Report on SWOT analysis of monitoring

Deliverable 1.4

Dissemination level

Public

This document contains four annexes, including an interactive pdf.
Please, refer to Annex 2 for instructions of how to use the interactive pdf.

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Contents

1. Technical summary

The DEVOTES project has produced a **Catalogue of the Monitoring Networks** currently used in European Seas, as reported by EU Member States and the Regional Sea Conventions, providing the basis for assessing the status of marine biodiversity. It focuses on MSFD descriptor 1 (biological diversity), 2 (non-indigenous species), 4 (food-webs) and 6 (seafloor integrity). The January 2014 version of the catalogue has 775 entries and includes over 210 monitoring programmes reported by ten EU Member States (Bulgaria, Denmark, UK, France, Germany, Greece, Italy, Lithuania, Portugal and Spain) and three countries that share European Regional Seas boundaries (Norway, Turkey and Ukraine).

The **DEVOTES Deliverable D1.4** aims to 1) present a critical overview of the monitoring activities in Europe (i.e. what monitoring is being currently performed, why it is being performed, whether it is fulfilling its objectives and what pressures it is linked to), 2) identify areas where no monitoring is performed, 3) identify needs for further development for marine biodiversity monitoring and make recommendations about how to improve and optimize the current and future monitoring for the MSFD.

A comprehensive overview of the content of the catalogue is given, including details at the European, scale, of legislative and geographic (at regional and subregional sea level) of each monitoring activity, as well as the four descriptors, 11 biodiversity components, 22 habitats (18 seabed and 5 water column) and the 37 pressures addressed (both local manageable and widespread unmanageable). Two GIS-based interactive pdfs were produced and are available to help the potential users (e.g. competent authorities in Member States and non-EU countries, policy makers, government agencies and the regulatory bodies ultimately responsible for implementing the MSFD and ensuring that Good Environmental Status is achieved). Ecosystem overviews for each Regional Sea and the Sea of Marmara have been put together to highlight the specific features of those areas that could be relevant to be accounted by the regional monitoring programmes.

The gaps in monitoring networks related with pressures were analysed per Regional Sea and subregional level. The metadata collated in the catalogue was subject to a SWOT analysis to indicate the strengths, weaknesses, opportunities and threats of the existing monitoring networks across Europe.

2. Introduction

2.1. Rational and scope of the deliverable

This Deliverable aims to identify gaps in monitoring networks used by Member States and Regional Sea Conventions, related to pressures and climate change. The metadata collated in the **DEVOTES Catalogue of Monitoring Networks** (see Annex 1) was subject to a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis to indicate the successes, failings and opportunities in the present monitoring systems (i.e. spatial and temporal adequacy, duplication of sampling efforts, availability of GIS data and supporting physicochemical parameters, data sources and key contacts, etc) especially in relation to the different types of pressures (managed and/or unmanaged), the biodiversity components and the biodiversity-related Marine Strategy Framework Directive (MSFD) descriptors of Good Environmental Status (GEnS) (i.e. D1: biological diversity; D2: Non-indigenous species; D4: food-webs and D6: seafloor integrity). This exercise forms an initial step in assessing the potential for Member States to meet the requirements of the MSFD, highlighting geographical areas where monitoring for particular biodiversity components or pressures may be completely lacking.

This report aims to:

- present a critical overview of the monitoring activities in Europe (i.e. what monitoring is being currently performed, why it is being performed, whether it is fulfilling its objectives and what pressures it is linked to);
- identify areas where no monitoring is performed;
- identify needs for further development for marine biodiversity monitoring, focusing on MSFD descriptors 1 (biological diversity), 2 (non-indigenous species), 4 (food-webs), and 6 (seafloor integrity) and;
- make recommendations about how to improve and optimize the current and future monitoring for the MSFD;

Two **GIS-based interactive pdfs** were produced to visualize the spatial distribution of monitoring activities at Regional and subregional Sea level (see Annex 2). The interactive pdf '*Regional Overviews'* provides a summary of monitoring at the regional sea level, whilst interactive pdf '*Summary Maps*' provides a summary of monitoring at subregion level. These pdfs provide interactive layered maps which can be selected and de-selected to provide a graphical representation of information provided in the **DEVOTES Catalogue of Monitoring Networks**. These maps identify the presence or absence and nature (independent or simultaneous) of monitoring currently undertaken in regional and subregional seas which are relevant for the MSFD. The maps identify and sum (number) the monitored descriptors and identify

and sum (total number) the monitored biodiversity components and habitats and pressures that are currently being assessed.

It is of note that the catalogue has been compiled by DEVOTES partners and therefore monitoring activities carried out by Member States not involved in DEVOTES may not necessarily be fully covered. Development of the catalogue will continue throughout the DEVOTES project to encompass as many monitoring programmes as possible. Therefore, whilst the presence or absence of monitoring within each Regional Sea is representative, any outputs relating to numbers of monitoring programmes should be considered preliminary. It is of note that as the deadline for Member States reporting their MSFD monitoring strategy to the European Commission is July 2014 then at the time of this deliverable many Member States are still formulating these strategies.

Brief summary of the structure of this report

This report is organised in seven sections:

1. **Technical Summary:** recapitulates the main aims of the deliverable, indicates the structure of the document, summarises the monitoring activities in Europe and highlights the major strengths, weaknesses, opportunities and threats of the current monitoring programmes reported in the **DEVOTES Catalogue of Monitoring Networks** (**Annex 1**).
2. **Introduction:** it is divided in two subsections. The rational and scope of the deliverable are addressed and the GIS-based interactive pdfs (**Annex 2**), produced to visualize the spatial distribution of monitoring activities at regional and subregional sea level, are briefly explained (section 2.1). In addition, to assist the project stakeholders (e.g. Member States, Regional Authorities, etc.) in developing and/or planning MSFD monitoring in the most effort efficient manner, we include a brief screening of the monitoring requirements imposed by the MSFD and other EU legislation and international agreements (section 2.2). With this exercise we aim to indicate where the MSFD monitoring requirements overlap with the requirements of EU legislation and international agreements and emphasize that these programmes should already provide some of the data required for MSFD monitoring.
3. **DEVOTES Catalogue of Monitoring Networks – overall content**: it is a comprehensive overview of the content of the catalogue (January 2014 version), including details, at the European scale, of legislative and geographic scope (at regional and subregional sea level) of each monitoring activity as well as the descriptors, biodiversity components, habitats and the pressures addressed.

4. **Gap and SWOT analysis per Regional Sea**: a comprehensive analysis of the current situation, structure, spread and coverage of monitoring programmes identified as suitable to address the GEnS of the MSFD descriptors D1, D2, D4 and D6 in the four Regional Seas (i.e. North Eastern Atlantic, Baltic Sea, Mediterranean Sea and Black Sea) and in the Sea of Marmara (non-EU marine waters connecting the Mediterranean Sea with the Black Sea) is given (sections 4.1.1, 4.2.1, 4.3.1 and 4.4.1). For a better understanding of the ecosystems from each regional sea, a comprehensive description can be seen in **Annex 3**. In addition, we present a gap analysis at regional and subregional sea scale, highlighting the aspects missing in the current monitoring situation (sections 4.1.2., 4.2.2., 4.3.2. and 4.4.2.) Finally, we carry out a detailed SWOT analysis specifying the strengths, weaknesses, opportunities and threats in the present monitoring networks of each Regional Seal and the Sea of Marmara (sections 4.1.3., 4.2.3., 4.3.3 and 4.4.3). The raw data (excel files) used to support the analysis can be consulted in **Annex 4**.
5. **Concluding Remarks**: this section summarises the results per regional sea, presenting an overall gap (section 5.1.) and SWOT analysis (section 5.2) of the current existing monitoring networks used across the North Eastern Atlantic, Baltic Sea, Black Sea, Mediterranean Sea and the Sea of Marmara.
6. **References**
7. **List of annexes:** the four supporting annexes of the results presented in this report are outlined at the end of the document.

Note

Box 1 below includes definitions of terms frequently used throughout the report. Although different definitions would be possible, these reflect the meaning they were attributed while used in the present document.

BOX 1. DEFINITION OF TERMS

SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis – *is a commonly-used assessment tool employed, in this report, to critique the monitoring networks in Europe, thus allowing us to:*

- *explore possibilities for new efforts or solutions to problems;*
- *make decisions about the best practices for MSFD monitoring. Identifying opportunities for success in the context of threats to success can clarify directions and choices;*
- *determine where amendments/ adjustments are possible and write recommendations.*

Gaps analysis – *is a commonly-used term in management allowing the determination of aspects missing in the current situation and hence allowing an analysis of what is required to fill those gaps.*

Marine Monitoring – *the systematic, repeated measurement of biotic and abiotic parameters of the marine environment, with predefined spatial and temporal schedule, having the purpose to produce datasets that can be used for application of assessment methods and derive credible conclusions on whether the desired state or target is achieved or not and on the trend of changes for the marine area concerned. In this frame, monitoring includes the choice of the elements to measure, the location of sampling sites, the periodicity of sampling, the collection of field samples and data from other observation techniques, processing of the samples in the laboratory and of alternatively gained data (e.g. satellite imagery) and the compilation and management of the data. Development of assessment methods and classification of status as good or less than good is not included although closely related to monitoring. In a nutshell, monitoring should provide the data to allow assessment methods to classify a marine area as reaching or failing to reach GEnS (Zampoukas et al., 2014).*

Monitoring Programme – *all substantive arrangements for carrying out monitoring, including general guidance with cross-cutting concepts, monitoring strategies, monitoring guidelines, data reporting and data handling arrangements. Monitoring programmes include a number of scheduled and coordinated activities to provide the data needed for the ongoing assessment of environmental status and related environmental targets (Zampoukas et al., 2014). A monitoring programme can include one or several monitoring activities.*

Monitoring Activities – *the repeated sampling and analysis in time or space of one or more ecosystem components and carried out by an individual agency or institution. Data and marine information are obtained on a routine or specific basis, using sea surveys, remote sensing (i.e. teledetection), ferry boxes, data mining, or any other way.*

Monitoring Network – *a group of monitoring programmes undertaken or used within broader programmes, such as International Conventions, Regional Sea, EU Directives and/or national monitoring.*

Web-platform and database levels – *this makes the distinction between data sets which are collated in widely accessible formats (i.e. a website) and those that are collated and stored by individual agencies. These may or may not be accessible on request*.

BOX 1. DEFINITION OF TERMS (cont.)

Types of monitoring – ***Condition monitoring*** *specifically relates to the conservation objectives and favourable conservation status. In contrast,* ***surveillance monitoring*** *can be any 'look-see' process; compliance monitoring relates to thresholds and trigger values which are stipulated in permits, investigative/diagnostic monitoring is the ability to determine the causes of change detected by the other types of monitoring (Elliott, 2011).*

Pressure – *the mechanism through which an activity has an actual or potential effect on any part of an ecosystem (Robinson et al., 2008).*

Local and manageable pressure – *pressures that occur as a result of human activities taking place on a localised scale (i.e. a discharge, a specific dredge disposal or aggregate extraction site, at the scale of the management unit). These pressures can be managed through permits/consents and monitoring. They are referred to as* ***ENDOGENIC MANAGED PRESSURES*** *where the causes are managed as well as the consequences (Elliott, 2011).*

Widespread and unmanageable pressures – *are those that are beyond the control of management that are occurring at regional scales and often outside the management unit. For example, temperature and hydrological changes associated with climate change, pH change due to volcanic activity (may be local but is not manageable). This is referred to as* ***EXOGENIC UNMANAGED PRESSURES*** *where the consequences are managed rather than the causes (Elliott, 2011).*

Impacts –*the adverse consequences of human activities and natural phenomena which require to be detected by monitoring over and above natural and inherent variability (summarized as a 'signal' of an activity over the environmental 'noise').*

Human uses and users – *the list of activities of the marine environment which may be summarized as activities which remove space and materials (habitat, fishing, aggregate extraction, water, salt, etc.) and those which input space-occupation or materials (building for land claim, bridges, heated effluents, pollutants, etc). The activity is the use and those performing it are the users.*

2.2. Monitoring for EU legislation and Regional Sea Conventions

2.2.1. Monitoring parameters according to MSFD

According to the MSFD Articles 5 and 11, EU Member States should by the 15th of July 2014, establish and implement coordinated monitoring programmes for the ongoing assessment of the environmental status of their marine waters and the assessment and regular updating of environmental targets. The scope of the MSFD includes marine waters under the sovereignty and jurisdiction of EU Member States, i.e.coastal and territorial waters and, where applicable, also Exclusive Economic Zones and the sea bottom and sub-soil of the extended continental shelf.

Monitoring programmes should be based on the initial assessment undertaken in 2012 where, according to Article 8, Member States were required to provide:

- an analysis of the essential features, characteristics and current environmental status of their marine waters;
- an analysis of the predominant pressures and impacts and;
- an economic and social analysis of the use of their marine waters and the cost of degradation of the marine environment.

Consequently, before drafting their monitoring programmes Member States should be well aware of the species and habitats they host, their current condition and the pressures impacting on them. Before finalizing monitoring programmes, Member States shall publish them and make them available for public consultation.

Member States sharing a marine region or subregion should aim for coherence and coordination by ensuring that monitoring methods are consistent across the marine region or subregion and that transboundary impacts and features are taken into account. Moreover, monitoring programmes should be based on and be compatible with the European *acquis*, such as the Habitats and Birds Directives and other international agreements, such as the RSCs. Further specifications can be found in Annex V of the Directive.

Member States shall notify the Commission of their monitoring programmes within three months of their establishment, i.e. by the 15th October 2014. According to Article 12, the Commission will assess within six months of receiving these notifications if the monitoring programmes constitute an appropriate framework to meet the requirements of the Directive and it may ask Member States for additional available required information. The Commission will particularly consider the coherence of frameworks within the different marine regions and subregions and across the EU and will inform Member States on the outcomes of this assessment and it will provide guidance on necessary modifications.

Member States shall in a coordinated manner review their monitoring programmes every six years after their initial establishment, i.e. in 2020, 2026 and so on, following the six years cycle of the MSFD that includes assessment, determination of GEnS, setting of environmental targets, establishment of monitoring programmes and identification and implementation of programmes of measures (see Figure 1, from Claussen *et al*., 2011). Monitoring programmes should include the characteristics, the pressures and impacts included in the Directive's Annex III.

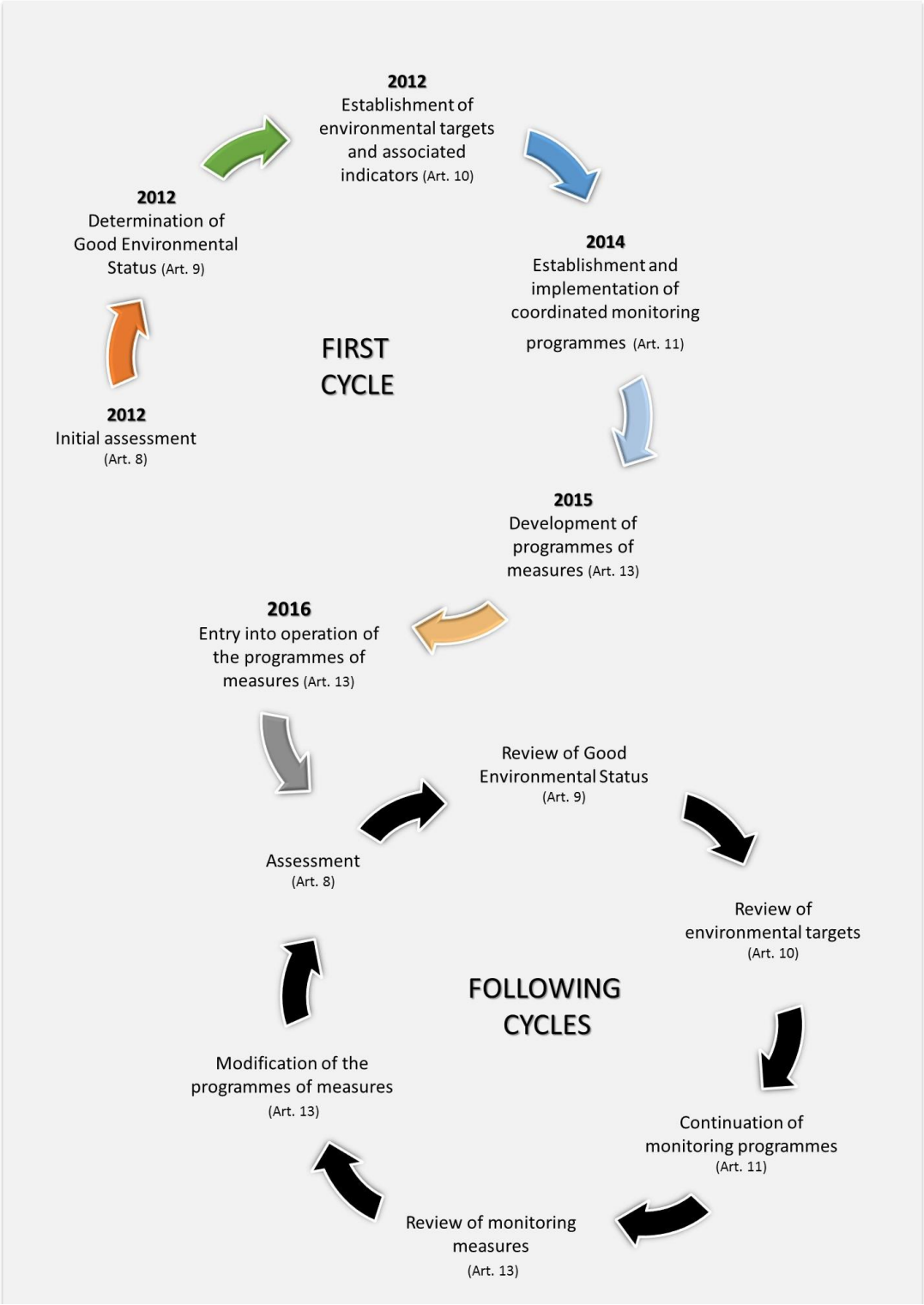


Figure 1. Marine Strategy Framework Directive management cycle (from Claussen *et al*., 2011).

