the North Sea, LFI showed a continuous decline until 2001 followed by a recovery in 2008. Yet, analyses of longer-term groundfish survey data suggest that, even reducing fishing pressure to early 20th century levels, LFI would unlikely rise to initial conditions (Figure 24a). In the Celtic Sea, the decline in LFI was consistent throughout the survey period (19 years) reflecting high exploitation rates (Figure 24b).

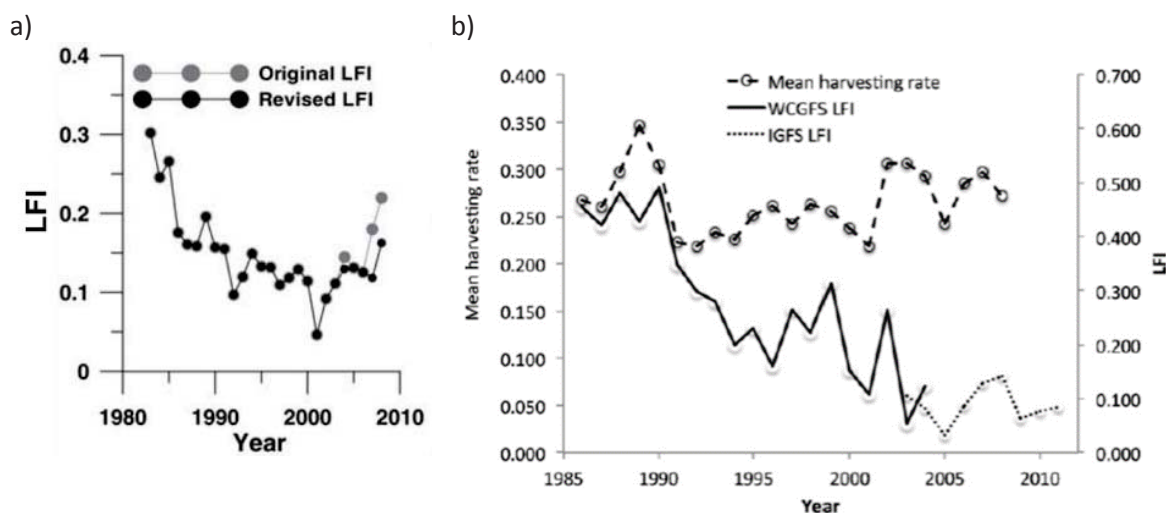


Figure 24: a) LFI trends in the North Sea (Greenstreet et al., 2011) b) in the Celtic Sea Celtic Sea. For 1b two overlapping LFI series are shown: the UK West Coast Groundfish Survey (WCGFS) that concluded in 2004, and the ongoing Irish Groundfish Survey (IGFS) (Shephard et al., 2013).

Another indicator, primary production of phytoplankton from the OSPAR pilot assessment, showed site-specific changes, but it was not possible to arrive at OSPAR-wide conclusions. For example, in the North Sea and Skagerrak, long-term primary production decreased from the mid-1980s to 2013, although the reasons for such a reduction have not been identified. In other areas, like Liverpool Bay, no long-term trend in the primary production of phytoplankton was identified (OSPAR, 2017e).

Long-term changes in zooplankton composition, observed in the North-east Atlantic Ocean through the Continuous Plankton Recorder survey, have been used to assess shifts in ecosystem function and dynamics. In particular, the copepod community of the Celtic and the Greater North Seas over 1960s to 2000s changed from a cold-water species *Calanus finmarchicus* to a warm water species *Calanus helgolandicus*. *C. finmarchicus* has a higher energy content than *C. helgolandicus*, and is considered to be a key element for the larval survival of some commercial fish species (EEA, 2015; 2019a). In fact, this shift in copepod community composition has been observed impacting the growth, recruitment and survival of other trophic levels such as seabirds (Wanless et al., 2005) and fish (Beaugrand et al., 2008). Since the 1970, there has also been a northward shift in fish species in the same area. Despite the observed warming of the surface ocean, the overall productivity level from oceanic features continues to sustain mesozooplankton and appears to be stable in the North Atlantic although with regional disparities (Druon et al., 2019).

In the Baltic Sea, fish body condition and weight-at-age of sprat and young herring correlate positively with copepod abundance/biomass. Consequently, indicators based on biomass of zooplankton and zooplankton/phytoplankton ratios have been used to assess

environmentally driven changes in the food web, and the possible impact of eutrophication (HELCOM, 2012). The underlying principle of the zooplankton/phytoplankton ratio is that higher grazing efficiency implies fewer losses in the food web, less energy and nutrients passing through the microbial loop, and, consequently, more energy transferred to the higher trophic levels such as fish.

Casini et al. (2009) showed quantitative evidence of a shift in the functioning of the central Baltic Sea ecosystem during the last 3 decades. In particular, until the end of 1980, the system had a cod-dominated configuration, characterised by low sprat abundance and a marked independence between zooplankton and sprat variations. From the beginning of 1990, the system shifted to a sprat-dominated configuration, characterised by low cod biomass and zooplankton strongly controlled by sprat predation (Figure 25). In the latter configuration, the sprat control on zooplankton biomass was substantially higher compared to the whole period investigated, suggesting a shift in the strength of sprat predation pressure on zooplankton. In the cod-dominated configuration, on the other hand, sprat and zooplankton were clearly uncoupled likely because sprat abundance was not high enough to regulate the zooplankton resource.

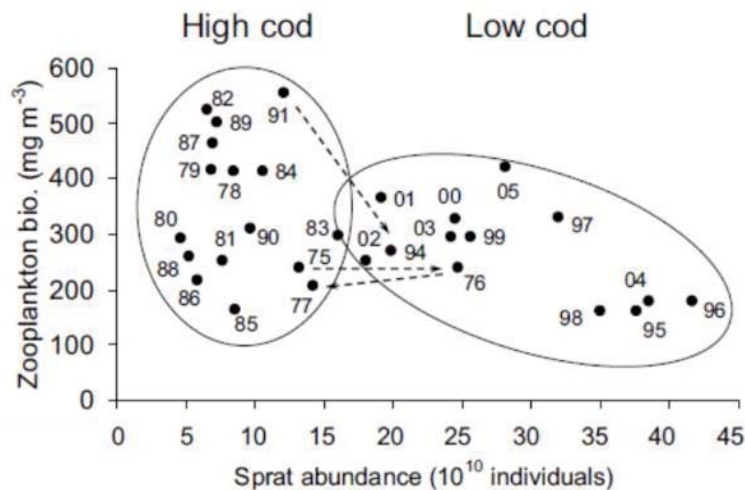


Figure 25: Relation between sprat abundance, cod abundance and zooplankton biomass. The configuration corresponds to the situations of high cod/low sprat (left ellipses) and of low cod/high sprat (right ellipses), respectively. Numbers associated with each point indicate observation years. The dashed lines show the transit from one configuration to the other (Casini et al., 2009).

Several food web indicators have been also used to assess Black Sea ecosystems and their regime shift. In particular, the keystone index evidenced a top-down control system, dominated by dolphins, in the 1960-1969 period and a bottom-up control system between 1988-1994 dominated by jellyfish (*Mnemiopsis*) (Figure 26). One other interesting outcome of the keystone analysis was the lack of recovery of dolphins, even though the dolphin fishery was banned after 1966 in the USSR, Bulgaria, Romania and 1983 in Turkey. This was supported by the study of energy transfer efficiency between trophic levels (Akoglu et al., 2014) that highlighted intensive eutrophication, which did not propagate up the food web because of the interference of the gelatinous population. As shown in Figure 26, in 1988–1994, *Mnemiopsis* was the second most significant keystone species after the zooplankton group.

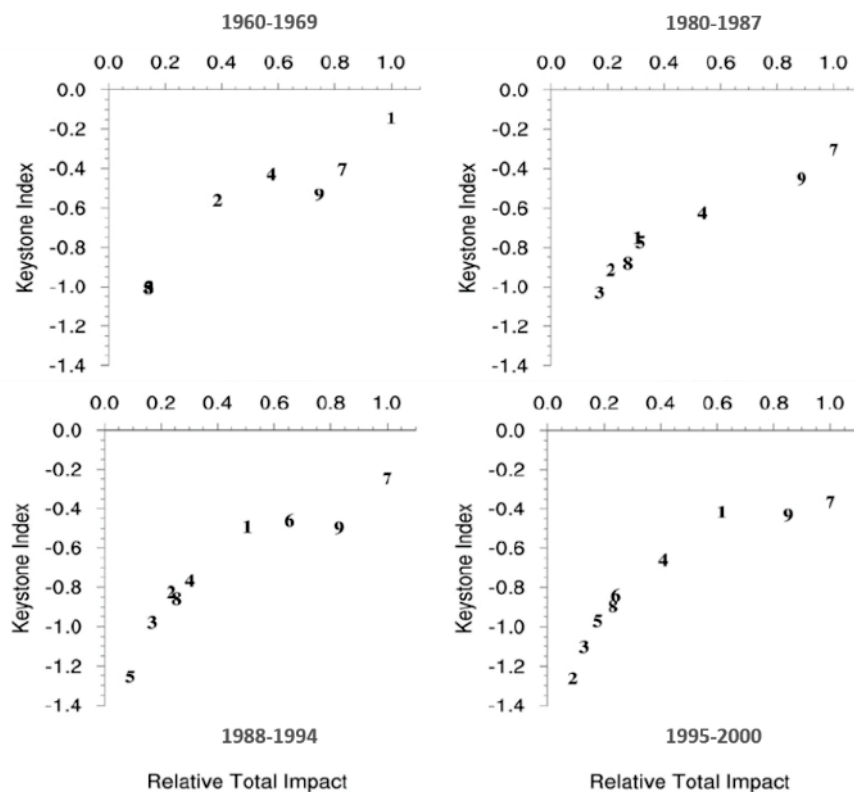


Figure 26: a) Keystoneness (key role in the ecosystem of certain species/groups of species) and relative total impact of functional groups on the structure of the Black Sea food web in four model periods. 1) dolphins, 2) piscivorous fish, 3) demersal fish, 4) small pelagic fish, 5) Aurelia, 6) Mnemiopsis (jellyfish), 7) zooplankton, 8) Noctiluca, 9) phytoplankton. b) Transfer efficiency (%) of flows across trophic levels in the four assessed periods. Source: Akoglu et al. (2014).

Other food web indicators used to assess the health status of European seas refer to those based on abundance and biomass of selected functional groups and/or species that can inform on the structural/functional properties of food webs. In the Mediterranean Sea, for example, these indicators have highlighted that fishing pressure and changes in environmental conditions caused the decline of forage fish (European sardine and anchovies) and demersal fish (European hake, Mullidae) biomasses and consequently the increase in invertebrates groups (crustaceans, benthos) (Piroddi et al., 2017). Sharks, rays and skates biomass, on the other hand, declined in the Western and Adriatic Sea but not in the Ionian and Eastern sub-areas. Overall, this analysis revealed the Mediterranean Sea to be a degraded ecosystem that has lost 41% of its top predators (e.g. marine mammals) and 34% of the total fish population over the past 50 years.

These type of biomass indicators in association with trophic levels indices have been also used to assess and overview the health status of several North and South European marine ecosystems (Figure 27, Coll et al., 2016). A combined analysis of predatory fish, total biomass and the distribution of trophic levels, showed an overall degradation of food webs and ecosystems in most of the European sub-basins (Figure 27).

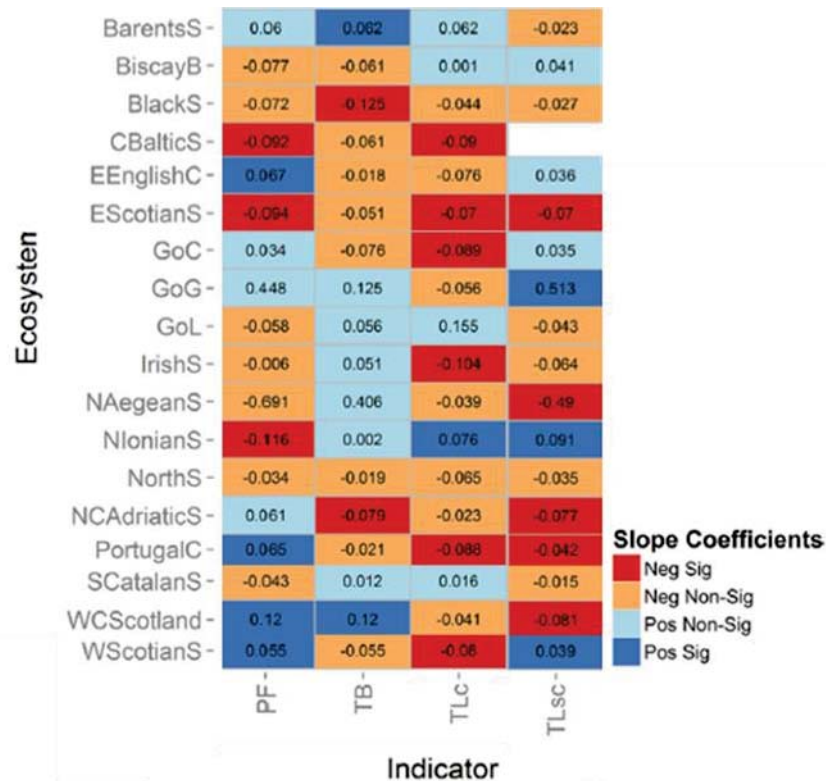


Figure 27: Trend indicators' slope coefficients (1980–2010) for selected indicators (PF: proportion of predatory fish; TB: Total biomass in the food web; TLc: mean trophic level of the catch; TLsc: mean trophic level of surveyed community) and marine ecosystems (BarentS: Barent Sea; BiscayB: Biscay Bay; BlackS: Black Sea; CBalticS: Central Baltic Sea; EEnglishC: Eastern English Channel; EScotianS: Eastern Scotian Shelf; GoC: Gulf of Cadiz; GoG: Gulf of Gages; GoL: Gulf of Lions; IrishS: Irish Sea; NAegeanS: North Aegean Sea; NlonianS: North Ionian Sea; NorthS: North Sea; NCA Adriatic: North and Central Adriatic Sea; PortugalC: Portuguese Coast; SCatalanS: Southern Catalan Sea; WCScotland: West Coast Scotland; WScotianS: West Scotian Shelf). Neg: negative, Pos: positive, Sig: significant, Non-Sig: non-significant trend.

In conclusion, multiple anthropogenic pressures are affecting: 1) the species or communities' diversity within a trophic guild; 2) the balance of the total abundance of species or species groups between trophic guilds; 3) the distribution of individual species within a trophic guild; and 4) primary production. The lack of wide scale assessments for Descriptor 4 and the delay in viewing the response of existing measures (e.g. fisheries management) will hamper achieving GES for Descriptor 4. Harmonized monitoring programmes and methods for the assessment of the D4 criteria are required to generate informative assessments at relevant geographical scales for trophic guilds.

3. TECHNICAL OBSERVATIONS

- Some of the best data available come from commercially exploited fish and shellfish stocks for which extensive monitoring programmes exist and from zooplankton communities through the Continuous Plankton Recorder, although this is the case only for the Atlantic Ocean. Other aspects of the food-web appear to be under-sampled in comparison. Satellite remote sensing of ocean colour (chlorophyll-a content and productive fronts) appears to be, in the last two decades, a synoptic source of data for monitoring changes of plankton (phyto-

and zoo-) distribution at community level after effect of climate variability and eutrophication, disentangling the impact of fishing on food-web productivity.

- Size-based approaches may be inappropriate for assessing processes in benthic communities, since both size dependent (e.g. predation) and size independent interactions (e.g. consumption of amorphous detritus) can co-occur, suggesting that the energy available to species of a particular size is not solely derived from smaller species in the food web.
- Theoretical and empirical models may help to identify potential impacts and elucidate key properties that should be monitored, thereby promoting the development of more effective and comprehensive operational food web indicators. The complementary use of empirical and modelling approaches to derive population, community and ecosystem indicators is key to the development operational food web indicators for ecosystem-based management in the marine environment.
- Harmonised monitoring programmes are required to generate proper assessments for trophic levels (and marine regions), to support potential management measures. These programmes should in turn be used to strengthen assessment baselines and targets for existing indicators. ICES (2015) and Tam et al. (2017) provide a wide performance analysis for potential indicators that better fit to the requirements of Descriptor 4. Such indicators could then be linked to human activities and their pressures. Long-term data series and cross-regional cooperation will further facilitate improved and consistent assessments.

4. KEY MESSAGES

- While the overall state of marine food webs across all European seas cannot be fully assessed, there are many examples of trophic guilds showing deteriorating trends over time, being affected by anthropogenic pressures. This especially concerns the reductions in abundance of several top predators, such as birds, sharks and marine mammals.
- There are examples of communities and possible entire trophic guilds that do not occur at the proper abundance to retain their full productive capacity, as observed for many commercial fish and shellfish stocks in the Mediterranean and Black seas, which are below their sustainable levels due to overfishing.
- Yet, few examples of recovery for key species or groups of species are observed in EU marine regions. This might be the direct response to on-going measures to manage the human activities, such as fisheries, contaminants or nutrients.
- There are also signs of changes in the size structure/distribution of species or communities (indicative of a trophic level) due to anthropogenic pressures, e.g., phytoplankton in the Baltic Sea and zooplankton (copepods) species in parts of the North-east Atlantic Ocean.
- The productivity of some trophic guilds is impacted, although the exact reasons are unclear.

- There is a lack of consistent approaches to assess the state of food webs across European seas. There are many instances where assessments are incomplete, thus associated with high uncertainty, or are simply impossible due to lack of suitable data.



Brussels, 25.6.2020
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

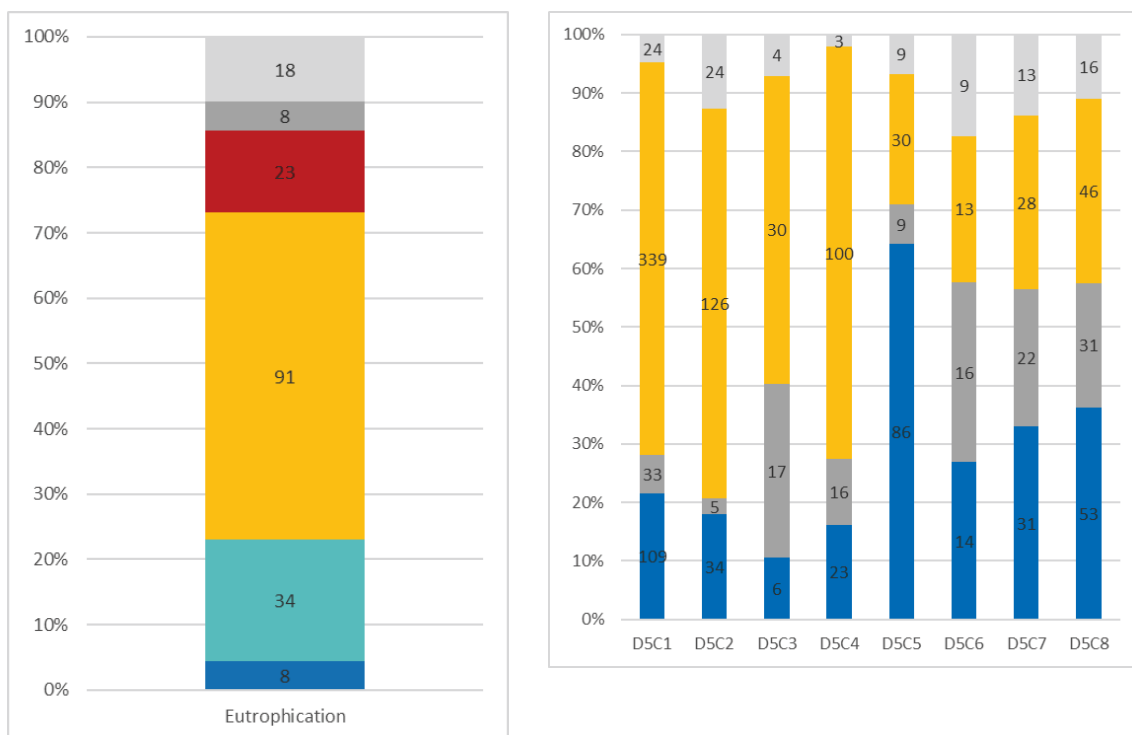
The criteria elements and threshold values of all D5 criteria shall be selected in accordance with the Water Framework Directive (WFD)¹ for coastal waters and consistent with those values for areas beyond coastal waters (if relevant).

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).

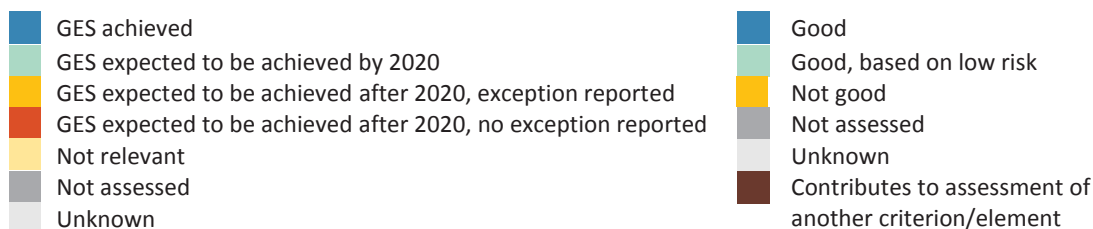


Figure 28: Latest MSFD status assessments of eutrophication (left) and associated criteria (right) under Descriptor 5. The information comes from 10 Member States' electronic reports.

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-Chlorophyll-a and D5C5-Dissolved oxygen) are assessed by most of the Member States (Figure 29).

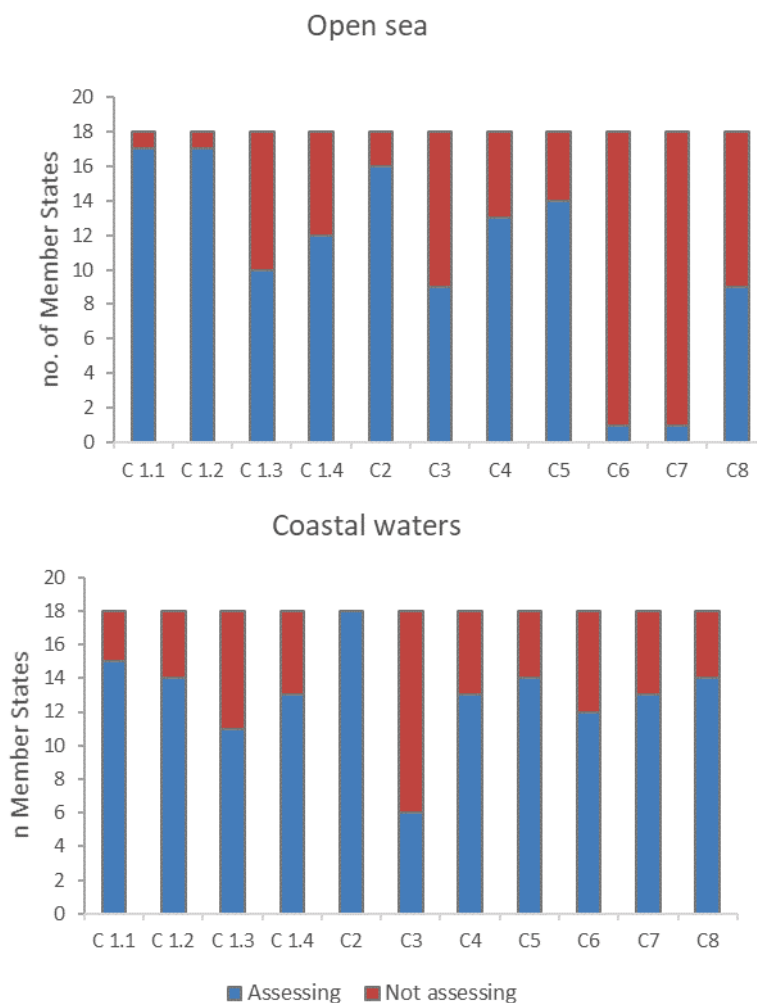
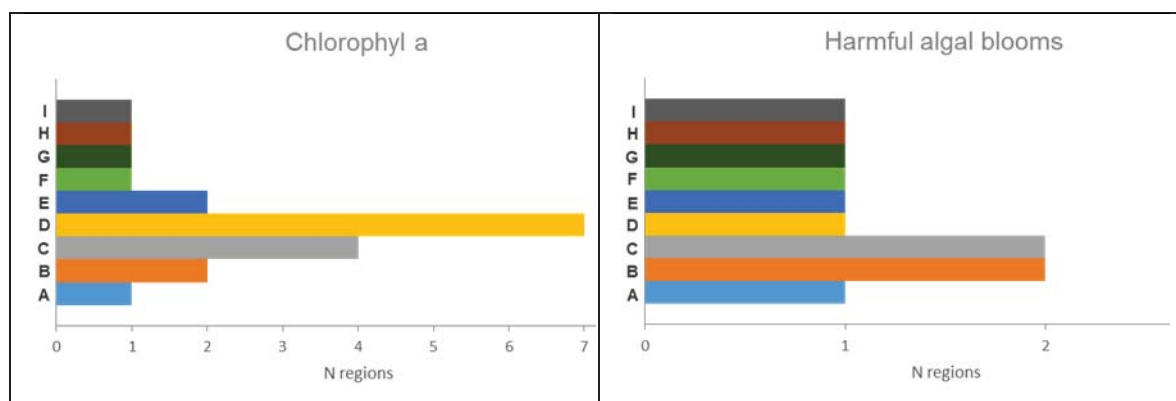


Figure 29: Criteria used at open sea and coastal waters by number of Member States.

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 Chlorophyll 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.