Table 1 of this report summarises the information on the criteria for GEnS and indicators (COM DEC 2010/477/EU) relevant to the Descriptor 1 (Biological Diversity), Descriptor 2 (Non-indigenous species), Descriptor 4 (Food-webs) and Descriptor 6 (Sea-floor integrity) of Annex I to Directive 2008/56/EC.

Table 1. Criteria for GEnS and indicators (COM DEC 2010/477/EU) relevant to the Descriptors 1, 2, 4 and 6 of Annex I to Directive 2008/56/EC.

DESCRIPTOR	CRITERIA	INDICATORS
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 climate conditions.	1.1 Species distribution	1.1.1 Distributional range
		1.1.2 Distributional pattern within the latter, where appropriate
		1.1.3 Area covered by the species (for sessile/benthic species)
	1.2 Population size	1.2.1 Population abundance and/or biomass, as appropriate
	1.3 Population condition	1.3.1 Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates)
		1.3.2 Population genetic structure, where appropriate
	1.4 Habitat distribution	1.4.1 Distributional range
		1.4.2 Distributional pattern
	1.5 Habitat extent	1.5.1 Habitat area
		1.5.2 Habitat volume, where relevant
	1.6 Habitat condition	1.6.1 Condition of the typical species and communities
		1.6.2 Relative abundance and/or biomass, as appropriate
		1.6.3 Physical, hydrological and chemical conditions
	1.7 Ecosystem structure	1.7.1 Composition and relative proportions of ecosystem components (habitats and species)
Descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.	2.1 Abundance and state characterisation of non-indigenous species, in particular invasive species	2.1.1 Trends in abundance, temporal occurrence and spatial distribution in the wild of non-indigenous species, particularly invasive non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species
	2.2 Environmental impact of invasive non-indigenous species	2.2.1 Ratio between invasive non-indigenous species and native species in some well studied taxonomic groups (e.g. fish, macroalgae, molluscs) that may provide a measure of change in species composition (e.g. further to the displacement of native species)
		2.2.2 Impacts of non-indigenous invasive species at the level of species, habitats and ecosystem, where feasible
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.	4.1 Productivity (production per unit biomass) of key species or trophic groups	4.1.1 Performance of key predator species using their production per unit biomass (productivity)
	4.2 Proportion of selected species at the top of food webs	4.2.1 Large fish (by weight)
	4.3 Abundance/distribution of key trophic groups/species	4.3.1 Abundance trends of functionally important selected groups/species
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.	6.1 Physical damage, having regard to substrate characteristics	6.1.1 Type, abundance, biomass and areal extent of relevant biogenic substrate
		6.1.2 Extent of the seabed significantly affected by human activities for the different substrate types
	6.2 Condition of benthic community	6.2.1 Presence of particularly sensitive and/or tolerant species
		6.2.2 Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species
		6.2.3 Proportion of biomass or number of individuals in the macrobenthos above some specified length/size
		6.2.4 Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community

Table 2 of this document details the 58 monitoring requirements (of MSFD Annex III) that we considered related to Descriptors 1, 2, 4 and 6. Monitoring requirements related to litter and noise, although they impact biodiversity, are not included in this list as they are not directly related to one of the D1, 2, 4 and 6 indicators and are explicitly addressed by Descriptors 10 and 11, respectively. Requirements related to physical, hydrological and chemical conditions are included as they relate to indicator 1.6.3 (physical, hydrological and chemical conditions of the habitat) and are usually measured as elements supporting biodiversity monitoring. Requirements related to contaminants are not included, although it could be argued that they are related to indicator 1.6.3, as they are not usually considered as standard supporting elements and are explicitly addressed by Descriptors 8 and 9.

2.2.2. Monitoring parameters under other community legislation

The pieces of EU legislation most related to marine biodiversity are the Habitats Directive[1] and Birds Directive[2] that apply to all areas where Member States have sovereignty and jurisdiction. The Water Framework Directive[3] (WFD), the Urban Waste-water Treatment Directive and the Common Fisheries Policy are also relevant. In particular, given the overlap in spatial jurisdiction between the WFD and MSFD, Member States appear to be using WFD monitoring to achieve the MSFD monitoring. In this subsectionmarine biodiversity related monitoring requirements of the European *acquis* are presented and related to MSFD indicators. This relationship does not necessarily mean that monitoring for these requirements fully covers monitoring required for MSFD descriptors.

The Habitats Directive includes species and habitats 'of community interest' that should be protected in order to be in "favourable conservation status". Member States should report every six years the measures taken and their impact on the conservation status of concerned habitats and species. Monitoring requirements are not explicitly defined but in order to assess the conservation status of species and habitats, data on the natural and current range and population dynamics of species and size of the habitats are required. According to the Technical Guidance on MSFD Monitoring (Zampoukas *et al.*, 2014) that is based on MSFD CIS (2012), there are eight marine or potentially marine habitats and 82 marine or potentially marine species listed in the annexes of the Habitats Directive. Potentially marine species and habitats are the ones that could occur in marine waters but possibly also outside them (e.g.

[1] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

[2] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds.

[3] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

in transitional waters). There are 15 monitoring requirements in the Habitats Directive and 13 that are relevant to MSFD descriptors 1, 2, 4 and 6 (Table 3).

Table 2. Marine biodiversity related monitoring requirements of the Marine Strategy Framework Directive (MSFD) Annex III and their relevant MSFD indicators of the COM DEC 2010/477/EU (based on Zampoukas *et al*., 2012).

	Parameter	Relevant MSFD Indicators
1	Angiosperms biomass and its annual/seasonal variability	1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
2	Angiosperms species composition and its annual/seasonal variability	1.6.2, 1.7.1, 2.1.1, 2.2.1, 4.3.1, 6.2.1, 6.2.2
3	Fish abundance	1.2.1, 1.7.1, 2.1.1, 2.2.1, 4.1.1, 4.2.1, 4.3.1
4	Fish age / size structure	1.3.1, 1.6.1, 4.1.1, 4.2.1
5	Fish distribution	1.1.1, 2.1.1, 2.2.1
6	Genetically distinct forms of native species abundance	1.3.2, 2.2.1, 4.3.1
7	Genetically distinct forms of native species occurrence	1.3.2
8	Genetically distinct forms of native species spatial distribution	1.1.1, 1.1.2, 2.2.1
9	Habitats'(predominant, special, protected and endangered) characteristics	1.4.1, 1.4.2, 1.5.1, 1.5.2, 1.7.1, 6.1.1
10	Introduction of non-indigenous species	2.1.1, 2.2.1
11	Invertebrate bottom fauna biomass and its annual/seasonal variability	1.2.1, 1.6.1, 1.6.2, 1.7.1, 2.1.1, 2.2.1, 4.3.1, 6.1.2
12	Invertebrate bottom fauna species composition and its annual/seasonal variability	1.6.2, 1.7.1, 2.1.1, 2.2.1, 4.3.1, 6.1.1, 6.2.1, 6.2.2
13	Macro-algae biomass	1.2.1, 1.6.1, 1.6.2, 1.7.1, 2.1.1, 2.2.1, 4.3.1, 6.1.2
14	Macro-algae species composition	1.6.2, 1.7.1, 2.1.1, 2.2.1, 6.2.1, 6.2.2
15	Marine mammals actual range	1.1.1
16	Marine mammals natural range	1.1.1
17	Marine mammals population dynamics	1.3.1, 4.1.1, 4.3.1
18	Marine mammals status	1.2.1, 1.3.1, 1.6.1
19	Non-indigenous or exotic species abundance	2.1.1, 2.2.1
20	Non-indigenous or exotic species occurrence	2.1.1, 2.2.1
21	Non-indigenous or exotic species spatial distribution	2.1.1, 2.2.1
22	Other protected species actual range	1.1.1
23	Other protected species natural range	1.1.1
24	Other protected species population dynamics	1.3.1

25	Other protected species status	1.2.1, 1.3.1, 1.6.1
26	Phytoplankton spp. composition and its geographical/seasonal variability	1.7.1, 2.1.1, 2.2.1
27	Reptiles actual range	1.1.1
28	Reptiles natural range	1.1.1
29	Reptiles population dynamics	1.3.1, 4.3.1
30	Reptiles status	1.2.1, 1.3.1, 1.6.1
31	Seabirds actual range	1.1.1
32	Seabirds natural range	1.1.1
33	Seabirds population dynamics	1.3.1, 4.1.1, 4.3.1
34	Seabirds species' status	1.2.1, 1.3.1, 1.6.1
35	Translocations of non-indigenous species	2.1.1, 2.2.1
36	Zooplankton spp. composition and its geographical/ seasonal variability	1.6.2, 1.7.1, 2.1.1, 2.2.1
37	Acidification	1.6.3
38	Abrasion	1.6.3, 6.1.1, 6.1.2
39	Currents	1.6.3
40	Depth	1.6.3
41	Extraction	6.1.2
42	Ice cover	1.6.3
43	Mixing characteristics	1.6.3
44	Nutrient concentrations	1.6.3, 5.1.1
45	Oxygen	1.6.3
46	Residence time	1.6.3
47	Salinity	1.6.3
48	Seabed Bathymetry	1.6.3
49	Seabed Structure	6.1.1, 6.1.2
50	Seabed Substrata Composition	6.1.1, 6.1.2
51	Seabed Topography	6.1.1, 6.1.2
52	Sealing	6.1.2
53	Siltation (changes in)	1.6.3
54	Smothering	6.1.2
55	Temperature	1.6.3
56	Turbidity	1.6.3
57	Upwelling	1.6.3
58	Wave exposure	1.6.3

Table 3. Monitoring requirements of the Habitats Directive and their relevant Marine Strategy Framework Directive (MSFD) indicators (COM DEC 2010/477/EU) (based on Zampoukas *et al*., 2012).

	Habitats Directive Parameter	Relevant MSFD Indicators
1	Natural range of natural habitat types of community interest	1.4.1, 6.1.1
2	Area covered by natural habitat types of community interest	1.4.1, 1.6.2, 1.7.1, 6.1.1
3	Specific structure of natural habitat types of community interest	6.1.1
4	Status of conservation of species in natural habitat types of community interest	1.6.1
5	Population dynamics of animal and plant species of community interest	1.3.1, 1.6.1
6	Natural range of animal and plant species of community interest	1.1.1
7	Presence of habitat for animal and plant species of community interest	1.5.1, 1.5.2
8	Population dynamics of animal and plant species of community interest in need of strict protection	1.3.1, 1.6.1
9	Natural range of animal and plant species of community interest in need of strict protection	1.1.1
10	Presence of (sufficiently large) habitat of animal and plant species of community interest in need of strict protection	1.5.1, 1.5.2
11	Population dynamics of animal and plant species of community interest in need of strict protection	1.3.1, 1.6.1
12	Natural range of animal and plant species of community interest in need of strict protection	1.1.1
13	Presence of (sufficiently large) habitat of animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures	1.5.1, 1.5.2

The Birds Directive requires Member States to take measures to maintain the population of listed species and report these measures every three years. This directive lists 68 marine or potentially marine bird species that require special protection areas (Zampoukas *et al.*, 2014). Monitoring requirements are not explicitly mentioned but for the setting of conservation measures Member States should take into account trends and variations in populations (Table 4).

According to Zampoukas *et al.* (2012), there are 38 monitoring requirements in the WFD of which 35 are related to Descriptors 1, 2, 4 and 6 (Table 5). It is assumed here that the MSFD will be implemented by Member States up to the tidal limit but excluding transitional waters; this may be represented by the bay-closing lines.

In the marine environment, the WFD monitoring only covers coastal waters at the water body scale and then to 1NM from the baseline as well as transitional waters. Data on taxa and their abundance and/or biomass are required for phytoplankton, macrophytes (macroalgae and angiosperms) and benthic invertebrate fauna. According to Zampoukas *et al.* (2012) there are 38 monitoring requirements in the WFD and 35 out of them are related to Descriptors 1, 2, 4 and 6 (Table 5).

The Common Fisheries Policy (CFP) applies to the management of fish stocks and fishing activities. The Data Collection Framework (DCF - Commission Regulation 665/2008[4] and Commission Decision 2010/93/EU[5]) specifies the stocks, areas, parameters and frequency for fish and shellfish monitoring, as well as for economic and transversal variables. According to Zampoukas *et al.* (2012) there are 26 monitoring requirements in the DCF and 24 of them are related to D1, 2, 4 and 6 (Table 6). However, Zampoukas *et al.* (2014) noted that no Member State is fully compliant with the DCF and, furthermore, the DCF monitoring is not specifically tailored to collect data on biodiversity (e.g. due to selectivity of the gear, seasonality of sampling, spatial coverage and habitat types).

Table 4. Monitoring requirements of the Birds Directive and their relevant Marine Strategy Framework Directive (MSFD) indicators (COM DEC 2010/477/EU) (based on Zampoukas *et al.*, 2012).

	Birds Directive Parameter	Relevant MSFD Indicators
1	Trends and variations in population for the species birds in the Annex I	1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1
2	Trends and variations in population for species in danger of extinction	1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1
3	Trends and variations in population for vulnerable species	1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1
4	Trends and variations in population for species considered rare	1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1
5	Trends and variations in population for other species requiring particular attention	1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1
6	Trends and variations in population for migratory species not listed in the Annex I	1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1
7	Listing and ecological description of areas important to migratory species	1.5.1, 1.5.2, 1.6.3
8	Listing population levels of migratory species as shown by ringing	1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1

[4] Commission Regulation (EC) No 665/2008 of 14 July 2008 laying down detailed rules for the application of Council Regulation (EC) No 199/2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

[5] Commission Decision of 18 December 2009 adopting a multiannual Community programme for the collection, management and use of data in the fisheries sector for the period 2011-2013 (notified under document C(2009) 10121) (2010/93/EU).

Table 5. Monitoring requirements of the Water Framework Directive (WFD) and their relevant Marine Strategy Framework Directive (MSFD) indicators (COM DEC 2010/477/EU) (Zampoukas *et al.*, 2012).

	Water Framework Directive Parameter	Relevant MSFD Indicators
1	Angiosperms Abundance	1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
2	Angiosperms Composition	1.6.2, 1.7.1, 2.1.1, 2.2.1, 6.2.1, 6.2.2
3	Angiosperms Cover	1.1.3, 1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
4	Angiosperms Depth Distribution	1.1.1, 1.2.1, 1.6.1, 1.7.1, 4.3.1
5	Angiosperms Presence of Sensitive Taxa	6.2.1
6	Benthic Invertebrate Fauna - Presence of Sensitive Taxa	6.2.1
7	Benthic Invertebrate Fauna Abundance	1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
8	Benthic Invertebrate Fauna Composition	1.6.2, 1.7.1, 2.1.1, 2.2.1, 6.1.1, 6.2.1, 6.2.2
9	Benthic Invertebrate Fauna Diversity	1.7.1, 6.2.2
10	Macro-algae - Presence of Sensitive Taxa	6.2.1
11	Macro-algae Abundance	1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
12	Macro-algae Cover	1.1.3, 1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
13	Macro-algae Depth Distribution	1.1.1, 1.2.1, 1.6.2, 1.6.1, 1.7.1
14	Macro-algae Species Composition	1.6.2, 1.7.1, 2.1.1, 2.2.1, 6.2.1, 6.2.2
15	Phytoplankton Abundance	1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1
16	Phytoplankton Biomass	1.6.2, 1.7.1, 4.3.1
17	Phytoplankton Bloom Frequency / Intensity	4.3.1
18	Phytoplankton Composition	1.7.1, 2.1.1, 2.2.1
19	Phytoplankton Diversity	1.7.1
20	Acidification	1.6.3
21	Ammonium	1.6.3
22	Nitrates	1.6.3
23	Nutrient Conditions	1.6.3
24	Oxygenation	1.6.3
25, 26, 27	Bed Quantity, structure and substrate	1.6.3, 6.1.1, 6.1.2
28	Conductivity	1.6.3
29	Depth Variation	1.6.3
30	Direction of Dominant Currents	1.6.3
31	pH	1.6.3
32	Salinity	1.6.3
33	Temperature	1.6.3
34	Transparency	1.6.3
35	Residence Time	1.6.3

Table 6. Monitoring requirements of the Common Fisheries Policy and their relevant Marine Strategy Framework Directive (MSFD) indicators (COM DEC 2010/477/EU) (based on Zampoukas *et al.*, 2012).

	Common Fisheries Policy Parameter	Relevant MSFD Indicators
1	Share in unsorted landings for species and areas referred in COM DEC 2010/93/EC Chapter III B1	1.1.1, 1.2.1, 1.7.1, 2.2.1, 4.1.1, 4.2.1, 4.3.1
2	Length distribution of species listed in Appendix VII in the catches	1.3.1, 1.6.1, 3.1.1, 4.2.1
3	Average weight of discards of species listed in Appendix VII	1.2.1, 1.6.1, 1.7.1, 2.2.1, 4.1.1, 4.2.1, 4.3.1
4	Length distribution of discards of species listed in Appendix VII	1.3.1, 1.6.1, 4.2.1
5	Age-reading of discards of species listed in Appendix VII	1.3.1
6	Weight of catches of recreational fisheries for the species and areas referred in Appendix IV (1 to 5)	1.2.1, 1.7.1, 2.2.1, 4.1.1, 4.2.1, 4.3.1
7	Individual age of species listed in Appendix VII	1.3.1
8	Individual length of species listed in Appendix VII	1.3.1, 1.6.1, 4.2.1
9	Individual weight of species listed in Appendix VII	1.6.1, 4.2.1
10	Individual sex of species listed in Appendix VII	1.3.1
11	Individual fecundity of species listed in Appendix VII	1.3.1, 1.6.1
12	Wild salmon stocks in index rivers running to the Baltic Sea III b-d: Abundance of smolt, parr and ascending individuals	1.2.1, 1.6.1, 1.6.2, 1.7.1, 2.2.1, 4.3.1
13	Species (data from fisheries-independent research surveys)	1.7.1, 2.1.1, 2.1.2
14	Species length (data from fisheries-independent research surveys)	1.3.1, 1.6.1, 4.2.1
15	Species abundance (data from fisheries-independent research surveys)	1.2.1, 1.6.1, 1.6.2, 1.7.1, 2.1.1, 2.2.1, 4.2.1, 4.3.1
16	Individual age (data from fisheries-independent research surveys)	1.3.1
17	Individual length (data from fisheries-independent research surveys)	1.3.1, 1.6.1, 4.2.1
18	Individual sex (data from fisheries-independent research surveys)	1.3.1
19	Catches of species (based on logbooks)	1.1.1, 1.2.1, 1.7.1, 2.2.1, 4.1.1, 4.2.1, 4.3.1
20	Catches length (based on logbooks)	1.3.1, 1.6.1, 4.2.1
21	Catches abundance (based on logbooks)	1.2.1, 1.6.1, 1.6.2, 1.7.1, 2.2.1, 4.3.1
22	Discards of species (based on observer trips)	1.2.1, 1.6.1, 1.6.2, 1.7.1, 2.1.1, 2.2.1, 4.3.1
23	Discards length (based on observer trips)	1.3.1, 1.6.1, 4.2.1
24	Discards abundance (based on observer trips)	1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.1.1, 4.3.1

2.2.3. Monitoring under the Regional Seas Conventions (RSCs)

Table 7, modified from Zampoukas *et al.* (2014), summarizes monitoring requirements in the four RSCs and relates them to MSFD indicators without necessarily implying that contracting parties are fully compliant.

Table 7. Monitoring requirements of HELCOM, OSPAR, Barcelona and Bucharest Conventions that are related to indicators within the Marine Strategy Framework Directive (MSFD) Descriptors 1, 2, 4 and 6.

HELCOM *	OSPAR**	Barcelona Convention***	Bucharest Convention****	Related MSFD indicators
Chl-a	Chl-a	Chl-a	Chl-a	1.6.2, 1.7.1, 4.3.1
Phytoplankton	Phytoplankton indicator species		Phytoplankton (total density, total biomass)	1.1.3, 1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
Phytobenthos			Macrophytobenthos	1.1.3, 1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
Zooplankton			Mesozooplankton, Biomass of *Noctilluca*	1.1.3, 1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
Zoobenthos	Benthic communities		Macrozoobenthos	1.1.3, 1.2.1, 1.6.1, 1.6.2, 1.7.1, 4.3.1, 6.1.2
Birds				1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1
Mammals				1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1
Fish			Fish landings	1.1.1, 1.2.1, 1.3.1, 1.6.1, 4.1.1, 4.3.1
Non-indigenous species				2.1.1, 2.2.1, 2.2.2
Hydrography	Salinity, Temperature, Oxygen	Temperature, Salinity, Dissolved oxygen	Oxygen, pH, Salinity, Secchi depth, Temperature	1.6.3
Nutrients	NH_4-N_2, NO_2-N_2, NO_3-N_2, PO_4-P_3, SiO_4-Si_4	NO_3-N, NO_2-N, NH_4-N, PO_4-P, SiO_4	N (NH_4, NO_2, NO_3, N-total), P (PO_4 & P-total), SiO_4	1.6.3
	TOC, POC		Total Suspended Solids	1.6.3

*Monitoring requirements listed are the ones included in the revised monitoring strategy.

** Information is based on existing formal monitoring programmes. Many of the existing monitoring activities and data streams (e.g. for EcoQOs or human activities) are not yet organised through a formal "monitoring programme" while still follow agreed and coordinated approaches, procedures, methods and standards.

*** With regard to biodiversity the countries do not implement yet a regionally coordinated biodiversity monitoring programme. However, biodiversity monitoring is included in the SPA/ Birds Directive Protocol (Articles 3, 7 and 20) as an obligation for the Contracting Parties.

**** Frequency of monitoring is affected by funding that is not always adequate and monitoring in the open sea seems to be only sporadic.

The four European RSCs are coordinating marine monitoring of their contracting parties. The MSFD strengthened the role of the RSCs in ensuring coordinated implementation of the Directive. The coordination appears to vary across the four RSCs. According to Zampoukas *et al.* (2014), HELCOM, in its revised strategy, seems to be much advanced in including the whole range of MSFD requirements and OSPAR has also developed plans to include more elements related to progress in developing and agreeing Ecological Quality Objectives (EcoQOs). In the Mediterranean, issues related to monitoring of biodiversity components additional to contaminants and eutrophication has not yet been agreed, while in the Black Sea, biodiversity related monitoring activities focus on plankton, benthos and fish.

3. Overview of the DEVOTES Catalogue of Monitoring Networks

The **DEVOTES Catalogue of Monitoring Networks** was produced under DEVOTES Task 1.2.1 and **Deliverable D1.3** (Patrício *et al.,* 2013). This is the first catalogue to provide an overall perspective to Member States on ongoing monitoring programmes and networks that can be used to assess the response of specific biodiversity components to managed and un-managed pressures in all Regional Seas at a range of spatial scales (subregion to subdivision to ecological assessment area). For a better understanding of the ecosystems from each regional sea, a comprehensive description can be seen in Annex 3. The focus of our analysis was on four MSFD descriptors, i.e. biological diversity (D1), non-indigenous species (D2), food-webs (D4), and seafloor integrity (D6). The structure and potential uses and value of the catalogue are described in detail in the **Deliverable D1.3.** (Patrício *et al*., 2013) and are summarized only briefly here.

The catalogue includes details of the legislative and geographic scope (at regional and subregional sea level) of each monitoring activity, together with details of the descriptors, biodiversity components, habitats and the pressures addressed. Associated information include the existence of related quality assurance (QA), programmes, and the availability of GIS data and the supporting parameters, as an indication of data quality. Thus, the **DEVOTES Catologue of Monitoring Networks** provides an essential resource to competent authorities in Member States and non-EU countries for identifying ongoing monitoring, research and datasets for ecologically important species and habitats.

The catalogue also provides an indication of whether the MSFD can already effectively be implemented in all regions and whether additional monitoring is required. Through this approach, the catalogue is of value in the development of comprehensive and coordinated monitoring networks throughout Europe. It

will therefore be of potential use to policy makers, government agencies and the regulatory bodies ultimately responsible for implementing the MSFD and ensuring that GEnS is achieved.

The information presented in the catalogue will enhance opportunities for data collation and sharing, coordination and harmonisation of monitoring programmes between Member States. Importantly, details of key contacts, data sources and timescales for data collection associated with each monitoring programme are contained within the catalogue. This will enable Member States to optimise their sampling by collating details of the spatial distribution, parameters and sampling frequency associated with existing monitoring, thus enabling optimal sampling design to complement (rather than replicate) existing monitoring efforts. Potentially, this could help to prevent duplication of sampling effort between nations and help Member States to coordinate their monitoring in terms of timing of their sampling, the parameters/data being collected and the geographical location, resulting in large, coordinated datasets for the subregions of each Regional Sea.

This coordinated approach can provide important information for Member States when establishing or recommending pressure—related monitoring strategies in their own waters (e.g. for the MSFD), by assessing whether the existing monitoring is fit for purpose, providing remedies to deficiencies, highlighting monitoring gaps, identifying elements that should be added to existing programmes and making recommendations for future monitoring. Ultimately, such coordinated monitoring will result in a better assessemnt of whether or not GEnS has been achieved at the Regional Sea level.

The current version of the catalogue (January 2014) considers the depth and breadth of marine monitoring of ten EU Member States (Bulgaria, Denmark, UK, France, Germany, Greece, Italy, Lithuania, Portugal and Spain) and three non-EU countries that share European Regional Seas boundaries (Norway, Turkey and Ukraine) (Figure 2). The information was gathered mainly by national research institutions that are partners in DEVOTES, often in collaboration with national authorities but not necessarily corresponding to the national official MSFD monitoring activities. In subsequent updates of the catalogue, additional EU Member States are expected to provide information regarding their monitoring activities.

The analysis of the meta-data provided by countries where the recorded monitoring programmes are based has revealed gaps in the geographic distribution of monitoring activities. However, the gaps should be interpreted carefully. They do not necessarily indicate lack of monitoring activities. At this stage, gaps in the monitoring should be interpreted as “missing data” rather than actual gaps. The Baltic Sea region is a good example of this constrain.

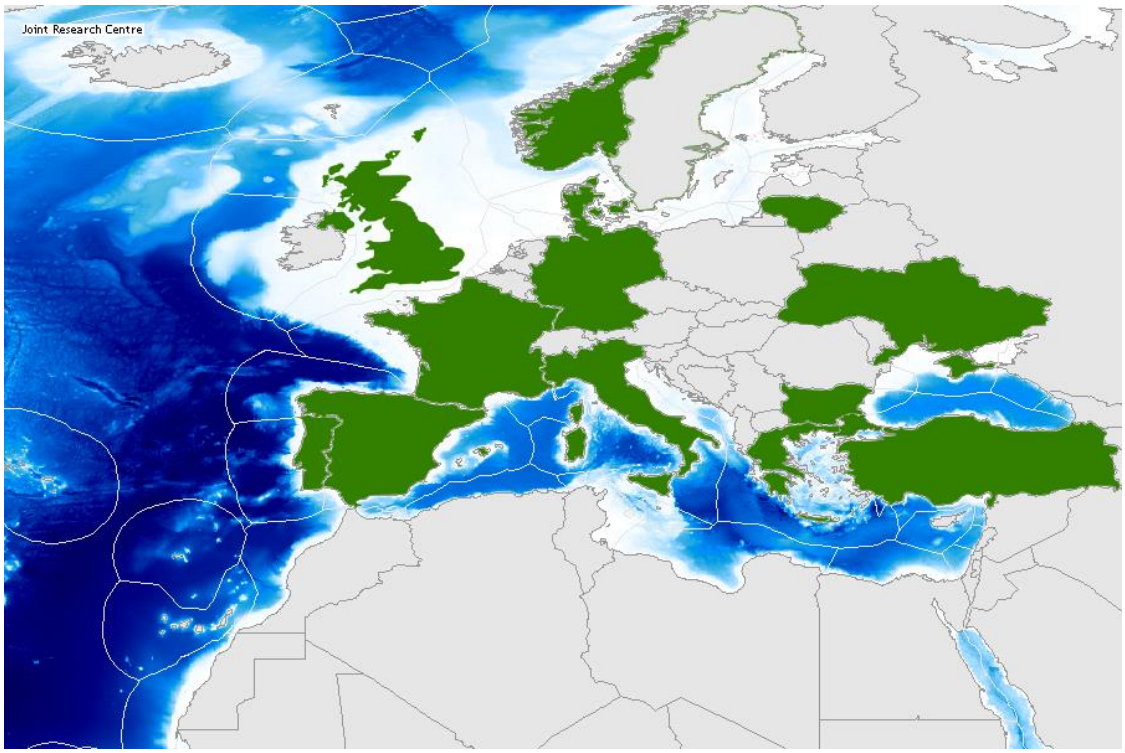


Figure 2. Countries that filled in the DEVOTES Catalogue of Monitoring Networks (green). (Figure taken and adapted from EMIS website: EMIS-EU-bathymetry-maritime boundaries-borders; http://emis.jrc.ec.europa.eu/4_1_gismap.php)

The catalogue is deliberately broad in scope and includes a very diverse set of programmes. This version has 775 entries and includes over 210 monitoring programmes. Several monitoring programmes include more than one monitoring activity that target distinct biodiversity components, and/or habitat types, and/or pressures, and /or marine regions, subregions or subdivisions.

The actual distribution of monitoring activity is not best represented by plotting the country carrying out the monitoring activity. Official marine region and subregion shapefiles for the MSFD are currently under development (by the Directorate-General for the Environment and the European Environment Agency) but are not yet available for external use due to the need to first formally recognise area boundaries.The marine region and subregion shapefiles which form the basis of the interactive pdf in this report (Annex 2) were therefore compiled using information from the OSPAR convention and FAO Major Fishing Areas. These shapefiles should therefore be used as general indicators of marine region and subregion spatial extent, but are not geo-referenced and should not be considered as official delineations of boundary extents (Figure 3).

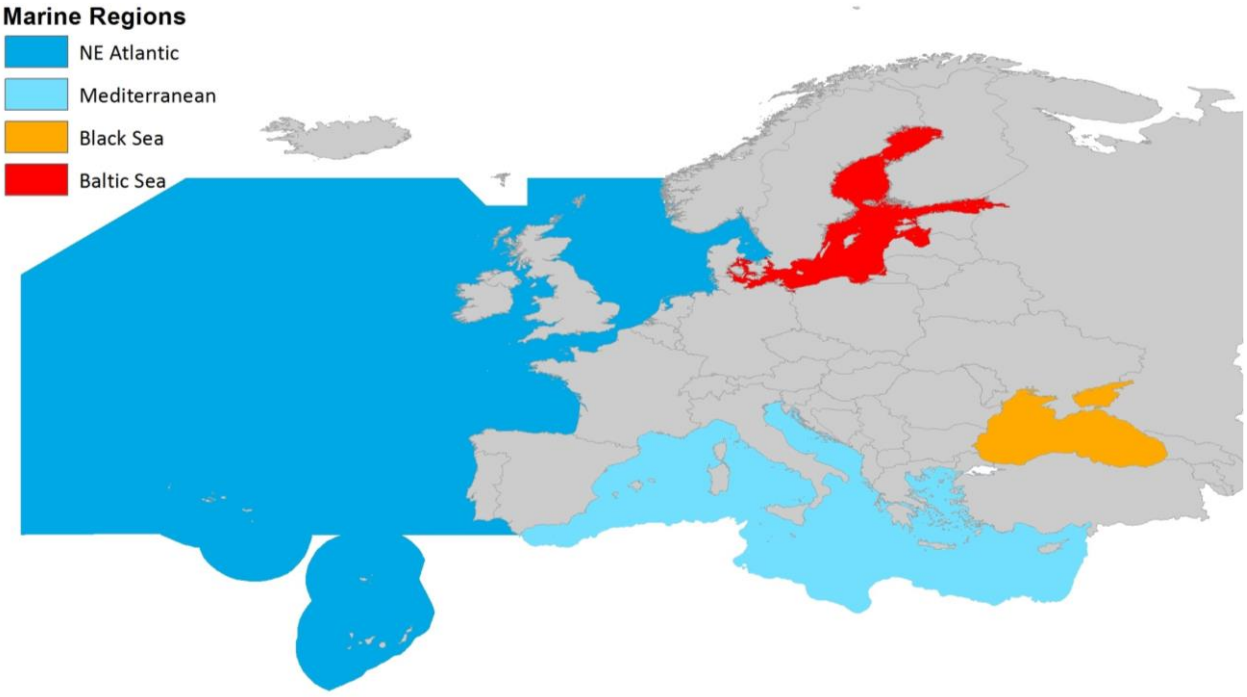


Figure 3. Marine regions used in the DEVOTES GIS-based interactive pdfs.