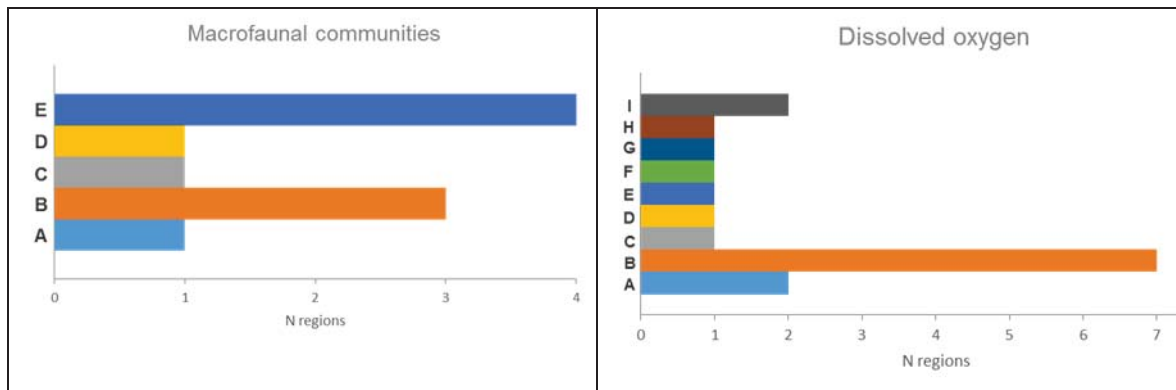


Figure 30: Illustration of the number of (sub)regions using different methods (labelled with letters) to assess eutrophication criteria in areas beyond coastal waters.

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 waters². Some biological quality elements (e.g. phytoplankton) 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 (Högländer 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).

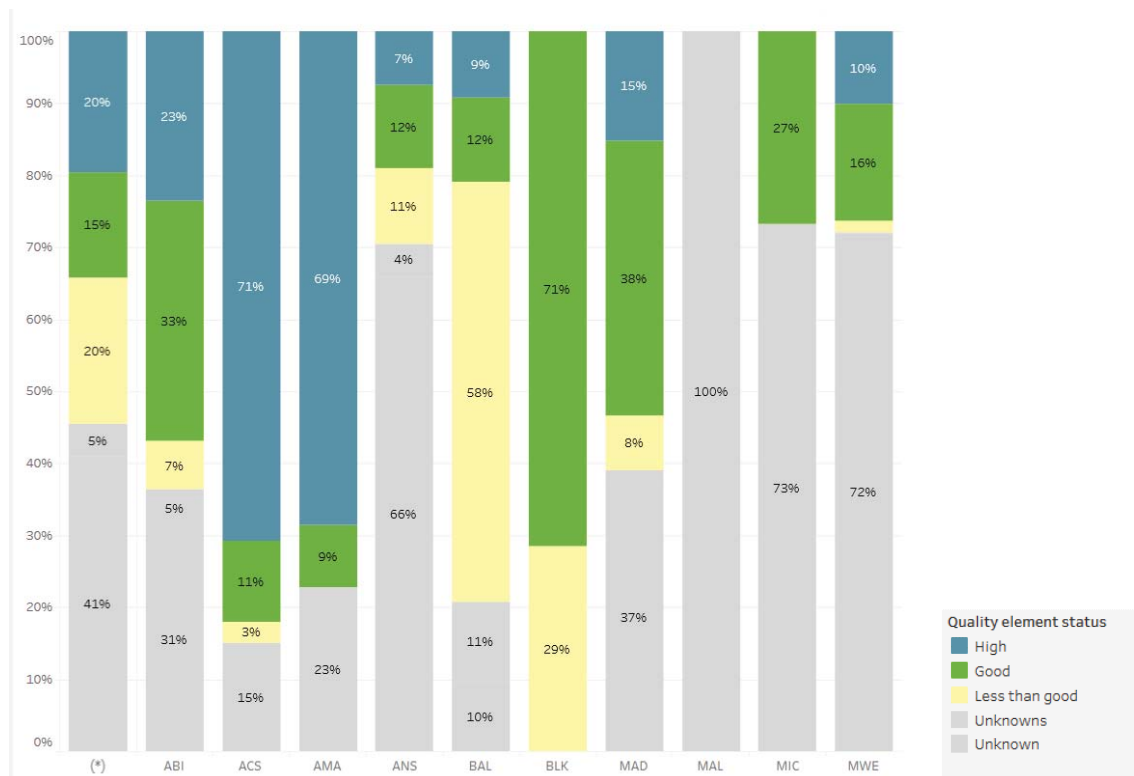


Figure 31: Nutrients (nitrogen and phosphorus) conditions in coastal water bodies by EU marine (sub)region (percentage of total area assessed as reported in the 2015 River Basin Management Plans). (*) refers to all water bodies in all marine (sub)regions. Marine sub-regions codes: ABI: The Bay of Biscay 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.

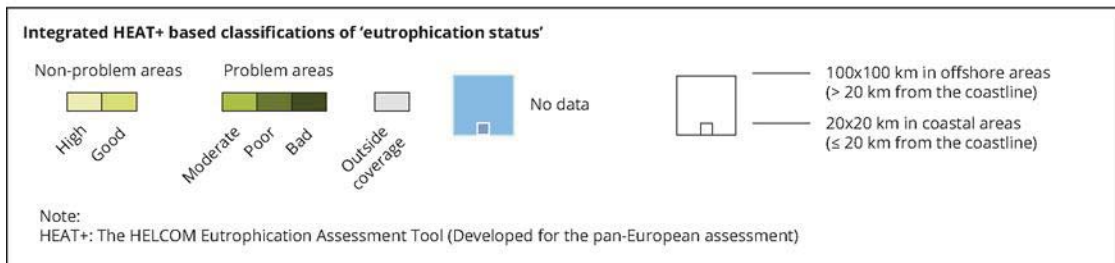
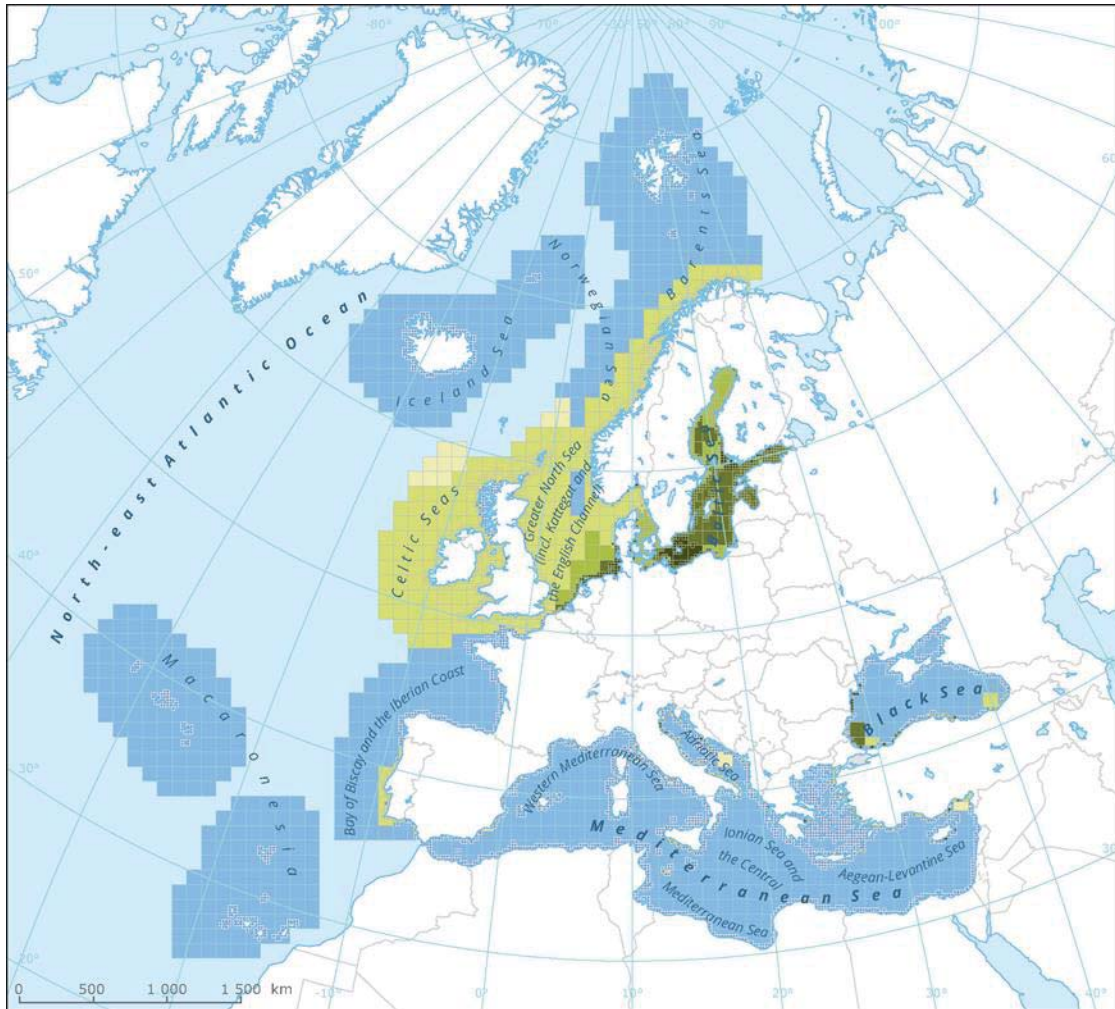


Figure 32: Interim map of eutrophication status of Europe's seas (EEA, 2019e). NPA = Non-Problem Area, PPA= Potential Problem Area, PA= Problem Area. No conclusions can be extracted for the southern European seas due to the lack of representative and robust datasets.

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

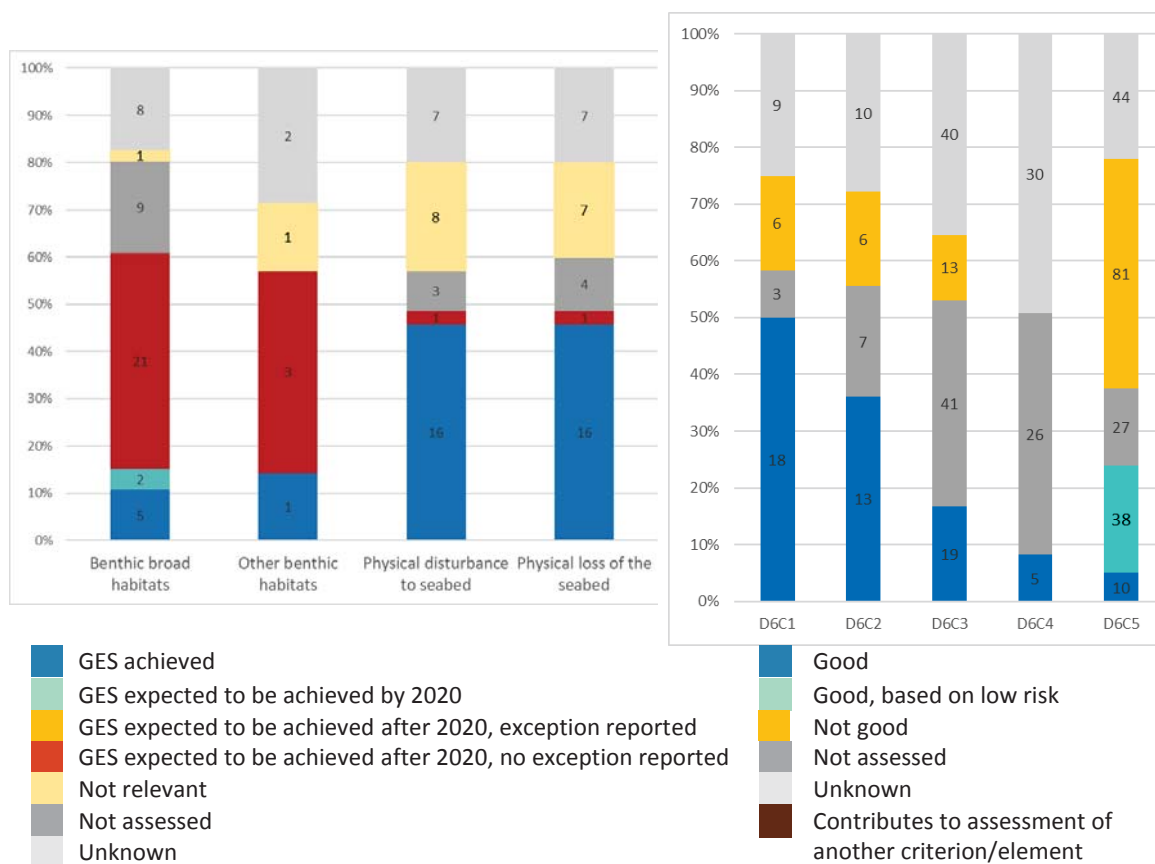


Figure 33: Latest MSFD assessments of good environmental status of benthic habitats (left) and associated criteria of sea-floor integrity (right) under Descriptor 6 (closely linked to Descriptor 1). The information comes from 10 Member States' electronic reports.