Concerning types of monitoring, in most countries, the prevailing one is *surveillance* (see Box 1 for definition). *Condition monitoring* represents only 13% of the reported activities (Figure 4A).

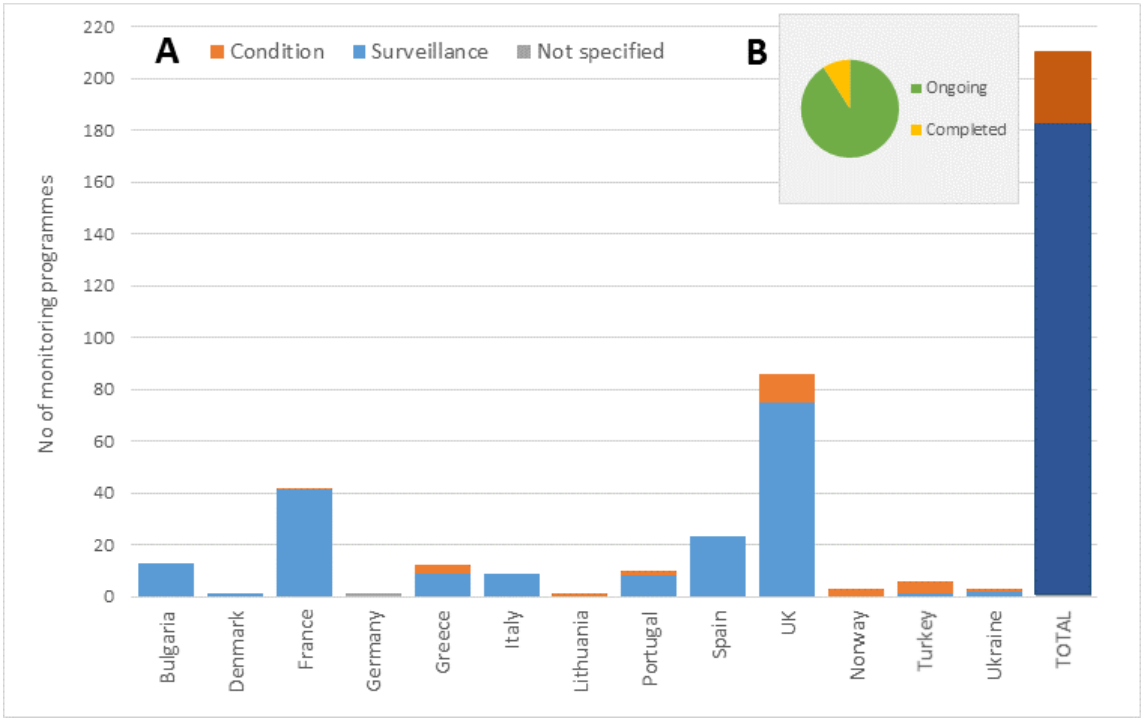


Figure 4. A. Number of monitoring programmes reported per country. Condition *vs* Surveillance and **B.** Percentage of ongoing *vs* completed monitoring programmes.

As expected from the guidelines for filling in the catalogue, the majority of the monitoring programmes reported are ongoing activities (Figure 4B). Althouhgt, the **DEVOTES Catalogue of Monitoring Networks** focus on ongoing programmes, 9% of the reported monitoring is completed, i.e. corresponds to activities that were carried out until but ceased in 2013.

According to the catalogue information, the UK has over 85 ongoing monitoring programmes that commenced prior to 1960. Bulgaria, Ukraine and France additionally reported monitoring programmes that have been in place since the 1960s. Spain and Greece have several ongoing monitoring programmes which commenced in the 1980s; whilst in Italy, Denmark, Lithuania and Portugal, a number of ongoing monitoring programmes commenced during the 1990s. Most of the monitoring activities reported in the catalogue commenced between the years 2000 and 2010 (Figure 5).

Throughout the catalogue, very different monitoring frequencies are reported, varying from minute to sub-hour, hourly, daily, weekly, twice a month, monthly, bi-monthly, 3-6 times a year, seasonally, 2/3 times a year, twice a year, annual, bi-annual, every 6 years, every 10 years to sporadic, depending on which biodiversity component is the target, the national and international environmental regulations and the budgetary constrains.

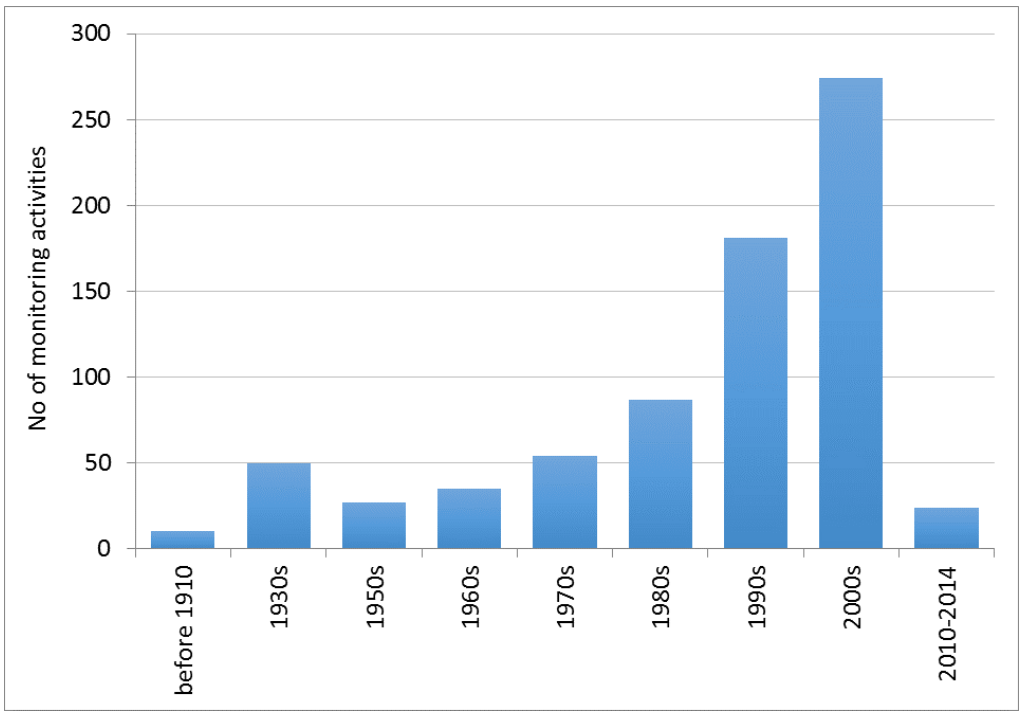


Figure 5. Histogram showing the decades when monitoring activities were started (considering the entire catalogue).

In addition to the specific scope of each monitoring activity, the majority of the actions are undertaken or used within broader programmes (Table 8).

Table 8. Scope of monitoring: list of entries collected from the DEVOTES Catalogue of Monitoring Networks.

International Conventions	Regional Sea Conventions	EU Directives	National Monitoring
AEWA – Agreement on the Conservation of African-Eurasian Migratory Waterbirds	HELCOM	MSFD – Marine Strategy Framework Directive (2008/56/EC)	PNAB (Portugal)
ASCOBANS - Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas	OSPAR	WFD – Water Framework Directive (2000/60/EC)	VMP (Denmark)
CBD -Convention on Biological Diversity	UNEP/MAP – United Nations Environment Programme/Mediterranean Action Plan for the Barcelona Convention	Habitats Directive (92/43/EEC)	RNN, RESOMAR, Code Minier and Code de l'Environnement (France)
IPA Adriatic Cross-Border Cooperation Programme	BSSAP - Black Sea Strategic Action Plan	Dangerous Substances Directive (67/548/EEC)	Biodiversity Action Plan, UK Marine Science Strategy, UK Wildlife and Countryside Act, GB Conservation of Seals Act, UK Biodiversity Action Plan for Cetaceans, Marine Act Scotland, Food and Environment Protection Act, SAP, London Convention (UK)
IWC - International Waterbird Census	BSIMAP – Black Sea Integrated Monitoring and Assessment Programme	Birds Directive (2009/147/EC)	SEPA, MAREM (Turkey)
CITES – Convention on International Trade in Endangerous Species of Wild Fauna and Flora		DCR – EU Data Collection Regulation	MEM - Programme for the Environmental Monitoring of the Black and Azov Seas (Ukraine)
ICES - International Council for the Exploration of the Sea		DCF - EU Data Collection Framework	
TMAP - Trilateral Monitoring and Assessment Programme		Nitrates Directive (91/676/EEC)	
		UWWTD - Urban Waste Water Treatment Directive (91/271/EEC)	
		CFP – Common Fisheries Policy	

This broader context includes International Conventions (e.g. Convention on Biological Diversity, International Council for the Exploration of the Sea, Convention on International Trade in Endangerous Species of Wild Fauna and Flora, IPA Adriatic Cross-Border Cooperation Programme), Regional Sea Conventions (e.g. HELCOM, OSPAR, UNEP/MAP, BSSAP, BSIMAP), EU Directives (e.g. MSFD, WFD, Habitats Directive, Birds Directive, Nitrates Directive, Common Fisheries Policy) and national monitoring (e.g. PNAB in Portugal, VMP in Denmark, RNN, RESOMAR, Code Minier in France, SEPA, MAREM in Turkey, MEM in Ukraine and Biodiversity Action Plan, Marine Science Strategy, Wildlife and Countryside Act, London Convention in the UK). The Continuous Plankton Recorder programme, coordinated by SAHFOS (Sir Alistair Hardy Foundation for Ocean Science) in Plymouth, has been monitoring using commercial plankton recorders since the 1940s and in some countries, e.g. the UK, will produce most of the data required for plankton. In addition, a few of the reported monitoring activities are undertaken within research programmes (e.g. MESH, MISTRALS and POPEX French research programmes).

The number of monitoring activities identified in all regions as suitable to address the GEnS of the MSFD descriptors (D1: biological diversity; D2: non-indigenous species; D4: food-webs; and D6: seafloor integrity) are represented in Figure 6A. Monitoring activities which address the descriptors biological diversity (D1) and food-webs (D4), are the most abundant. Although non-indigenous species (D2) and seafloor integrity (D6) descriptors are also covered these are addressed through a smaller number of monitoring programmes. In general, the monitoring programmes assess more than one descriptor simultaneously (for a detailed description per marine subregion see section 4 of this report).

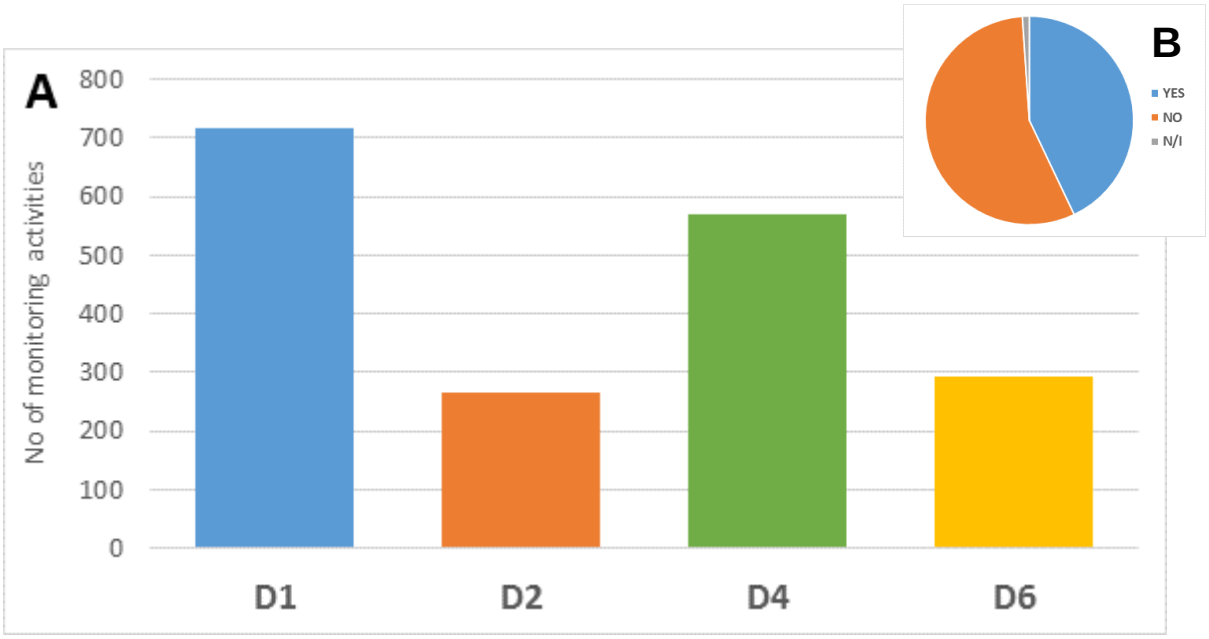


Figure 6. A. Number of monitoring activities per MSFD descriptor. D1: biological diversity; D2: non-indigenous species; D4: food-webs; and D6: seafloor integrity. **B.**Percentage of monitoring activities where supporting physicochemical data are collected.

In 43% of the ongoing monitoring activities, supporting physicochemical data are collected (Figure 6B). For more details regarding the list of parameters and/or physicochemical data measured, the measurement units and the list of associated biodiversity component/s please see the "*Param & physicochemical data*" worksheet of the catalogue (Annex 1). Inclusion of this information provides a broad indication of the level of detail and quality of a monitoring programme, providing information of the nature of the explanatory variables which may be linked to changes in environmental status. In addition, the information contained in these fields provide the opportunity to link the monitoring activities reported here to the "*Data requirements*" field of the **DEVOTES Catalogue of Indicators** (**Deliverable 3.1**, Teixeira *et al*., 2014, available in http://www.devotes-project.eu/deliverables-and-milestones/).

This link is useful in order to:

- Select, among the biodiversity indicators, those for which data are already being collected by ongoing programmes, thus optimizing human and financial resources.
- adjust the monitoring activities to better cover data requirements crucial to calculate the selected marine biodiversity indicators.

The catalogue provides information on the biodiversity components covered by the monitoring activities, including whether there is any quality assurance (Q/A) associated with the programme. Biodiversity components considered in the catalogue include microbes, phytoplankton, zooplankton, angiosperms, macroalgae, benthic invertebrates, fish, cephalopods, marine mammals, reptiles (i.e. sea-turtles) and birds. Benthic invertebrates and fish are targeted by many of the monitoring activities. Very few actions address microbes and cephalopods (Figure 7). Quality assurance (Q/A) protocols associated with the monitored biodiversity components vary per component, monitoring country and institute (for a detailed description per marine subregion see section 4 of this report).

The biodiversity component fish, cephalopods, marine mammals and birds are further divided into family or functional groups, which is broadly linked to differences in the associated sampling techniques. This level of detail allows differention between programmes which monitor one or more functional groups.

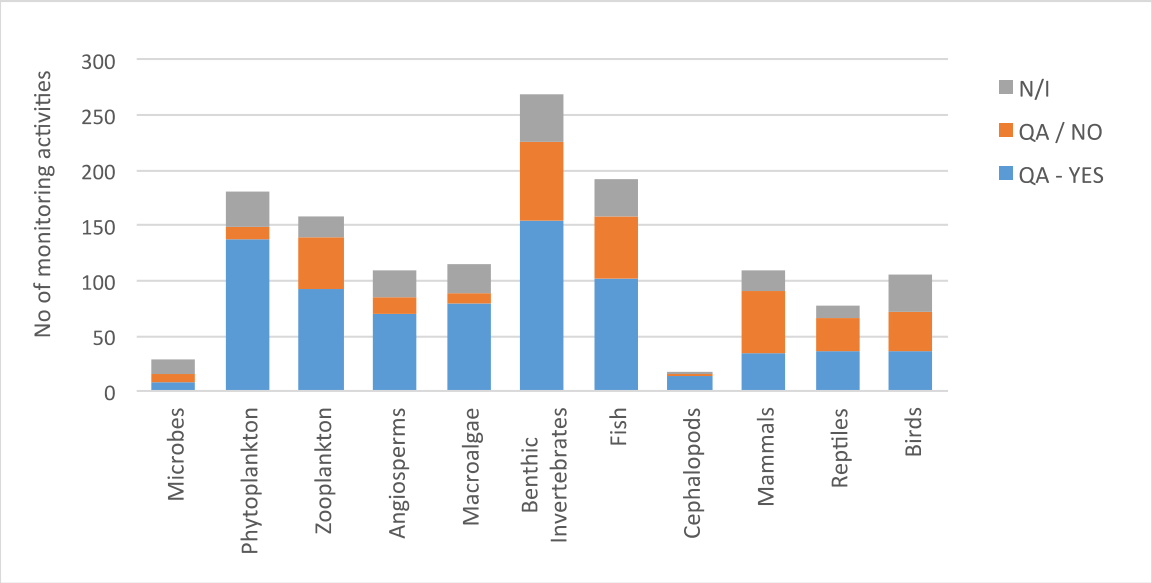


Figure 7. Number of monitoring activities per biodiversity component and if there is quality assurance (QA) associated with the programme. N/I: Not Identified.

The biodiversity component fish is divided into diadromous fish, coastal fish, pelagic fish, pelagic elasmobranchs, demersal fish, demersal elasmobranchs, deep-sea elasmobranchs, ice-associated fish and other (Figure 8). Across the European seas, most monitoring activities related with the biodiversity component fish target more than one family or functional group simultaneously (i.e. "Other"option).

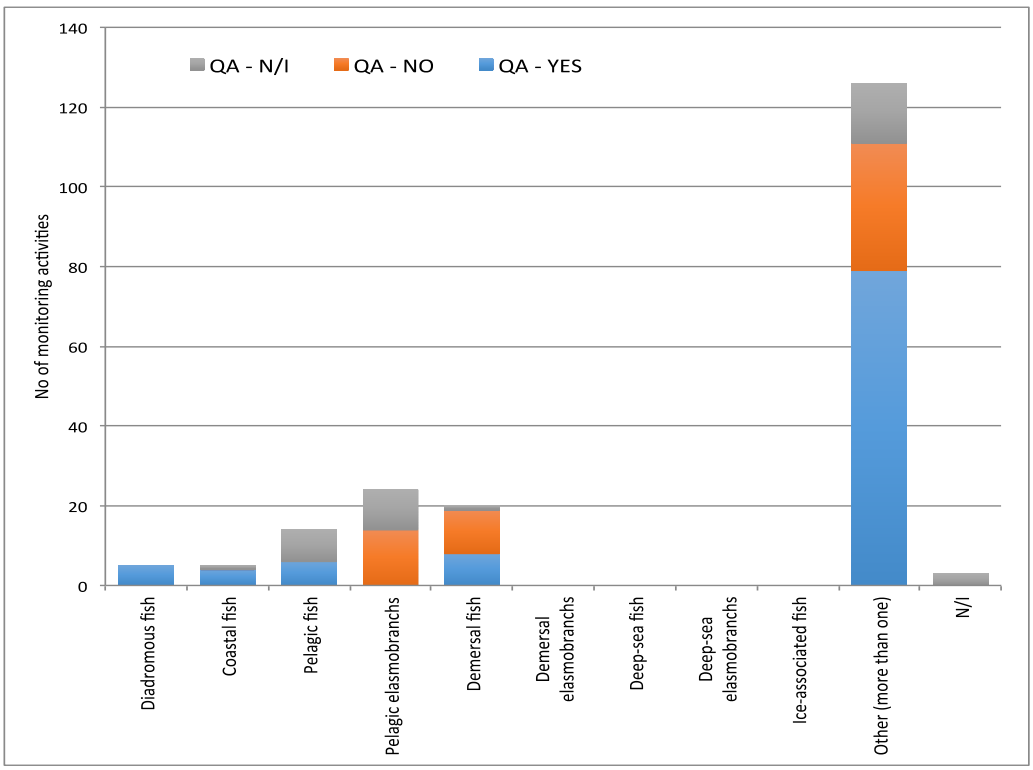


Figure 8. Number of monitoring activities related with different groups of fish showing those activities where there is quality qssurance (QA) and those where not. N/I: Not Identified.

The biodiversity component cephalopods is divided into two groups: coastal/shelf pelagic and deep-sea pelagic. According to the monitoring activities reported in the catalogue, few actions target this component (Figure 9). Although there are no activites exclusively dedicated to deep-sea pelagic cephalopods, Greece, Spain and Norway have ongoing activities that monitored simultaneously coastal/shelf and deep-sea cephalopods.

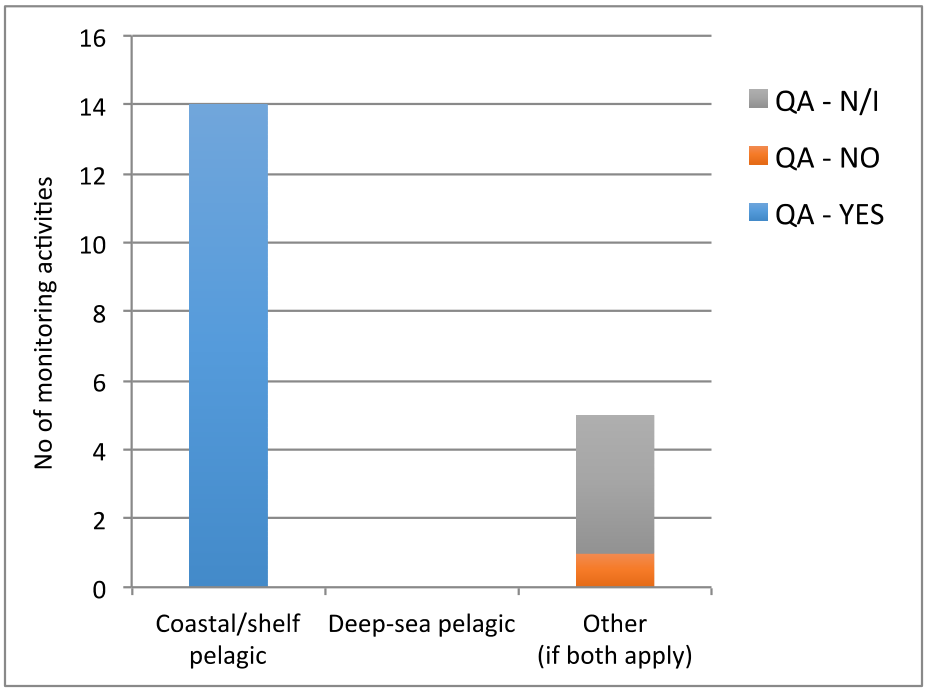


Figure 9. Number of monitoring activities related with different groups of cephalopods showing those activities where there is quality assurance (QA) and those where not.

The biodiversity component marine mammals is divided into toothed whales, baleen whales, seals, ice-associated mammals and "other" (i.e when more than one group is targeted and also other species are included). No activities related with ice-associated mammals are reported (Figure 10). Most monitoring activities target more than one group simultaneously (e.g. toothed whales, baleen whales and seals). Several activities also target porpoises and dolphins.

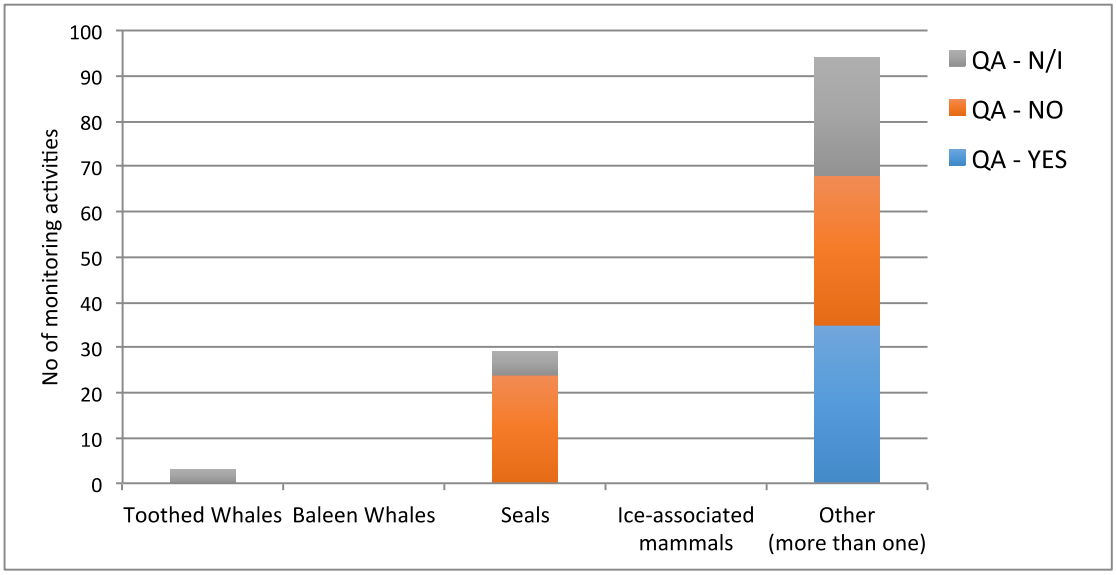


Figure 10. Number of monitoring activities related with different groups of marine mammals showing those activities where there is quality assurance (QA) and those where not.

The biodiversity component birds is divided into intertidal benthic-feeding, inshore surface-feeding, inshore pelagic-feeding, inshore benthic-feeding, offshore surface-feeding, offshore pelagic-feeding, Ice-associated birds and other (i.e. when more than one group is monitoried simultaneously). The majority of the activities monitoring more than one group and actions targeting ice-associated birds were not reported (Figure 11).

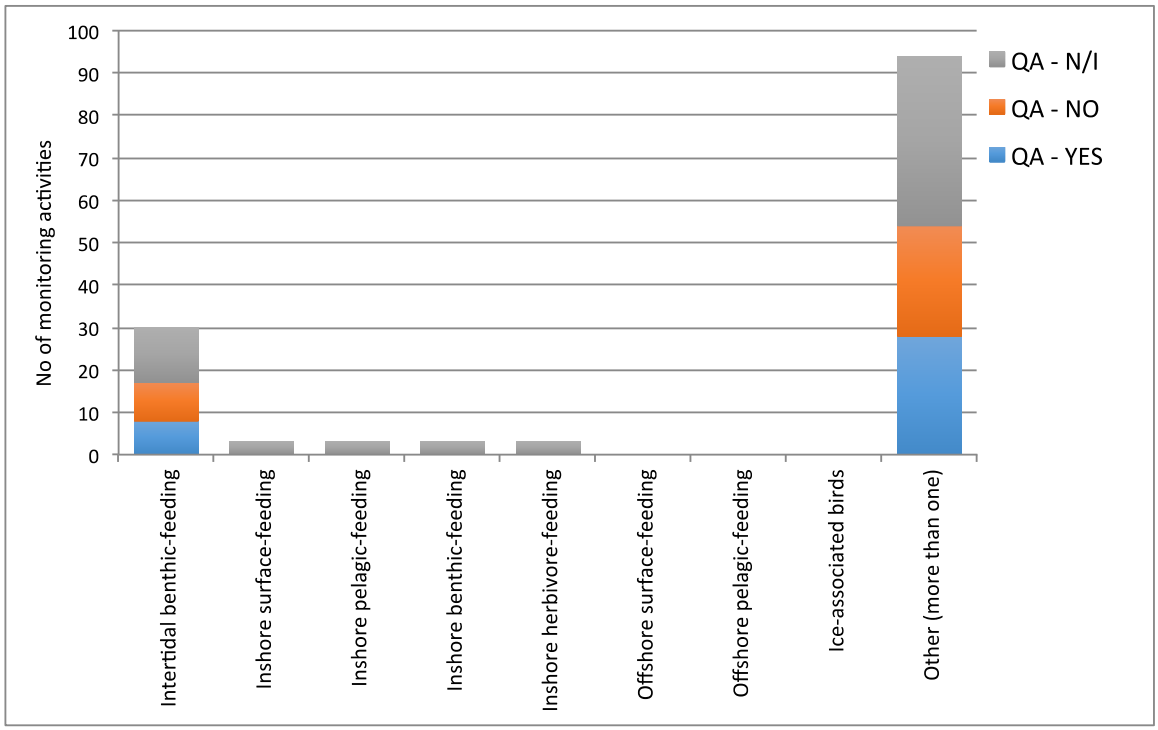


Figure 11. Number of monitoring activities related with different groups of Birds showing those activities where there is quality assurance (QA) and those where not.

The habitat types addressed in the catalogue include seabed, water column and ice habitats. None of the reported monitoring programmes assess ice habitats. The catalogue addresses 18 seabed habitat types: littoral rock and biogenic reef, littoral sediment, shallow sublittoral rock and biogenic reef, shallow sublittoral coarse sediment, shallow sublittoral sand, shallow sublittoral mud, shallow sublittoral mixed sediment, shelf sublittoral rock and biogenic reef, shelf sublittoral coarse sediment, shelf sublittoral sand, shelf sublittoral mud, shelf sublittoral mixed sediment, upper bathyal rock and biogenic reef, upper bathyal sediment, lower bathyal rock and biogenic reef, lower bathyal sediment, abyssal rock and biogenic reef, abyssal sediment and other (more than one habitat). From these, nine are not targeted in isolation by the reported monitoring activities (see Figure 12 for details), they are monitored together with other habitat types (i.e. accounted in the "other" category). Most of the ongoing programmes that identified the type of habitat monitored more than one seabed habitat.

The five water column habitats [i.e. marine water: oceanic, marine water: shelf, marine water: coastal, variable salinity (estuarine) water and reduced salinity water] are addressed by the monitoring programmes included in the report but not in all European marine subregions (for a comprehensive description per marine subregion see section 4 of this report). Most of the ongoing programmes that identified the type of habitat monitored more than one water column habitat.

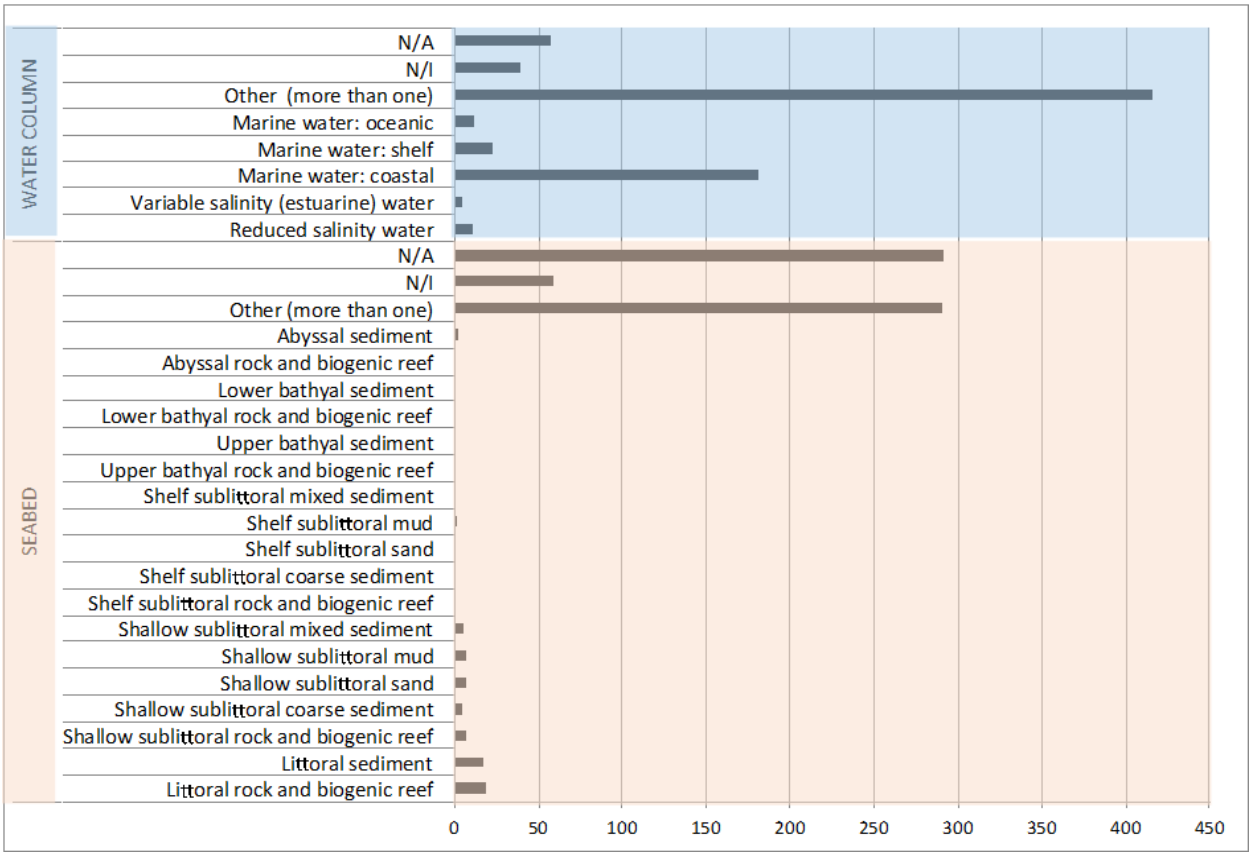


Figure 12. Number of monitoring activities per habitat type: seabed habitats and water column habitats.