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).

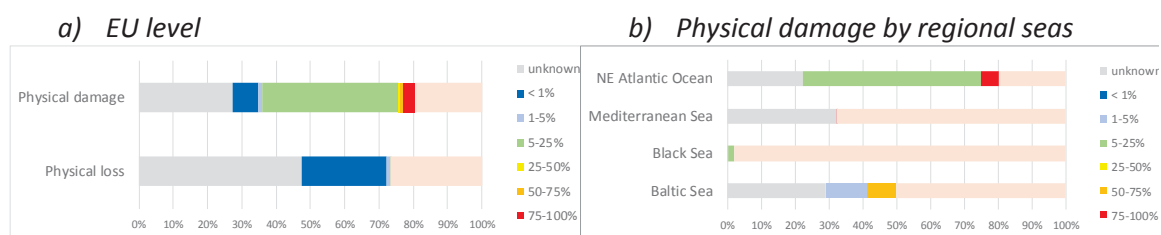
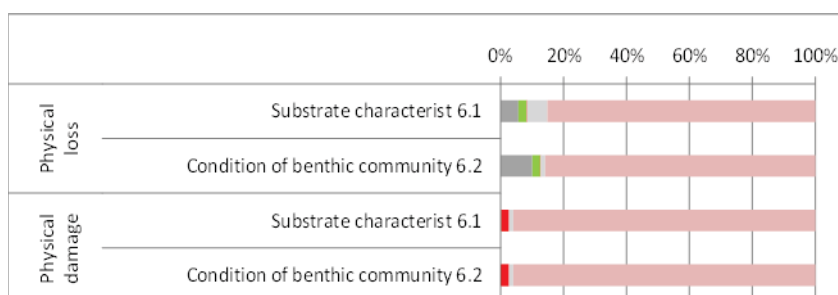


Figure 34: Percentage of area of the seabed exposed to different intensity of pressures reported during the initial assessment of the MSFD in 2012, at EU level and per marine region (ETC/ICM, 2015).



■ Unknown ■ Good ■ Not Good ■ Other status ■ Not reported/not assessed

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

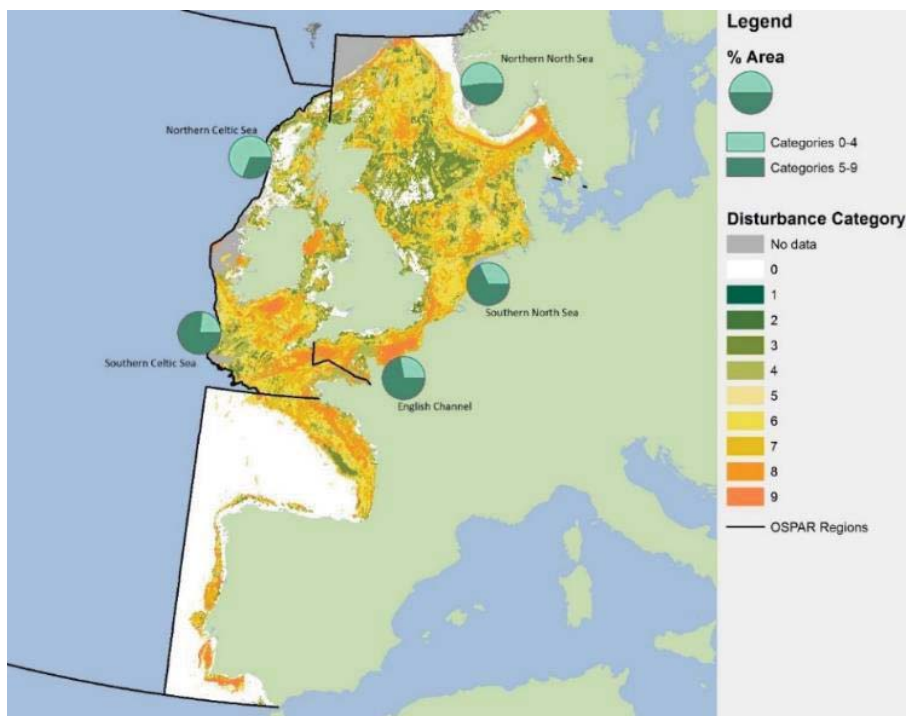


Figure 36: OSPAR assessment of the Extent of Physical Damage to Predominant and Special Habitats. Spatial distribution of aggregated disturbance using the 2010–2015 data series across OSPAR sub-regions. Disturbance categories 0–9, with 0= no disturbance and 9= highest disturbance. Pies show percentage 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).

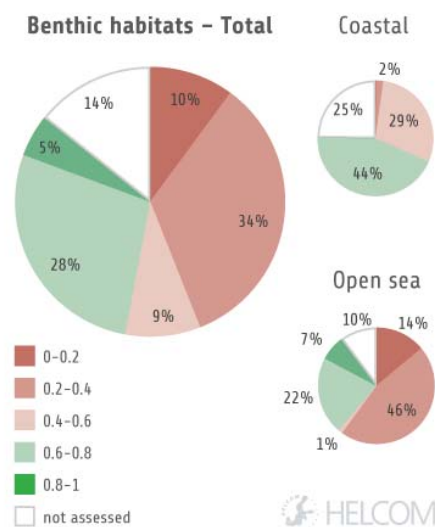


Figure 37: Integrated assessment of benthic habitats in the Baltic Sea. Status is shown in five categories based on integrated biological quality ratios (BQR). Values of at least 0.6 correspond to good status. The assessment is based on the core indicators 'State of the soft-bottom macrofauna community' 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 km² 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).

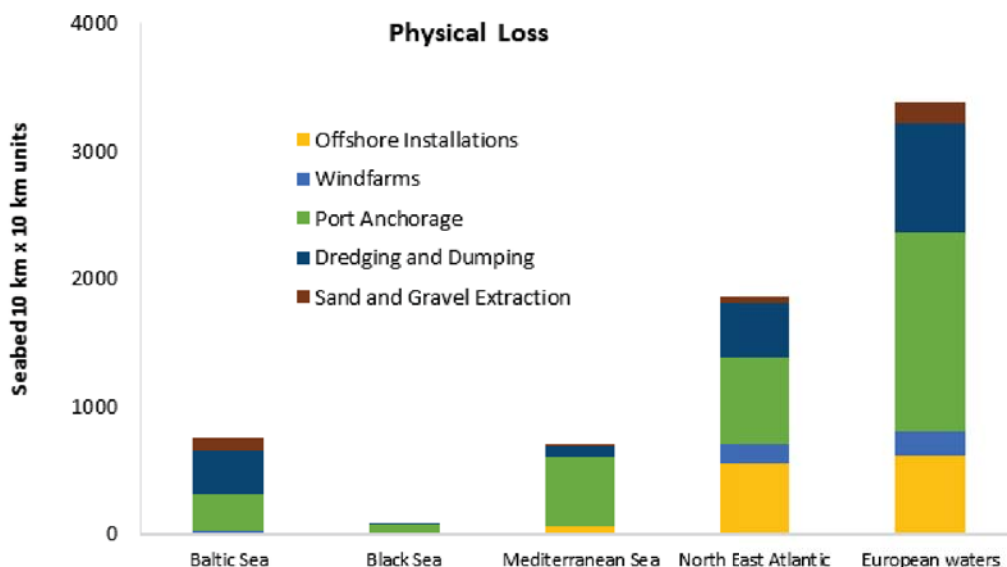


Figure 38: Extent of seabed at all depths (10x10 km units) estimated to have some physical loss per regional sea and for all Europe's seas together. The area is split between different human activities causing physical loss. As the assessment units are 10x10 km, the area is likely overestimated, given 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 x 10 km assessment units and, thus, can be overestimated.

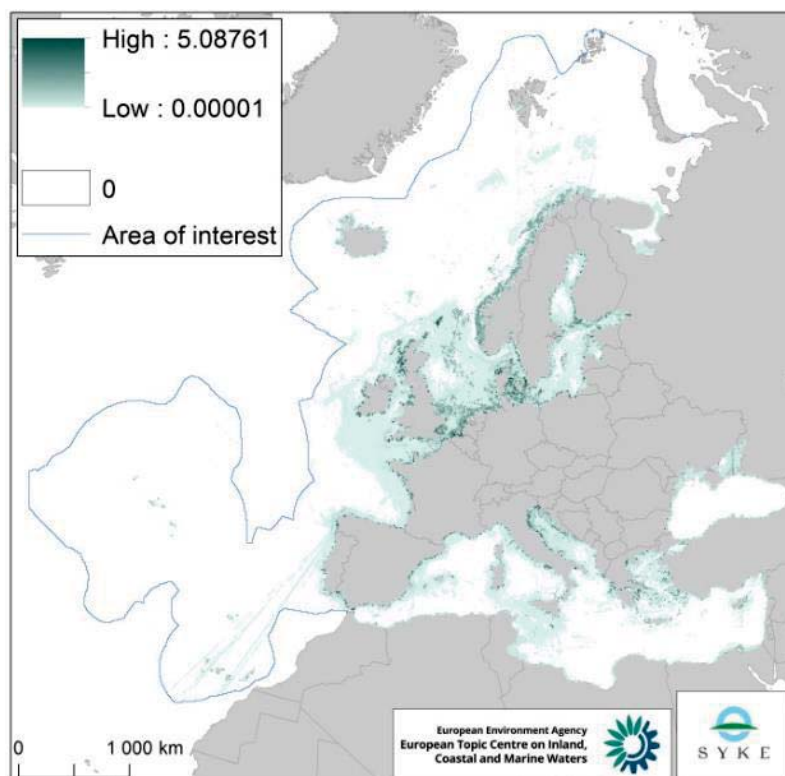


Figure 39: Spatial distribution of the physical disturbance to Europe’s seabed. Source: EEA (2019b).

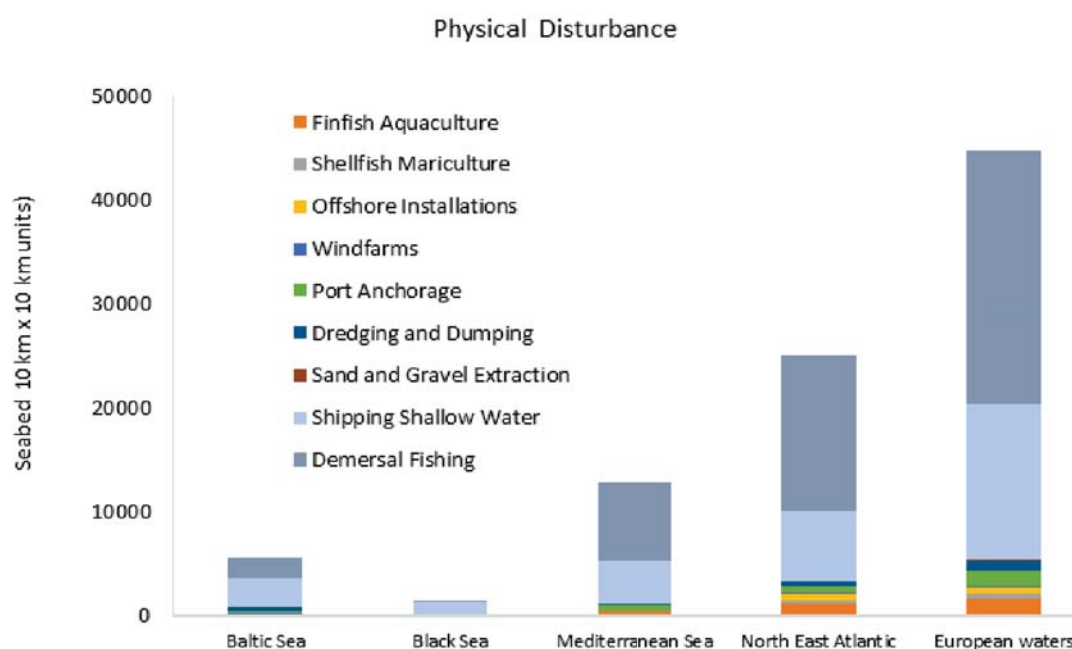


Figure 40: Seabed area (number of 10 km x 10 km units) estimated as physically disturbed across all Europe’s seas together. The area is split between different human activities causing physical disturbance. Demersal trawling is likely to be underestimated due to data gaps. Source: EEA (2019b).

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

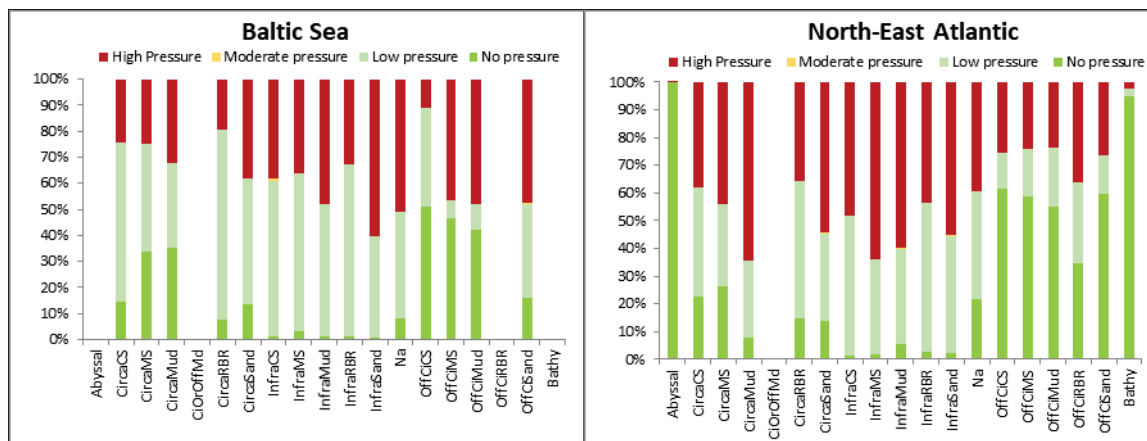
the assessment units were trawled at least once across Europe's seabed over the period 2011-2016, although this figure increased to 35 % when focusing on the shelf/slope area only. Another pressure, shipping in shallow waters (down to 50 m depth), potentially causes physical disturbance in 75% of the 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.



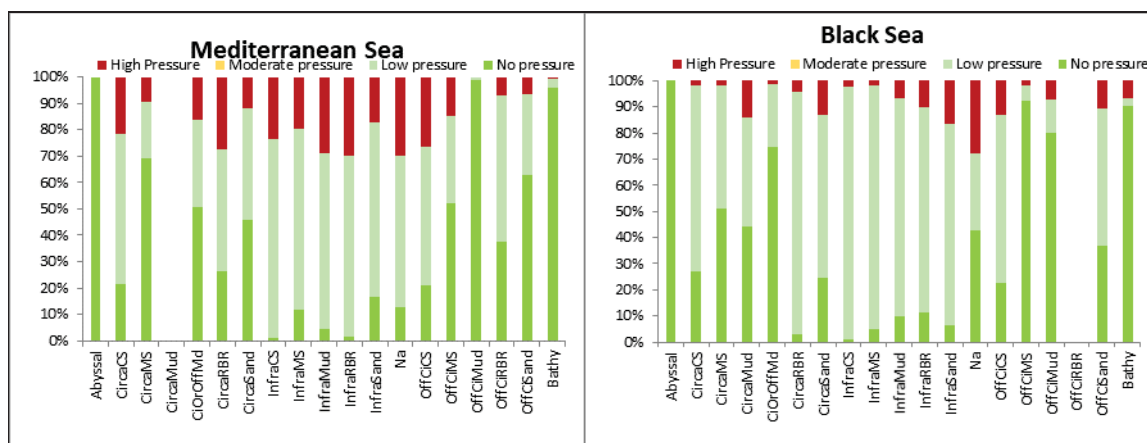


Figure 41: Combined effects of multiple pressures on benthic (broad) habitats⁵ across Europe's seas including (i) the indirect effects of nutrient enrichment (eutrophication), (ii) sediment contamination, (iii) non-indigenous species impacts, (iv) hydro-morphological alterations, (v) physical disturbance, and (vi) 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 = Circalittoral Mud; CiOrOffMd = Circalittoral or Offshore Circalittoral 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.
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.

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

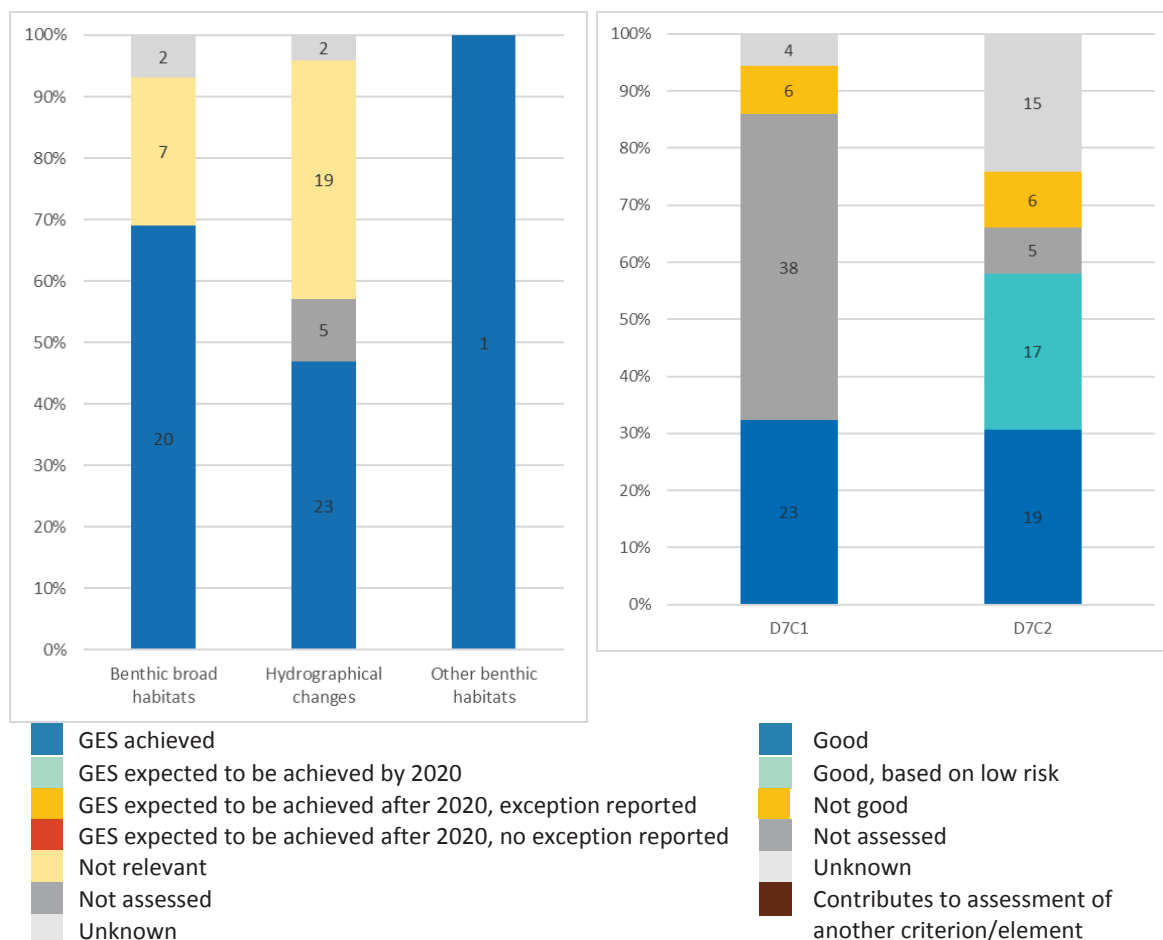


Figure 42: Latest MSFD assessments of good environmental status of the hydrographical conditions per feature (left) and per criteria (right) under Descriptor 7. The information comes from 10 Member States' electronic reports.

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 hydromorphological pressures causing changes in seawater movement, salinity and temperature⁸.

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

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).

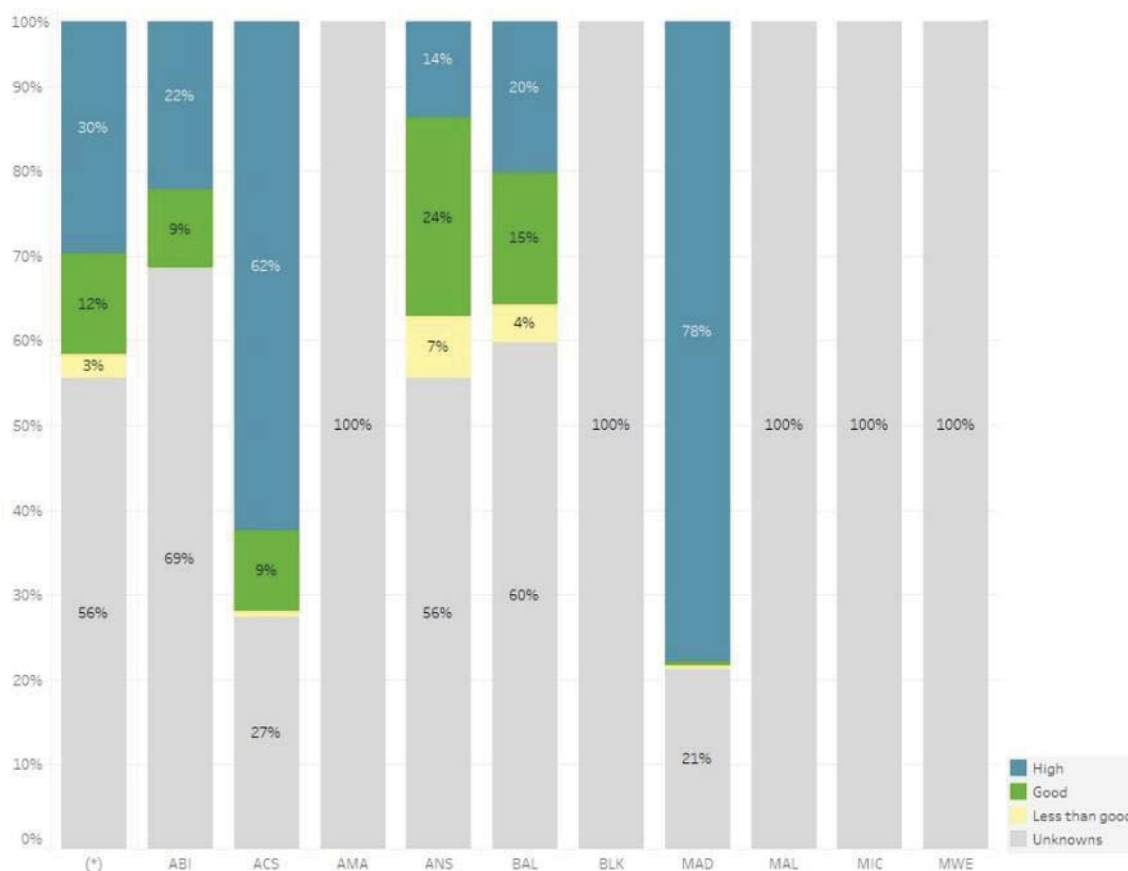


Figure 43: Morphological conditions in coastal water bodies by marine (sub)region (percentage of total area assessed). as reported in the 2015 River Basin Management Plans). (*) refers to all water bodies in all marine (sub)regions. Marine sub-regions codes: ABI: The Bay of Biscay and the Iberian Coast; 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.

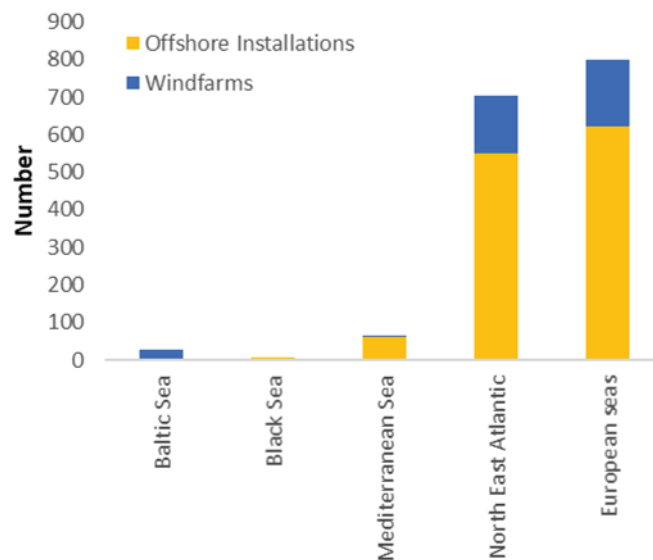


Figure 44: Number of offshore energy installations in 10 km × 10 km grid cells (ETC/ICM, 2019b).