The pressures (both local manageable and widespread unmanageable) addressed by the monitoring programmes are considered within the catalogue. The pressures list is consistent with that proposed by Koss *et al*. (2011) and includes 37 pressures (e.g. substratum loss, selective extraction of non-living resources, marine litter, introduction of synthetic compounds, etc.). Figure 13 shows the number of monitoring activities per pressure type, considering the overall content of the catalogue. Further details on what pressures are being monitored in each Regional Sea are described in section 4 of this report.

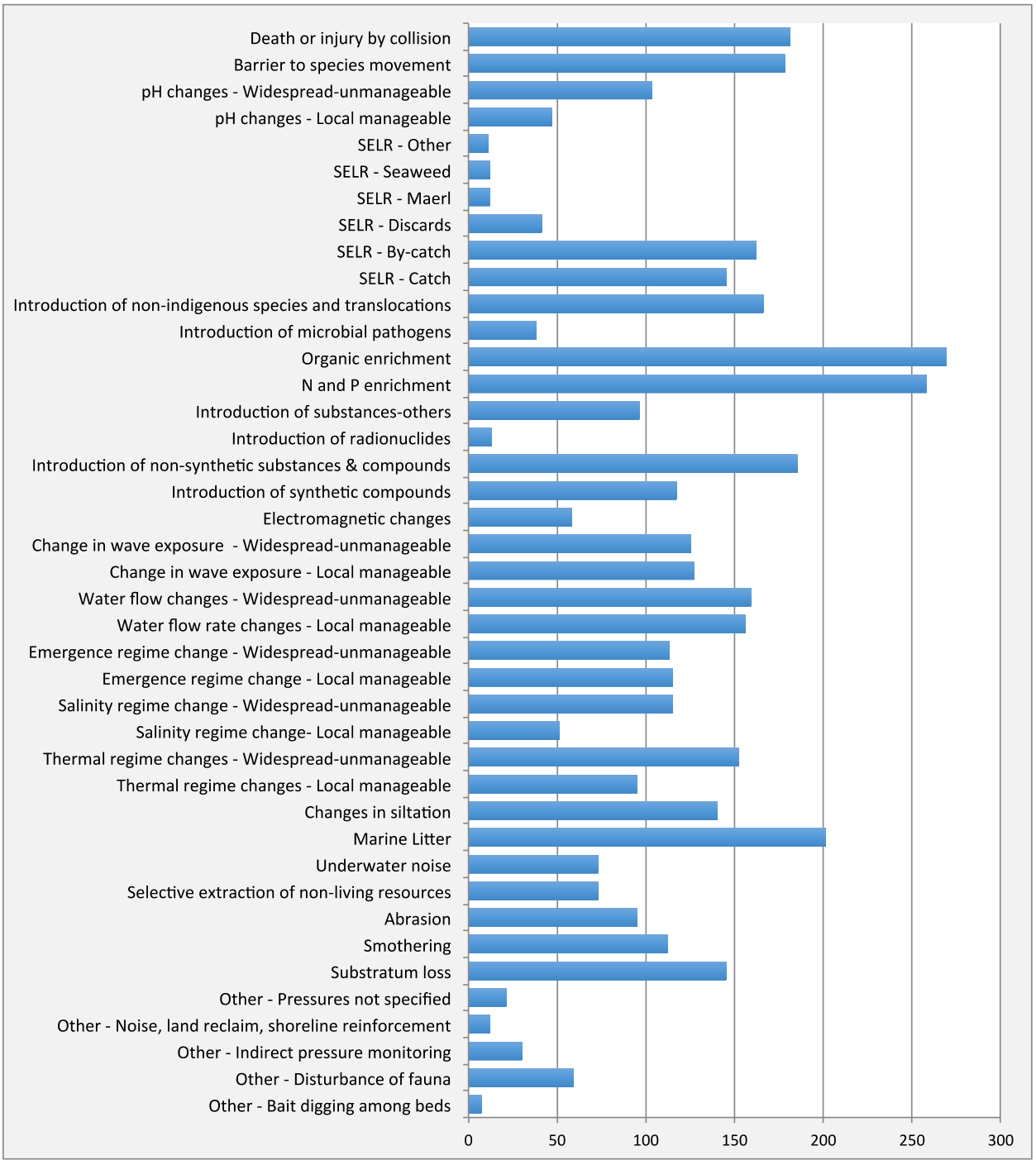


Figure 13. Number of monitoring activities per pressure type.

From the reported monitoring activities, 59% do not have GIS data available (Figure 14). In the 23% that have, the link to GIS data and the contact person responsible for GIS data is specified.

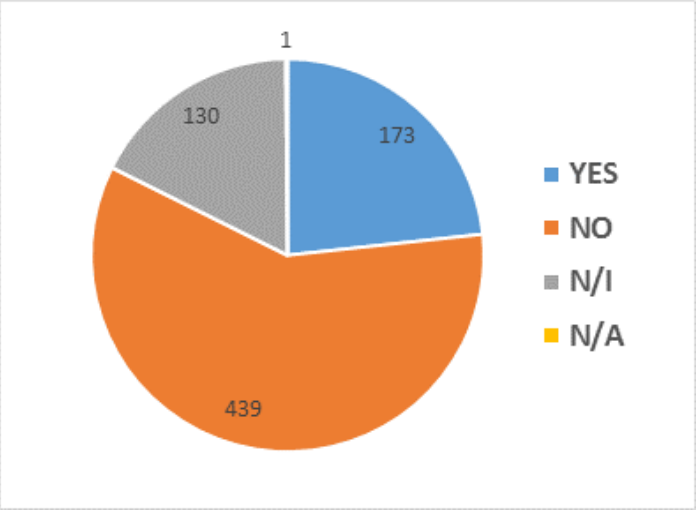


Figure 14. Number of monitoring activities that have GIS data available.

The **DEVOTES Catalogue of Monitoring Networks** is structured into three levels: monitoring programme level, monitoring networks level and web-platform level. The above summarises the content of the first level. The Monitoring Networks level of the catalogue includes information relating to collaborations between countries. This level aims to answer questions such as: are the monitoring programmes undertaken within a monitoring network of institutions? If so, what is the monitoring network name and what are the countries involved in that network? In the current version of the catalogue, 338 monitoring activities are undertaken within a network of institutions (Figure 15A).

In addition, most of those monitoring programmes provide data to international web platforms (e.g. MyOcean2, SeaDataNet, EMODnet, British Oceanographic Data Centre, CEDaR – Centre for Enviromental Data and Recording, NBN Gateway – National Biodiversity Network, DCR – Data Collection Regulation, DATRAS – ICES, JellyWatch, Si.Di.Mar., etc). Only 3% of the monitoring programmes take information from existing web platforms (Figure 15B).

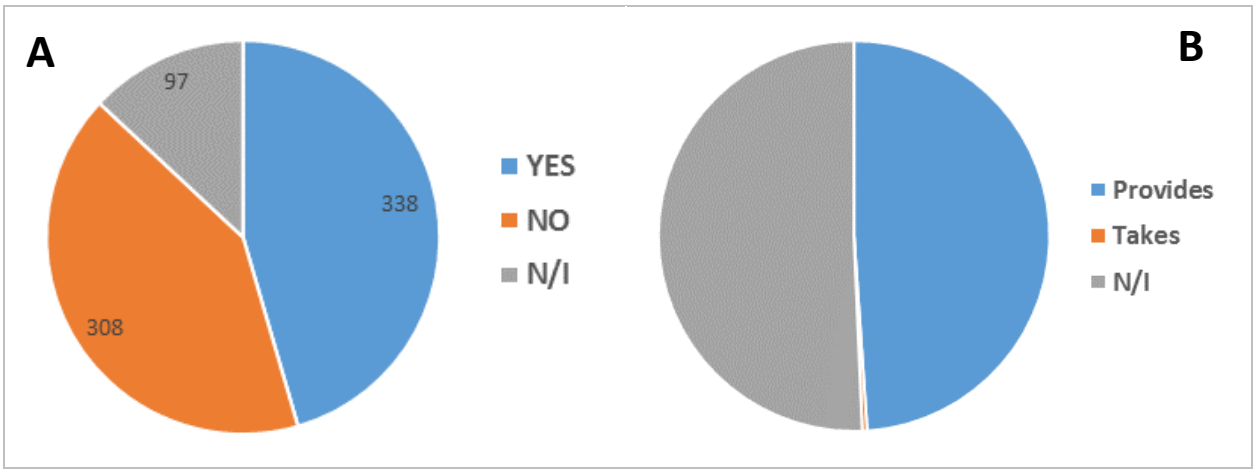


Figure 15. **A**. Number of monitoring activities that are undertaken within a monitoring network of institutions. **B.** Percentage of monitoring activities that provide or take information and/or data to/from any international web platform.

4. Gap and SWOT analysis per Regional Sea:

4.1. North Eastern Atlantic

4.1.1. Monitoring Networks - overview

The information of the **DEVOTES Catalogue of Monitoring Networks** (Annex 1) relating to the North Eastern Atlantic, upon which this analysis is based, has been categorised on the basis of the four subregions established in the MSFD into the North Eastern Atlantic marine region (Figure 16):

- The Greater North Sea, including the Kattegat, and the English Channel;
- The Celtic Seas;
- The Bay of Biscay and the Iberian Coast;
- The Macaronesian biogeographic region, being the waters surrounding the Azores, Madeira and the Canary Islands.

The monitoring catalogue includes a number of programmes which monitor outside of these listed subregions, and as such are classified as “Non EU”. Programmes listed in the catalogue that do not state the subregion within which monitoring occurs are classified as “Not specified” (N/I).

There are 141 ongoing monitoring programmes reported in the catalogue of monitoring networks for the North Eastern Atlantic region. The Celtic Seas subregion has the greatest number of monitoring programmes, followed by the Greater North Sea subregion (Figure 17 and Table 9). It is likely that more

monitoring programmes exist within the Macaronesian biographic region than those currently listed in the catalogue of monitoring networks. If that is the case, these programmes should be identified and added to the catalogue. This, in principle, indicates that monitoring activities exist within each subregion of the North East Atlantic and implies that implementation of the MSFD is feasible and likely to be successful in this region, assuming that the spatial and temporal scale of the monitoring is adequate and that the relevant biodiversity components and pressures are addressed.

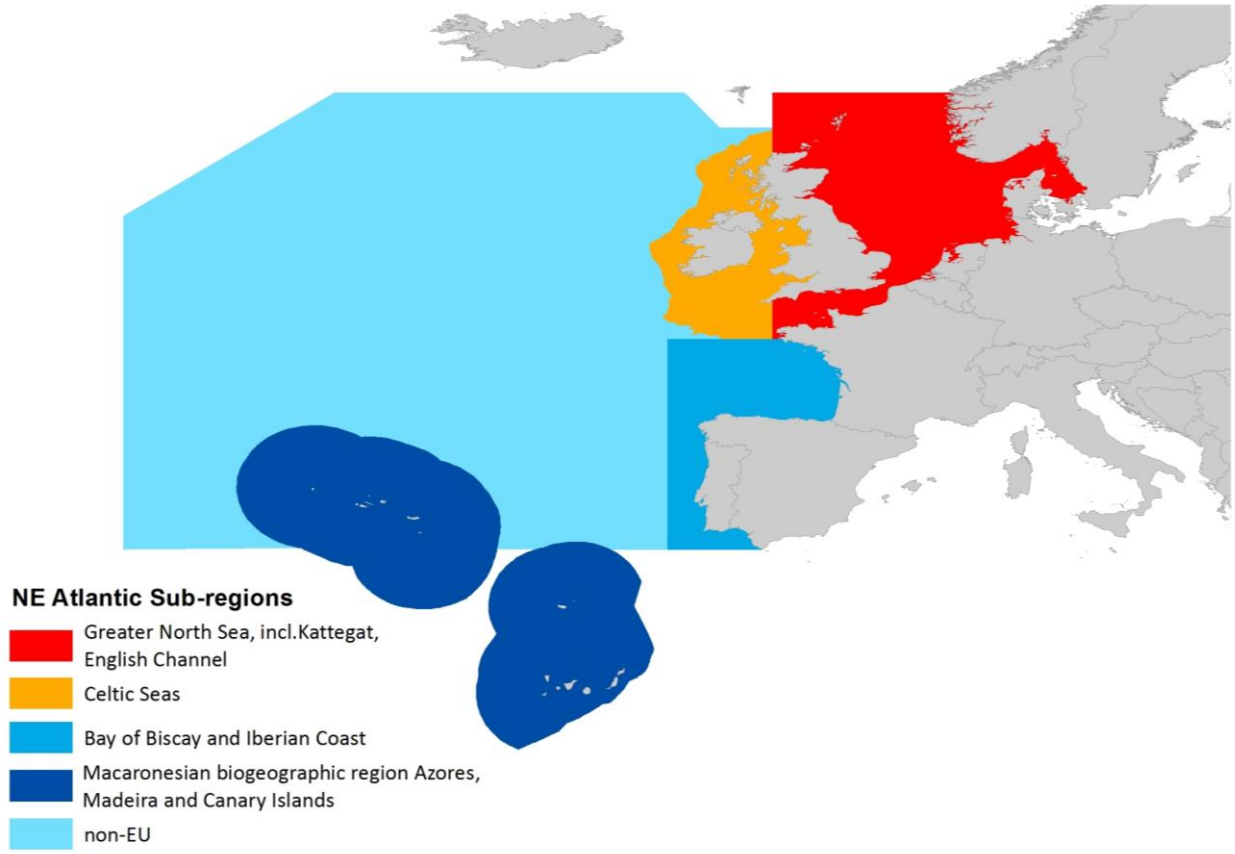


Figure 16. North Eastern Atlantic marine subregions used in the DEVOTES GIS-based interactive pdfs. The DEVOTES Catalogue of Monitoring Networks includes a number of monitoring programmes that are being conducted, in the context of OSPAR and ICES programmes, in other non-EU waters besides those represented in this figure (e.g. Faroe islands, the Norwegian Sea, the Barents Sea). Although these activities are being carried out in non-MSFD subregions, they are listed in the catalogue and were considered in the analysis.

The analysis described in the present section is based on current ongoing monitoring programmes that are relevant to the implementation of the MSFD. Three research programmes are reported in the catalogue for the Bay of Biscay and Iberian Coast subregions have been excluded from the SWOT analysis, as they have already been concluded (Figure 17).

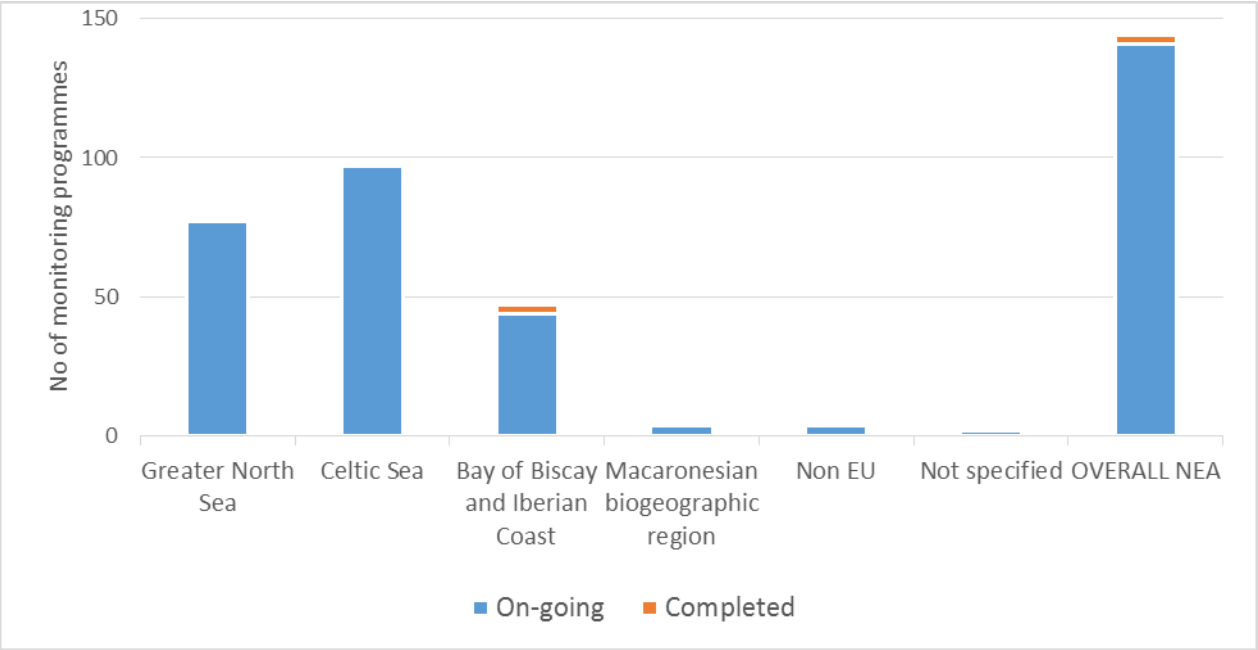


Figure 17. Number of ongoing and completed monitoring programmes in the North Eastern Atlantic (NEA) region and subregions.