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 sources⁹ 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 CO₂ 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 CO₂. 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 deposit 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

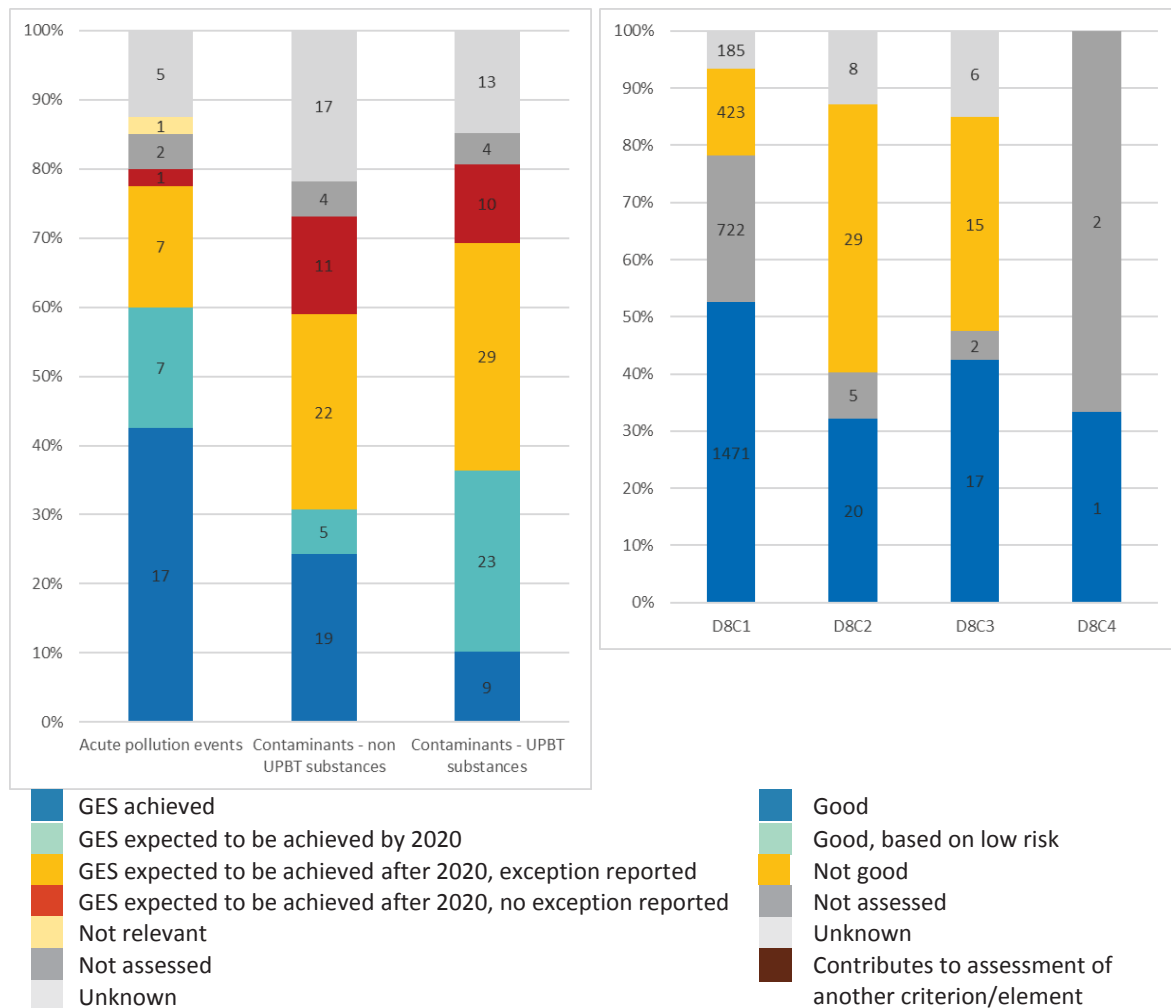


Figure 45: Latest MSFD assessments of good environmental status for contaminants and associated criteria under Descriptor 8. The information comes from 10 Member States' electronic reports.

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%.

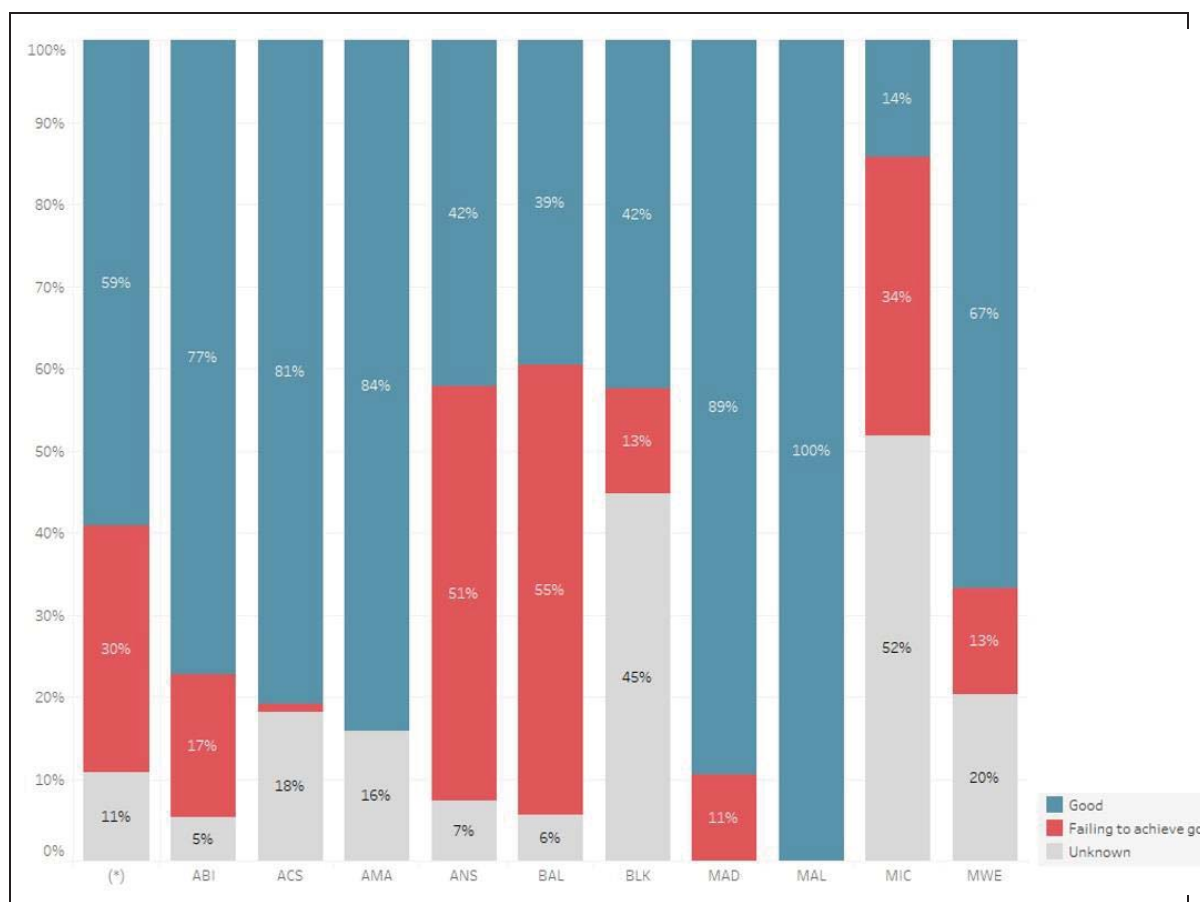
There have been some assessments on the adverse effects of contaminants (D8C2) and on significant acute pollution events (D8C3), resulting in ‘good’ status only the around

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 environment¹¹. 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 countries¹² 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 seas¹³ (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.

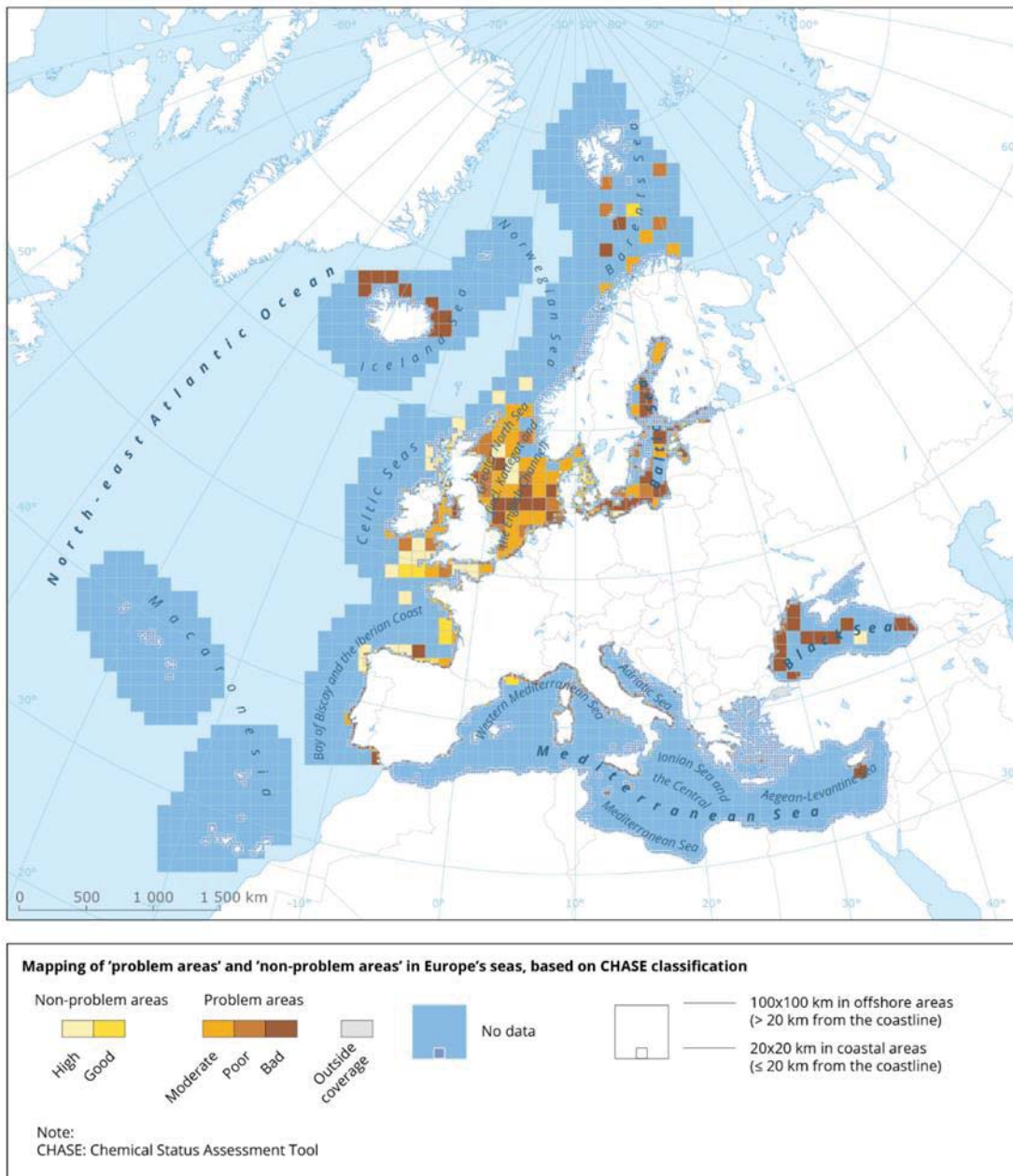


Figure 47: Mapping of 'problem areas' and 'non-problem areas' in Europe's seas (EEA, 2019f). Assessment includes also non-EU countries, this is not directly related to MSFD purposes.

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, Western and 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 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 stopped 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).

Mediterranean Sea

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 not 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 Bulgaria¹⁴. 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 significant 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.

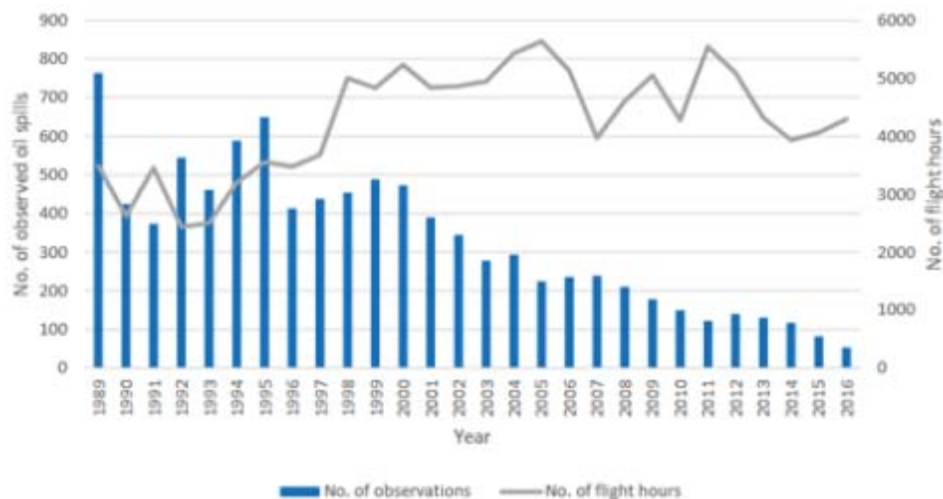


Figure 48: Number of flight hours and confirmed oil spills in the Baltic Sea during aerial surveillance 1988-2016 (HELCOM, 2017).

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 status¹⁵.

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 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 proper¹⁶.

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 Sea¹⁷.

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 Article 17 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

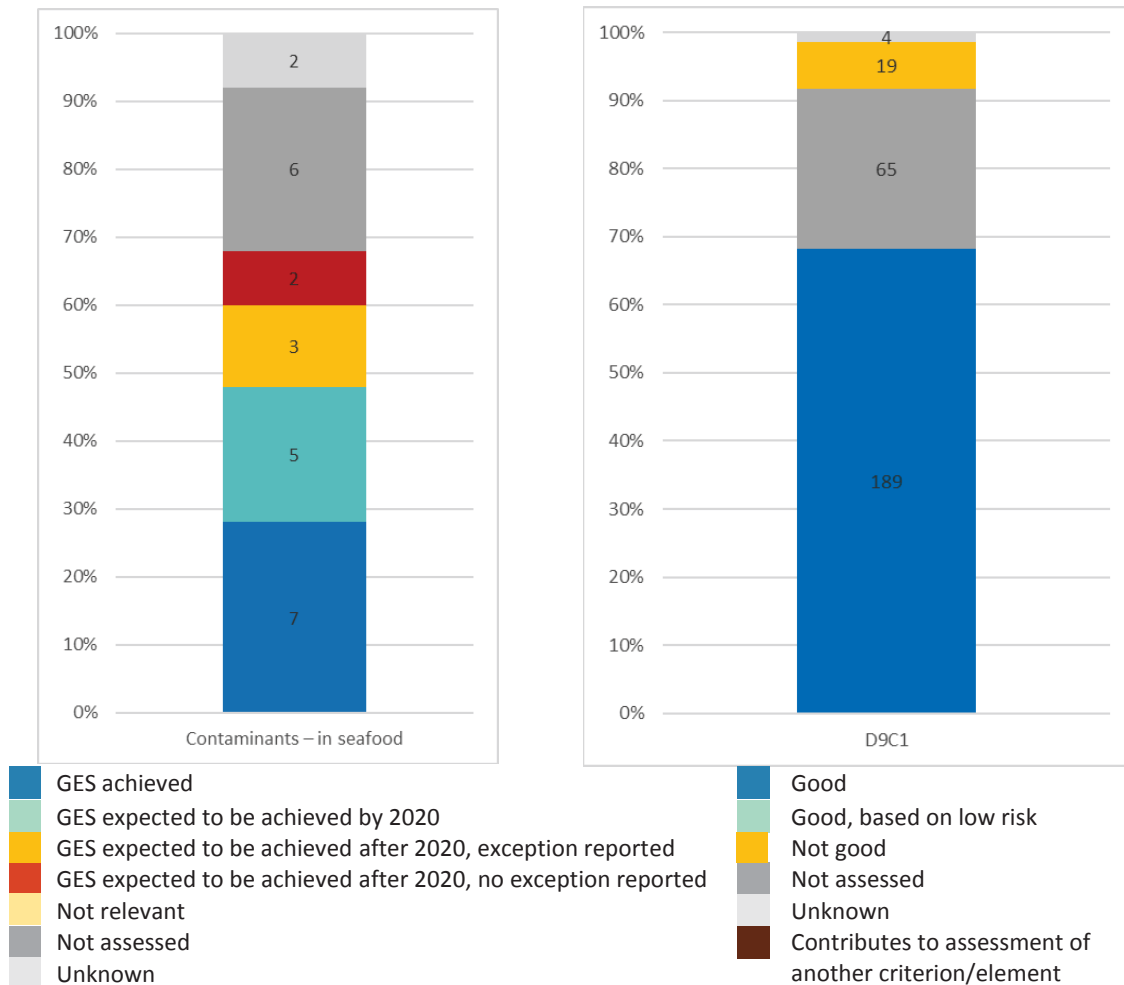


Figure 49: Latest MSFD assessments of good environmental status for contaminants in seafood and the associated criterion under Descriptor 9. The information comes from 10 Member States' electronic reports.

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 2019²⁰.

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 1881/2006²¹.
- 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
<i>Metals</i>		
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 1379/2013²⁵. 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 (<i>Mytilus edulis</i>) and eelpout (<i>Zoarces viviparus</i>) (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 (<i>Clupea harengus</i>) and mussels. ESB study: Blue mussel (<i>Mytilus edulis</i>) and eelpout (<i>Zoarces viviparus</i>).
	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.
<i>Black Sea</i>	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 (<i>Rapana venosa</i> and <i>Mytilus galloprovincialis</i>).
<i>Mediterranean Sea</i>	EL	Adriatic Sea Ionian and Central Mediterranean Aegean and Levantine and Seas	Fish and shellfish collected by food authorities and data from literature: <i>Mullus barbatus</i> , <i>Boops boops</i> , <i>Mytilus galloprovincialis</i> , <i>Mullus surmuletus</i> , <i>Coris julis</i> , <i>Eutrigla gurnardus</i> , <i>Spicara smaris</i> , <i>Serranus cabrilla</i> , <i>Mugil cephalus</i> , <i>Sarpa salpa</i> , <i>Siganus rivulatus</i> , <i>Liza saliens</i> , <i>Engraulis encrasicolus</i> , <i>Merluccius merluccius</i> , <i>Atherina boyeri</i> , <i>Sardina pilchardus</i> , <i>Parapenaeus longirostris</i> , <i>Loligo vulgaris</i> .
	IT	Adriatic Sea Ionian and Central Mediterranean Western Mediterranean	Data from specific monitoring for MSFD: <i>Mullidae</i> , <i>Merluccidae</i> , <i>Muricidae</i> , bivalve molluscs.

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

Conclusions about the status of Descriptor 9:

- 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 aldrin²⁶. 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, <i>Rapana venosa</i> and <i>Mytilus galloprovincialis</i>)	GES (< thresholds in molluscs)	No determined	No determined	No determined	GES (5.7% samples above thresholds in molluscs, <i>Rapana venosa</i> and <i>Mytilus galloprovincialis</i>)
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 1831/2003 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 project²⁷, 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-Aleman 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 Project²⁸).
- 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

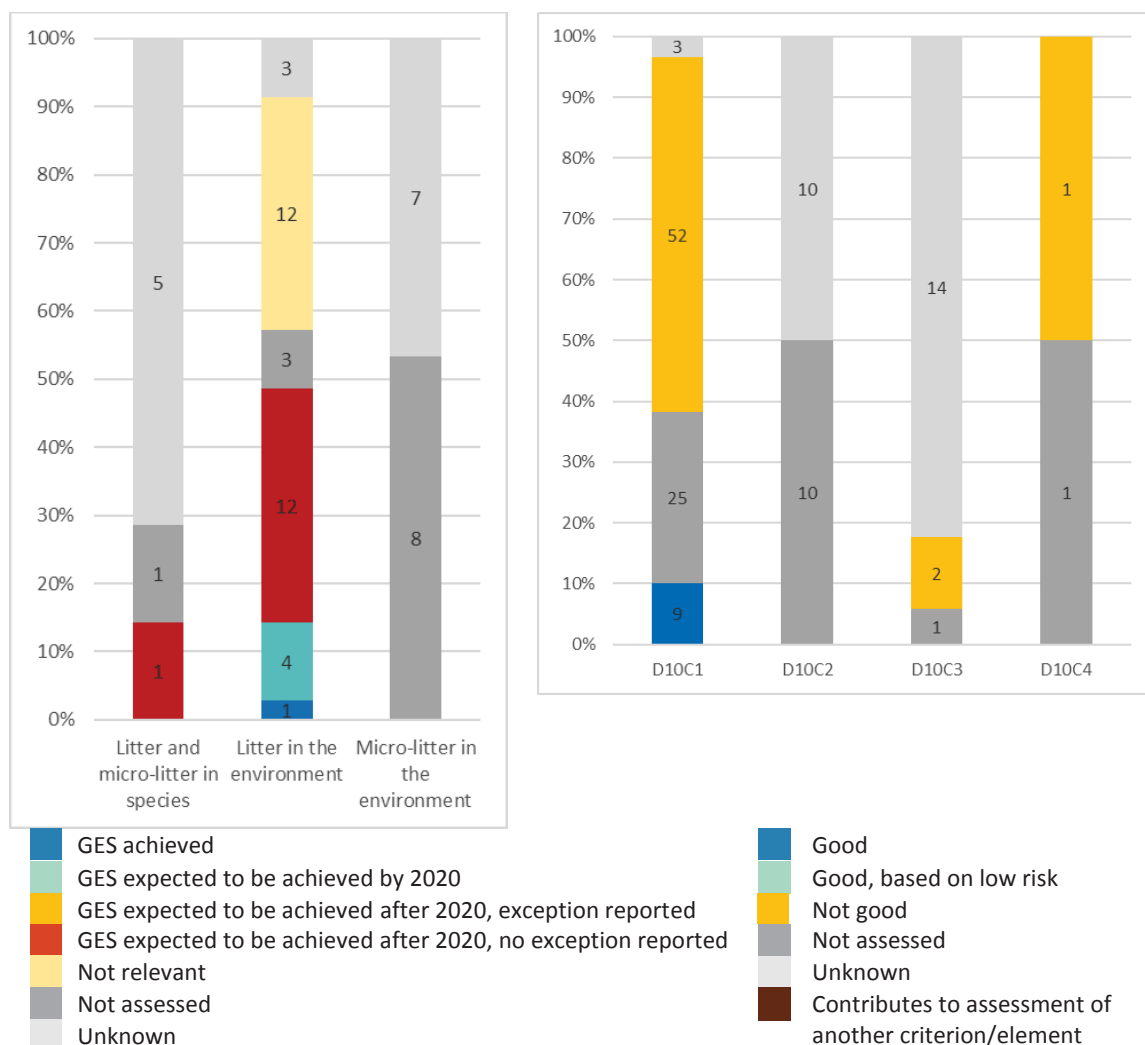


Figure 50: Latest MSFD assessments of good environmental status for marine litter per feature (left) and associated criteria (right) under Descriptor 10. The information comes from 10 Member States' electronic reports.

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 D10³⁰.

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

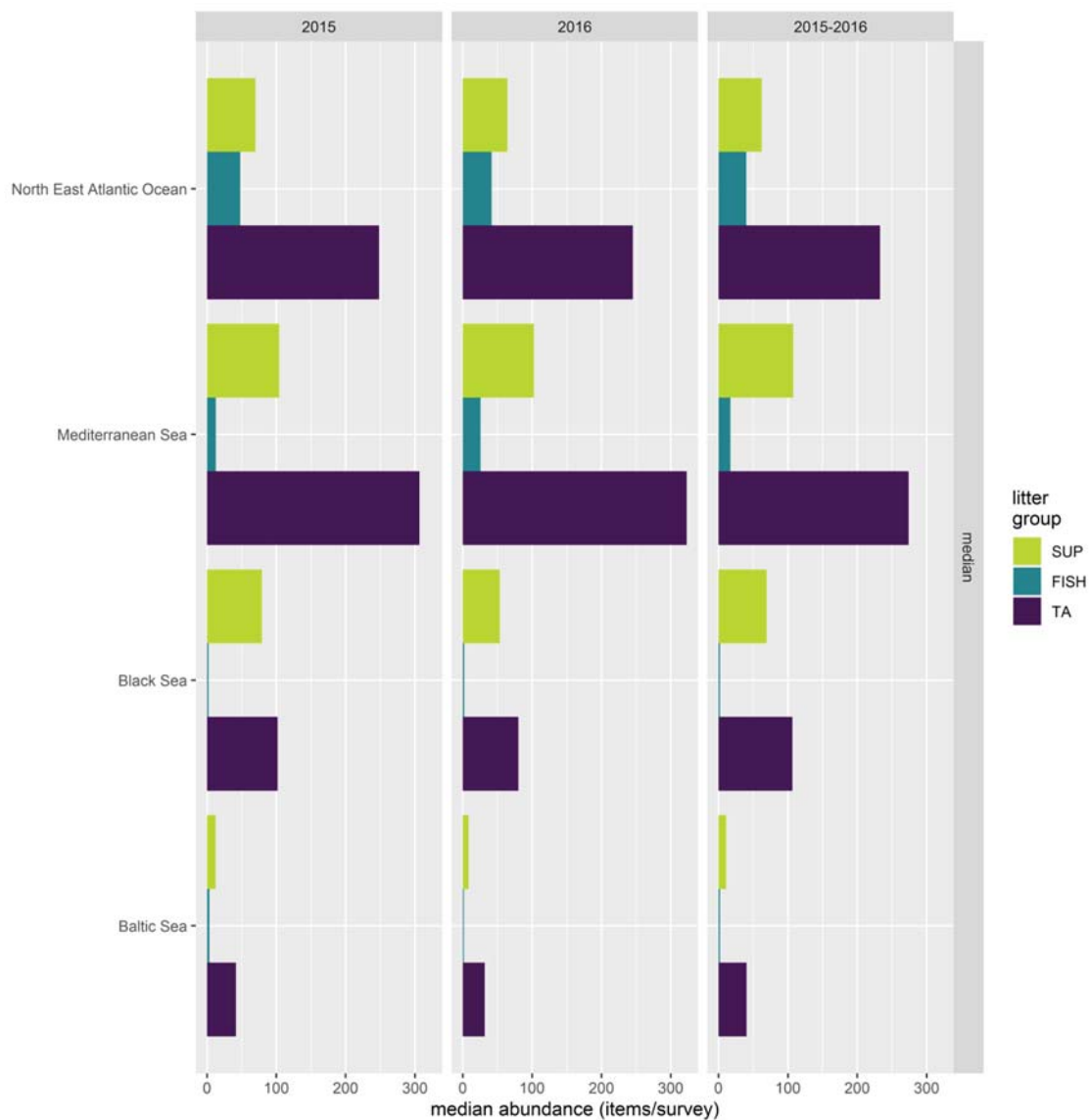


Figure 51: Beach litter abundance per category (SUP=single use plastics, FISH=fishery related items, TA=other litter items). Data have been aggregated as median values per region.