Monitoring programmes classified as "Non EU" correspond to programmes undertaken in the Barents Sea and the Norwegian Sea, as well as well as two additional programmes undertaken in the wider area of the North Eastern Atlantic, which is not covered by the MSFD. These programmes correspond to the "Continuous Plankton Recorder" in the Va, Vb, Xb, XIIa, XIIc, XIVa, XIVb and XIIa ICES areas, and the "Atlantic Meridional Transect" in the XIIc, Xb and Xa ICES areas.

It should be noted that the total number of monitoring programmes in the North Eastern Atlantic cannot be a straightforward addition of the different monitoring programmes in each subregion/category, as a number of monitoring programmes are undertaken within several subregions.

The number of monitoring programmes identified in the North Eastern Atlantic region as suitable to address the GEnS of the MSFD descriptors (D1: biological diversity; D2: non-indigenous species; D4: food-webs; and D6: seafloor integrity) are represented in Figure 18. It is of note that the number of non-EU programmes is low compared to other regions and that this may be a function of the fact that most of the OSPAR contracting parties are EU Member States.

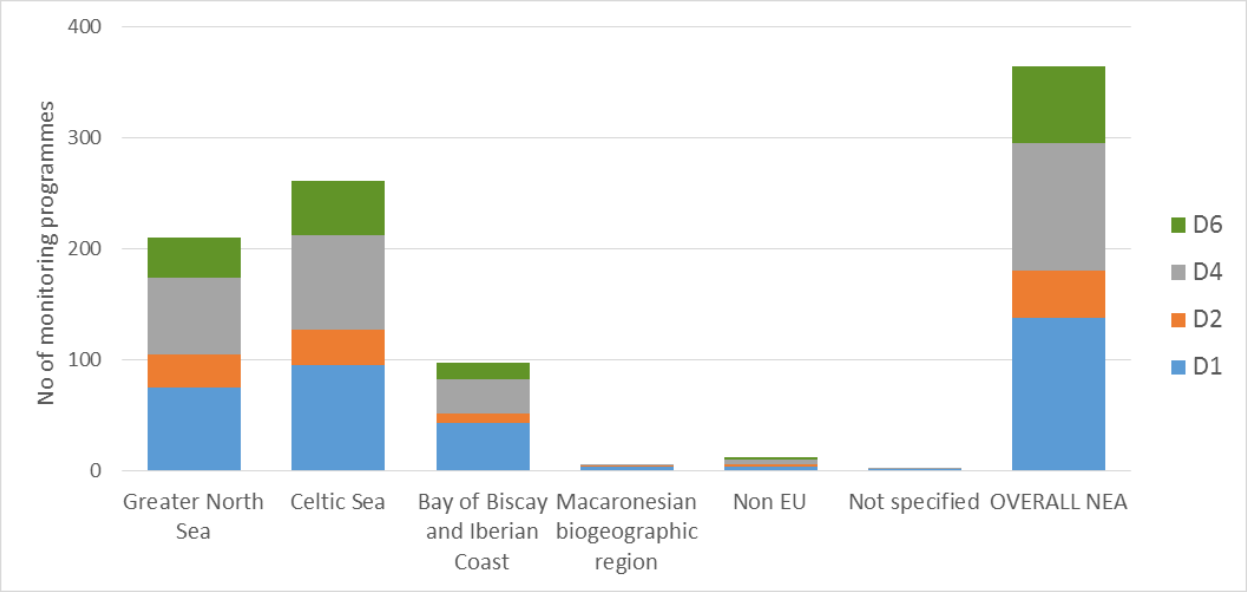


Figure 18. Number of ongoing monitoring programmes covering the D1, D2, D4 and D6 MSFD descriptors to achieve GEnS in the North Eastern Atlantic (NEA) region and subregions.

Monitoring programmes which address the descriptors biological diversity (D1) and food-webs (D4), are the most abundant in all subregions and, subsequently, the North Eastern Atlantic region as a whole. There are 138 and 115 monitoring programmes addressing addressing D1 and D4, respectively. Although non-indigenous species (D2) and seafloor integrity (D6) descriptors are also covered in the catalogue, these are addressed through a smaller number of monitoring programmes (Figure 18 and Table 9).

Table 9. Number of ongoing monitoring programmes in the North Eastern Atlantic region and subregions. MSFD: Marine Strategy Framework Directive; PQ: physicochemical; N/I: Not identified.

North Eastern Atlantic subregions	MSFD Descriptor				No of pressures	No of habitats		Biodiversity components											Supp. PQ		
	D1	D2	D4	D6		Seabed	Water	Mic	Phy	Zoo	Ang	MacAlg	Binv	Fish	Cep	Mam	Rep	Bir	Yes	No	N/I
Greater North Sea	75	30	69	36	37	12	4	3	17	15	11	12	33	22	3	17	9	17	33	43	1
Celtic Seas	95	32	86	48	37	17	5	2	15	14	15	14	46	33	1	16	10	10	47	50	0
Bay of Biscay and Iberian Coast	43	9	31	14	25	14	5	4	13	15	6	6	13	16	4	10	9	15	23	19	2
Macaronesian biogeographic region	4	1	1	0	11	0	3	0	1	1	1	1	1	1	1	2	2	3	2	2	0
Non-EU	4	2	4	2	10	0	3	1	4	4	0	0	2	0	2	2	0	2	4	0	0
Not Specified	2	0	1	0	8	0	3	0	2	1	0	0	0	0	0	0	0	0	1	1	0
OVERALL NEA	138	43	115	69	37	18	5	6	34	34	22	22	68	49	8	31	14	28	74	65	2

Within the North Eastern Atlantic region, monitoring programmes generally assess two or three of the relevant descriptors simultaneously (38% and 35% of the monitoring programmes, respectively), whilst a small number assess all four descriptors simultaneously (16%) or a single descriptor only (11%) (Annex 4). This pattern is similar in the Greater North Sea and Celtic Sea subregions, but in the Bay of Biscay and

Iberian Coast subregion the percentage of monitoring programmes that assess individual descriptors is greater (27%). In the Macaronesian biogeographic region two of the monitoring programmes recorded assess two of the considered descriptors simultaneously, and the remaining two programmes address individual descriptors.

The biodiversity components considered in the catalogue include microbes, phytoplankton, zooplankton, angiosperms, macroalgae, benthic invertebrates, fish, cephalopods, marine mammals, reptiles and birds, all of which are monitored throughout the North Eastern Atlantic, although to differing extents. Benthic invertebrates are included in many of the catalogued monitoring programmes, particularly in Greater North Sea and Celtic Seas subregions. A large number of monitoring programmes address the biodiversity components fish, phytoplankton and zooplankton within the North Eastern Atlantic subregions. In contrast, very few monitoring programmes address the biodiversity components microbes, cephalopods and reptiles at either the subregion or region level (Figure 19 and Table 9).

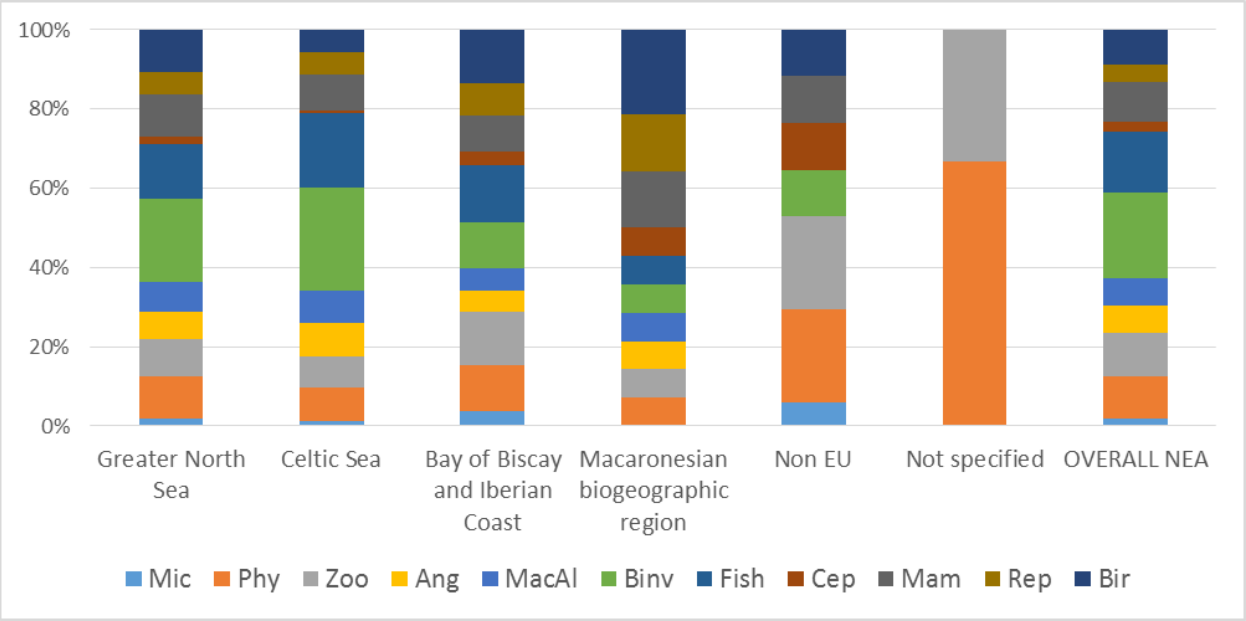


Figure 19. Percentage of ongoing monitoring programmes per biodiversity component in the North Eastern Atlantic region and subregions. Biodiversity components addressed include: microbes (Mic), phytoplankton (Phy), zooplankton (Zoo), angiosperms (Ang), macroalgae (MacAl), benthic invertebrates (Binv), fish, cephalopods (Cep), marine mammals (Mam), reptiles (Rep) and birds (Bir).

Of the monitoring programmes recorded in the North Eastern Atlantic, 47%, 23% and 13% simultaneously assess one, two or three, biodiversity components respectively. Details of this are presented for each subregion in Annex 4. An exception to this is the M@rBis (Marine Biodiversity Information System) monitoring programme, which simultaneously assesses eight biodiversity components in the subregions of the Bay of Biscay and Iberian Coast, and the Macaronesian biogeographic regions.

Quality assurance (QA) protocols associated with the monitored biodiversity components vary per component, monitoring country and institute. In the UK for example, the National Marine Biological Analytical Quality Control (NMBAQC) scheme is a national programme whereby members of the scheme are annually assessed. Other QA schemes may only apply to a single laboratory. Overall, Q/A is not associated with all of the monitored biodiversity components or this information has not been or cannot be provided. However, supporting physicochemical data are collected in association with the majority of the monitoring programmes (Figure 20 and Table 9).

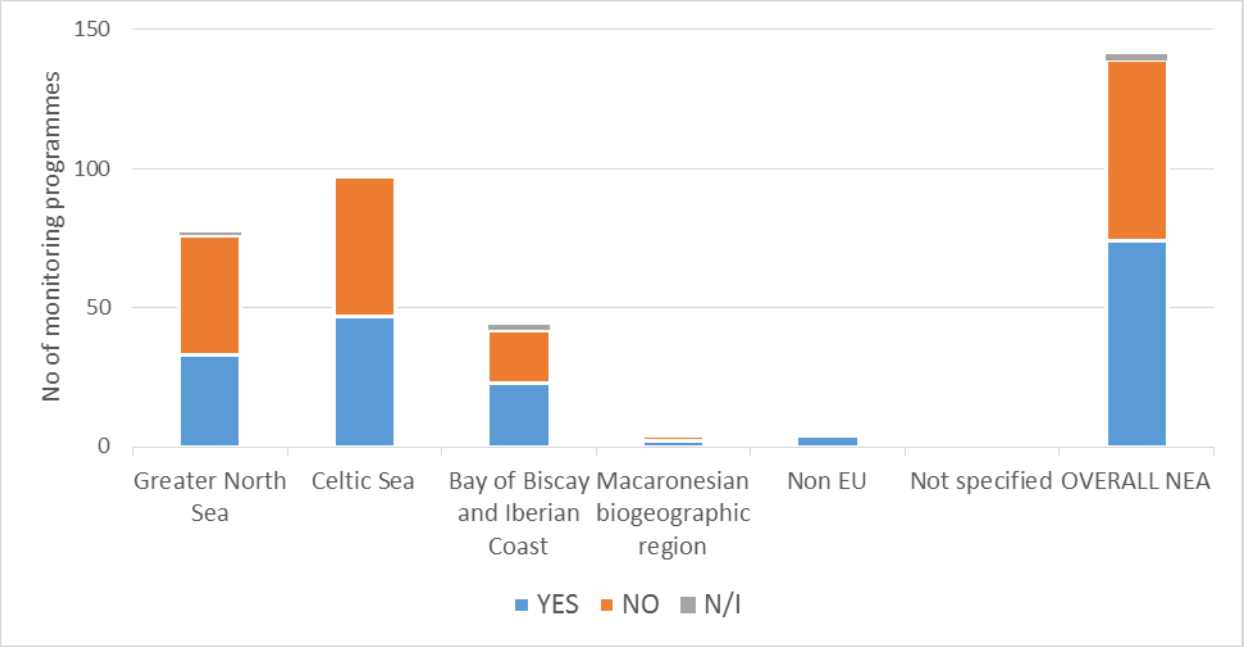


Figure 20. Number of ongoing monitoring programmes that collect supporting physicochemical parameters in the North Eastern Atlantic region and subregions. N/I: no information provided.

In the Greater North Sea and the Celtic Seas subregion all 37 listed pressures are addressed through monitoring programmes, while in the Bay of Biscay and Iberian Coast subregion 25 out of 37 are addressed, and in the Macaronesian biogeographic region only 11 out of 37 (Figure 21 and Table 10). Whereas some of the pressures best covered by the catalogued programmes include e.g. increase in siltation, selective extraction of living resources, organic matter enrichment, etc., other pressures (e.g.

selective extraction of mearl or seaweed, and introduction of radionuclides) are only covered by one or two of the monitoring programmes recorded in this catalogue.

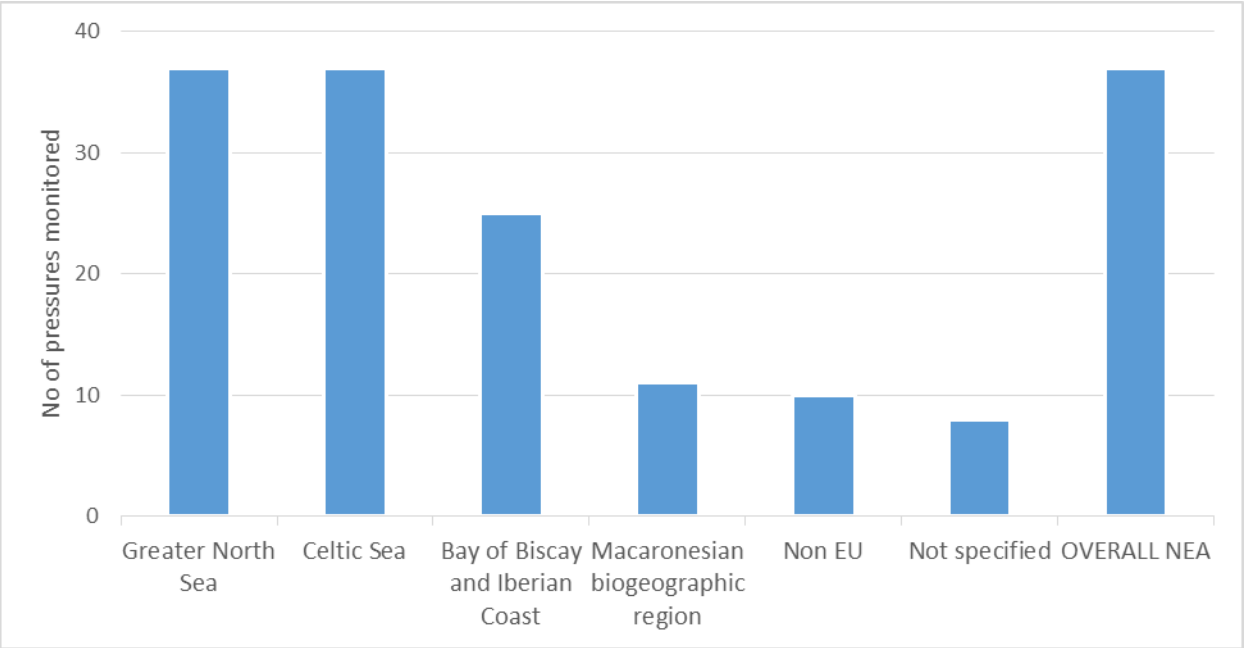


Figure 21. Number of different pressures monitored in the North Eastern Atlantic region and subregions.