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.

MSFD Top Beach Litter Items

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 Economy³¹ and subsequent proposal for single-use plastics directive³².

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).

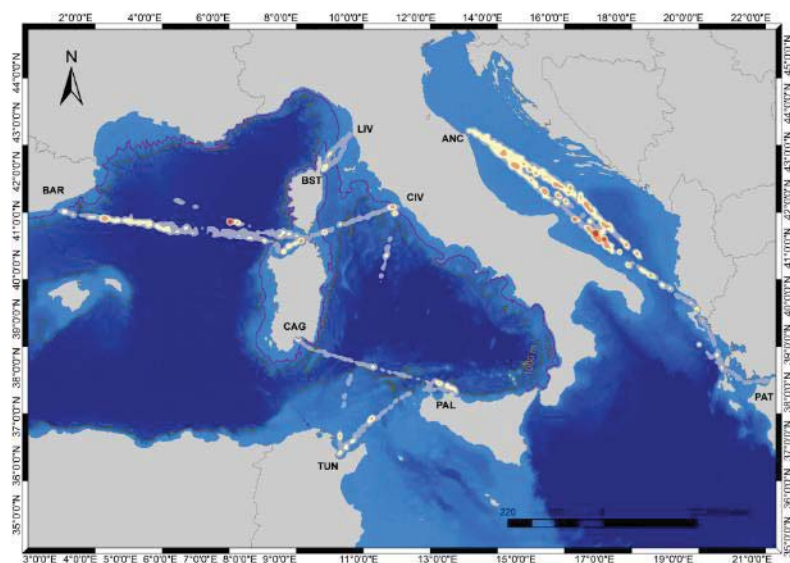


Figure 53: MEDSEALITTER floating macro litter observations from ferry lines in the Mediterranean Sea. From Arcangeli et al. (2018).

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.

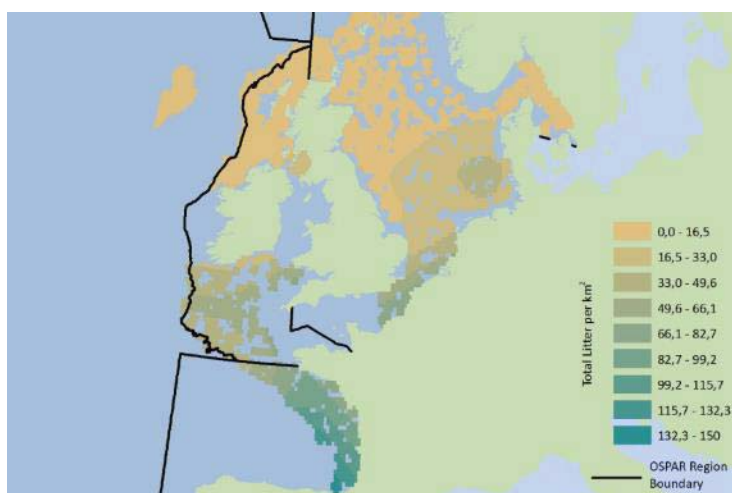


Figure 54: Seafloor litter distribution in the North Sea and other North-east Atlantic areas (OSPAR, 2017g). Note that not all results are directly comparable as different trawling gear were employed.

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/km², 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 accessibility³³ (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 tow 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 10⁵ particles/km², up to 4x10⁵ 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 ($1.2 \pm 1.1 \times 10^3$ particles/m³) were higher than in February ($0.6 \pm 0.55 \times 10^3$ 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 project³⁴, 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 litter³⁵. 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

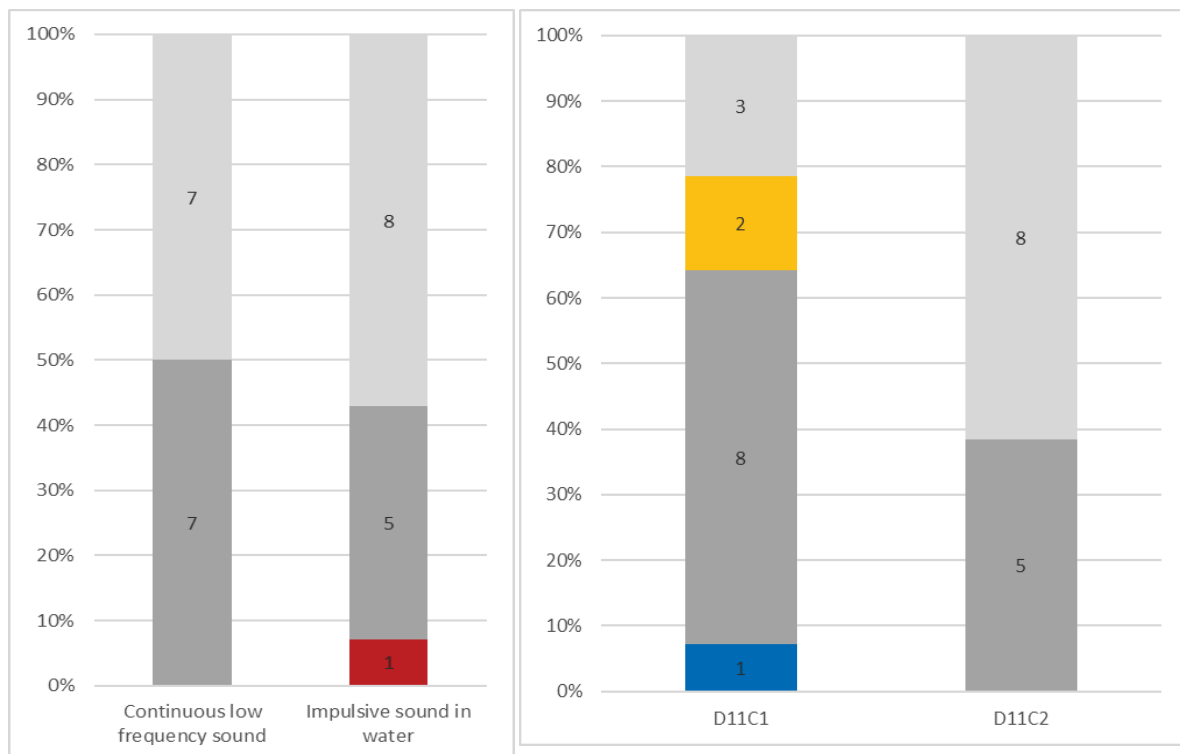
1. MSFD FRAMEWORK

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



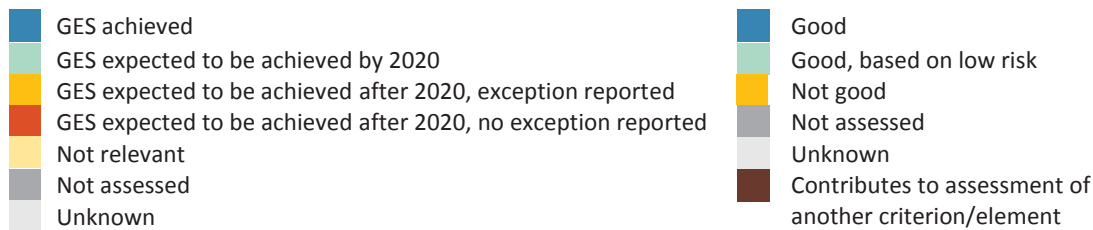


Figure 55: Latest MSFD status assessments of underwater noise at overall level (left) and at criteria level (right) under Descriptor 11. The information comes from 10 Member States' electronic reports.

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 et 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 knowledge³⁶, 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 deliver 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 ICES³⁷. 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).

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.

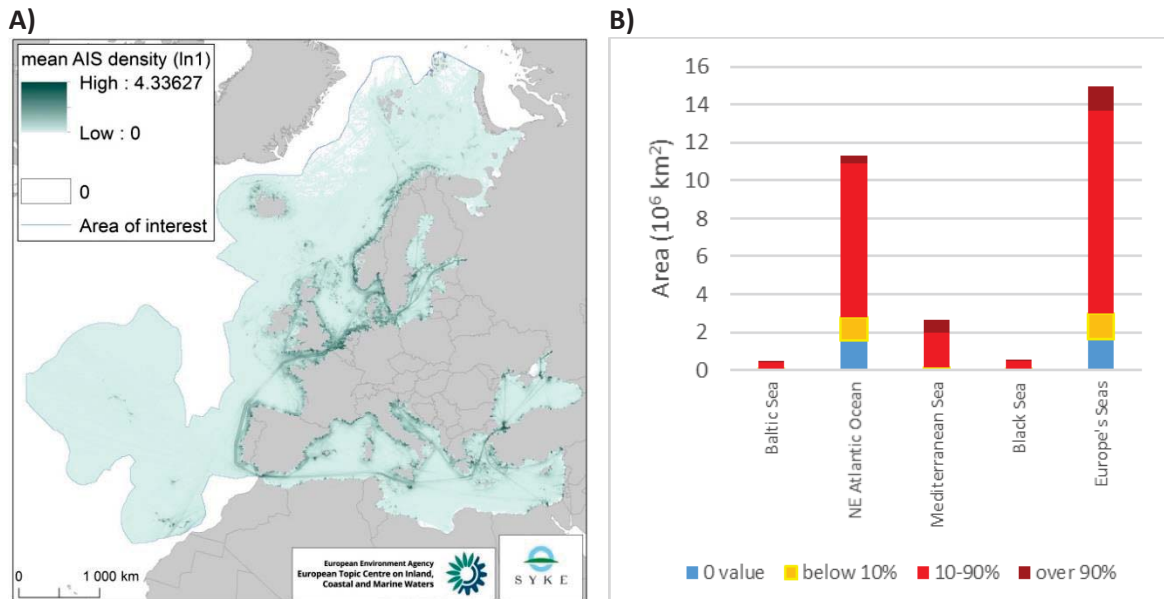


Figure 56: A) Distribution of maritime traffic across Europe's seas over the period 2011-2016 (from ETC/ICM, 2019b). B) Overall area of Europe's seas covered by shipping and proportion of each EU marine region where shipping takes place (from ETC/ICM, 2019b). Colours show four categories according to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

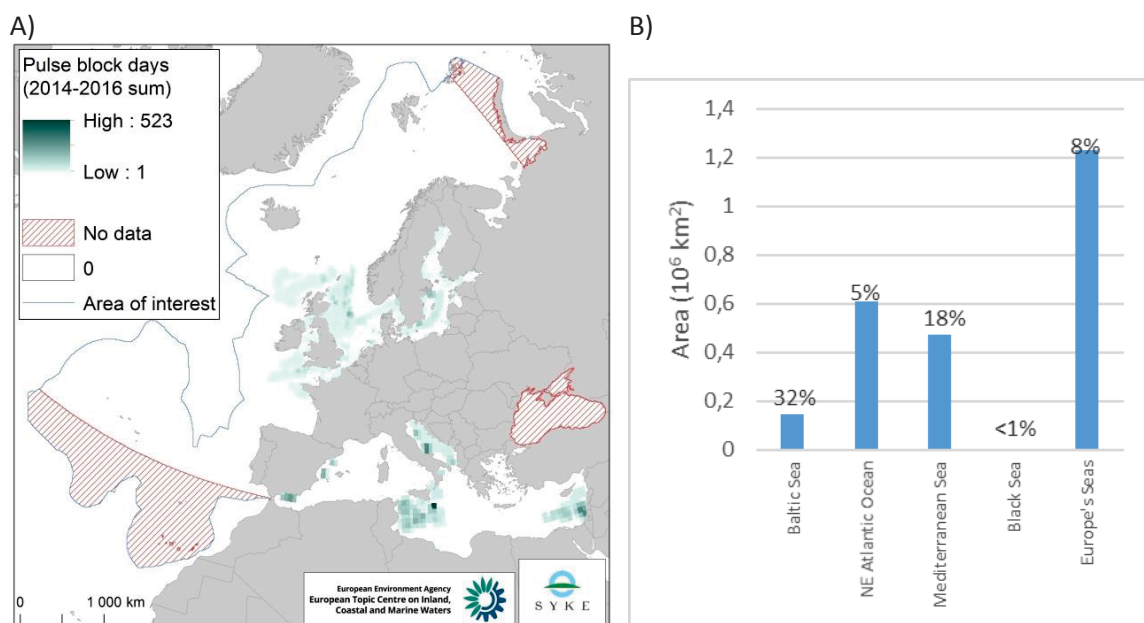


Figure 57: A) Distribution of activities causing impulsive underwater noise across Europe's seas over 2011-2016 (from ETC/ICM, 2019b). B) Overall area of Europe's seas covered by activities causing impulsive underwater noise and proportion of each EU marine region under the effect of relevant activities (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 ICES³⁸), 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 ACCOBAMS³⁹. 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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