Most monitoring programmes recorded for the North Eastern Atlantic, simultaneously assess four or fewer pressures (Table 10). However, there are three monitoring programmes in the Greater North Sea and Celtic Seas subregions (SAC and SPA Monitoring, Western Channel Observatory and Dove Marine Station Long Term Monitoring) that can assess up to 20 pressures simultaneously. Full details of the pressures monitored under each programme are presented in Annex 4, at the subregional sea level.

The habitat types addressed through the monitoring programmes include seabed, water column and ice habitats. For obvious reasons, ice habitats are not monitored throughout the entire North Eastern Atlantic marine region. The catalogue considers 18 seabed habitats, all of which are addressed within the North Eastern Atlantic (Figure 22 and Table 9), however not in all subregions (e.g., reported monitoring programmes throughout the Bay of Biscay and Iberian Coast subregion do not cover “upper bathyal rock and biogenic reef” or “upper bathyal sediment”).

Table 10. Summary table of the number of ongoing monitoring programmes per pressures catalogued for the North Eastern Atlantic region and subregions.

North Eastern Atlantic subregions	No of Monitoring Programmes	Substratum loss	Smothering	Abrasion	Selective extraction of non'living resources	Underwater noise	Marine Litter	Changes in siltation	Thermal regime change - LOCAL-manageable	Thermal regime change - WIDESPREAD-unmanageable	Salinity regime change - LOCAL-manageable	Salinity regime change - WIDESPREAD-unmanageable	Emergence regime change - LOCAL-manageable	Emergence regime change - WIDESPREAD-unmanageable	Water flow rate changes - LOCAL-manageable	Water flow rate changes - WIDESPREAD-unmanageable	Change in wave exposure - LOCAL-manageable	Change in wave exposure - WIDESPREAD-unmanageable	Electromagnetic changes	Introduction of synthetic compounds	Introduction of non-synthetic substances and compounds	Introduction of radionuclides	Introduction of substances - others	Nitrogen and phosphorous enrichment	Organic matter enrichment	Introduction of microbial pathogens	Introduction of non-indigenous species and translocations	Selective extraction of living resources (catch)	Selective extraction of living resources (by-catch)	Selective extraction of living resources (discards)	Selective extraction of living resources (maerl)	Selective extraction of living resources (seaweed)	Selective extraction of living resources (other)	ph changes - LOCAL-manageable	ph changes - WIDESPREAD-unmanageable	Barrier to species movement	Death or injury by collision	Other	No of pressures/monitoring programme (min/max)
Greater North Sea	77	17	12	11	10	8	27	15	10	13	4	6	13	13	14	15	14	14	5	14	19	2	13	26	26	4	17	16	17	4	2	2	1	5	8	18	19	16	1-20
Celtic Seas	97	22	22	18	14	11	28	26	14	17	8	10	19	19	21	22	19	19	8	16	20	1	14	29	31	4	24	30	16	3	1	1	1	9	13	22	24	11	1-20
Bay of Biscay and Iberian Coast	44	2	1	2	2	0	11	0	0	1	0	1	0	0	1	1	0	0	0	2	3	1	1	6	7	3	2	10	12	10	0	0	1	0	1	3	5	12	0-8
Macaronesian biogeographic Region	4	0	0	0	0	0	1	0	0	1	0	1	0	0	1	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0-8
OVERALL NEA	**141**	**26**	**24**	**21**	**16**	**11**	**43**	**28**	**15**	**18**	**8**	**10**	**20**	**20**	**23**	**24**	**20**	**20**	**8**	**21**	**29**	**2**	**17**	**36**	**39**	**5**	**27**	**43**	**26**	**12**	**2**	**2**	**1**	**10**	**14**	**24**	**26**	**16**	**0-20**

Similarly, the five water column habitats considered in the catalogue are all addressed in the North Eastern Atlantic region although "reduced salinity water" and "variable salinity (estuarine) water" habitats are only addressed in some subregions (i.e. Celtic Seas and Greater North Sea). This may be a function of the fact that partners were asked to include programmes which they felt were of relevance to the MSFD. Reduced and variable salinity habitats may have been excluded by some partners on the basis of their greater relevance to the WFD. Therefore, this apparent gap is unlikely to be reflective of a lack of monitoring in these habitats. Furthermore, and as indicated previously, inputs depended on those participating in the "development of the catalogue", providing more complete data information for certain areas.

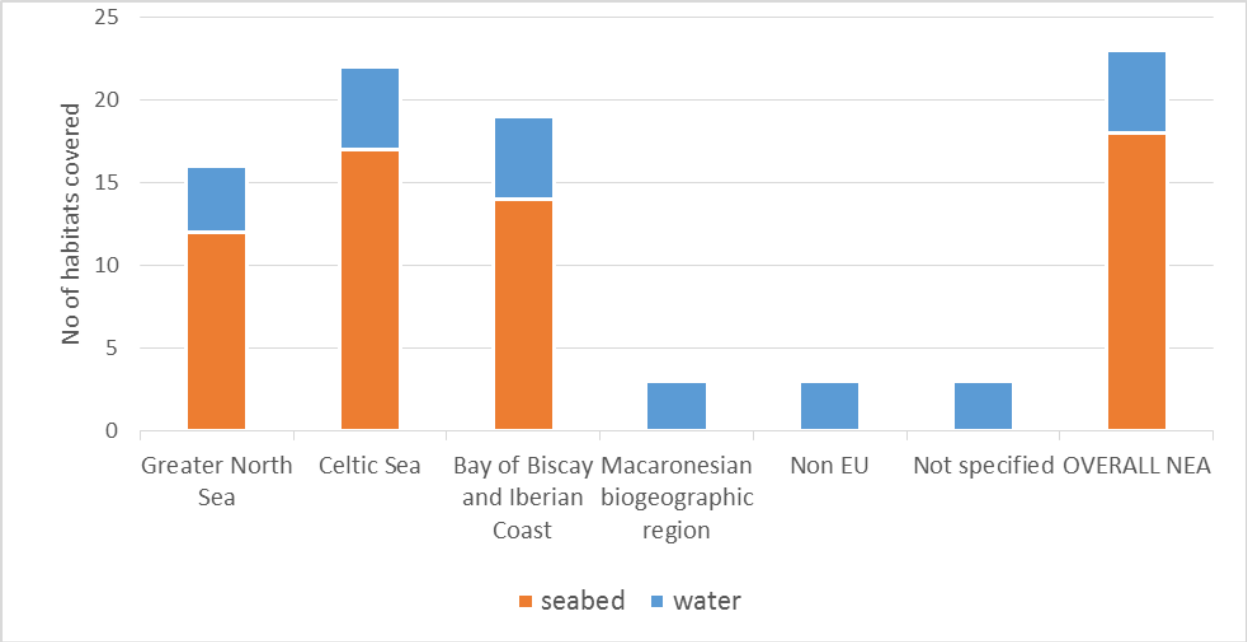


Figure 22. Number of different seabed habitats and water column types monitored in the North Eastern Atlantic region and subregions.

4.1.2. Identification of gaps

Regular OSPAR monitoring was initially established for the OSPAR thematic strategies Hazardous Substances and Eutrophication, followed by other pollutants. Monitoring for the thematic strategy 'Biodiversity and ecosystems' is more recent and still in development. In 2012-2013 the process of

reviewing and, when necessary, adjusting the OSPAR monitoring programmes has continued (OSPAR, 2013).

The current gap analysis is based on the results presented in the Monitoring Networks - overview section (4.1.1). Results suggest that monitoring undertaken in the northern subregions of the North Eastern Atlantic marine region may be more robust than monitoring undertaken in southern subregions (i.e. a greater number of monitoring programmes simultaneously addressing multiple pressures, descriptors and components). The results suggest that the Macaronesian biogeographic region and the wider Atlantic (offshore areas) may be poorly monitored.

Although all MSFD descriptors are monitored within the North Eastern Atlantic region, the **DEVOTES Catalogue of Monitoring Networks** does not currently include monitoring programmes for the descriptor seafloor integrity (D6) in the Macaronesian biogeographic region (Table 9). This may however be due to incomplete reporting as not all monitoring programmes for all subregions have been included. Nevertheless, it may also be an indication of poorer monitoring in this biographic region.

A small number of biodiversity components have limited coverage in the North Eastern Atlantic region. These include microbes, cephalopods and reptiles. It is however important to explore whether these existing monitoring programmes are sufficient or require further development. Considering there are also few indicators for these biodiversity components (**DEVOTES Deliverable 3.1**, Teixeira *et al.*, 2014), it is likely that a significant effort may be required to monitor these components once indicators are developed.

Despite extensive monitoring of the main pressures of the North Eastern Atlantic, there are pressures, which are not monitored in the Macaronesian biogeographic region or are in general poorly monitored (e.g. underwater noise and Introduction of radionuclides). Furthermore, as indicated in the **DEVOTES Deliverable 3.1.** (Teixeira *et al.,* 2014), there are few indicators developed for such pressures and, consequently, possibly less related monitoring. It is also worth noting that even where underwater noise is monitored, the impact of noise on many biodiversity components is not well understood and the outputs of such monitoring cannot be used effectively at the present time.

Monitoring of bathyal and abysal habitats is not undertaken in many subregions. The water column habitats are, in general, covered throughout the North Eastern Atlantic region.

Finally, it is of note that for a number of biodiversity components quality assurance is either non-existent (or unreported), which should be rectified in future monitoring programmes.While chemical

contaminants have been subjected to AQC/QA (Analytical Quality Control/Quality Assurance) since the 1970s, biological AQC/QA has only been used since the 1990s and even then only for the benthos and sediment particle size analysis (e.g. Gray and Elliott, 2009). A similar scheme for macroalgae is under development.

4.1.3. SWOT analysis – North Eastern Atlantic

Strengths S

- Almost all GEnS descriptors and biological components are addressed through monitoring programmes within the North Eastern Atlantic, although there is a high degree of spatial variability in where this monitoring occurs.
- A large number of monitoring programmes address GEnS Descriptors 1 and 4.
- All ongoing monitoring programmes simultaneously address more than one descriptor. This catalogue only focuses on the four biodiversity-related descriptors relevant to the MSFD; therefore, it is likely that the catalogued monitoring programmes will also be suitable to address more descriptors of the MSFD.
- The northern subregions of the North Eastern Atlantic have an extensive system of monitoring programmes (i.e. Greater North Sea and Celtic Seas).
- In general, the proportions of monitoring programmes for the different biological components are similar across the different subregions.
- A higher proportion of monitoring programmes address benthic invertebrates and fish.
- In contrast with other subregions, the proportions of monitoring programmes for birds, reptiles, and marine mammals are higher in the Macaronesia.
- The collection of physicochemical data in conjunction with biodiversity component monitoring is a common practice in monitoring programmes undertaken in the North Eastern Atlantic.
- Overall, monitoring programmes undertaken within the North Eastern Atlantic region address all pressures.

Weaknesses W

- The monitoring programmes undertaken within southern subregions of the North Eastern Atlantic (i.e. Bay of Biscay and Iberian Coast, and specially the Macaronesian biographic region) apparently are of limited number and scope (i.e. simultaneous monitoring) when compared to northern subregions (i.e. Greater North Sea and Celtic Seas). However, factors such as the geographic scope of these monitoring programmes and the sampling intensity is not known and it is entirely possible that a single, large scale programme may be equally adequate to numerous smaller scale programmes.
- Collating monitoring programme information at the subregion scale masks information about the spatial extent and distribution of monitoring within that subregion. Within each subregion of the North Eastern Atlantic, monitoring programmes address a specific focus (e.g. habitat, species, pressure, etc.), resulting in an uneven distribution of spatial monitoring stations/sites, sampling interval and frequency and monitored components. Coverage of monitored attributes (e.g. descriptors, biological components, habitats and pressures) may therefore be shown as addressed at a subregion level; however, in reality monitoring may only take place in a small number of specific subregion sub-sections.
- In the North Eastern Atlantic region the number of monitoring programmes that address Descriptors 2 and 6 are limited, compared to programmes which address Descriptors 1 and 4.
- In the Bay of Biscay and Iberian Coast subregion the proportion of monitoring programmes that assess descriptors individually is high (if compared with more northern subregions of the North Eastern Atlantic).

Strengths S

- Although these may be exceptions, some monitoring programmes assess 18-20 pressures at once, suggesting the potential for monitoring programmes to become more efficient.
- All five water column types are addressed within the monitoring programmes of the North Eastern Atlantic region.
- Overall, the monitoring programmes of the North Eastern Atlantic address a large number of the 18-listed seabed habitats.

Weaknesses W

- A number of monitoring programmes address single biological components. There is a need for monitoring programmes to become more efficient and robust, integrating several biological components through simultaneous monitoring.
- In all North Eastern Atlantic subregions a number of biological components are poorly monitored (e.g. cephalopods)
- Despite existing intensive efforts to monitor fish, there are no catalogued monitoring programmes that address this biological component in non-EU waters.
- A number of monitoring programmes have no or no reported quality assurance (QA) associated with the monitored biological components. This has implications for the standardisation (within and between institutes) of data collection techniques, laboratory analysis methods and data handling, treatment and presentation methods. There is therefore high potential for poor comparability between data sets where QA procedures are not in place.
- Overall, all pressures are assessed in the North Eastern Atlantic region. However, not all pressures are assessed in all subregions. It is important to identify whether this is due to the absence of that particular pressure or to a weakness of the monitoring programmes at subregion level.
- Although some implemented programmes have demonstrated capability to assess up to 20 pressures at once (out of 37), most programmes assess four or less pressures. Although the simultaneous monitoring of pressures may not be necessary for all monitoring programmes, there is a potential for them to become more efficient.
- There are no reported monitoring programmes covering seabed habitats in the Macaronesian biographic region.

Opportunities

- The Gap and SWOT analysis has highlighted a number of inadequacies in the monitoring currently being carried out in the North Eastern Atlantic. At a high level, this presents an opportunity to develop new monitoring programmes or to modify and expand existing ones. In particular, this exercise has pinpointed where those monitoring gaps are. This presents an opportunity to the Monitoring Agencies within the North Eastern Atlantic region and subregions to collaborate and to form collaborations with other Member States in order to develop harmonised monitoring programmes that maximise the use of the best available data.
- Opportunities for knowledge transfer on efficiency (e.g. monitoring programmes capable for simultaneously assessing many pressures at once) and specialized skills (e.g. marine mammals, birds and reptiles monitoring programmes from the Macaronesia).
- This catalogue indicates that several monitoring can simultaneously assess indicators from different descriptors, which provides an opportunity for monitoring programmes to widen their scope and improve integration of all monitoring programmes.
- Since most monitoring programmes have no or no reported quality assurance (QA) associated with the monitored biological components, there is an opportunity for defining and/or implementing commun QA protocols across the differing EU regional seas.
- The catalogue indicates which biological components, descriptors and pressures are currently addressed but does not indicate the adequacy of the associated monitoring. There is now an opportunity to investigate pressure-impact links, our ability to quantify them and implement this knowledge more effectively in the assessment of GEnS in the North Eastern Atlantic region and subregions.
- There is a general lack of monitoring associated with microbes in the context of MSFD but microbial quality of shellfish and bathing waters is routinely monitored. There is an opportunity to expand and adapt this monitoring.
- These opportunities form the basis of further research requirements.

Threats

- The most obvious and significant threat to monitoring includes budgetary constraints within the EU Member States concerned with the North Eastern Atlantic Region (e.g. several programmes have recently been cancelled).
- Each EU Member State within the North Eastern Atlantic region has a long history of monitoring which has been expanded, modified and developed over time. As a result of these developments, together with methodological differences between nations, integration and holistic assessment of the data (at a Regional Sea level) may be difficult.
- Furthermore, lack of quality assurance on monitoring programmes may hinder harmonization and comparability across the EU.
- Certain indicators, descriptors, pressures, habitats and even subregions have limited monitoring programmes; such gaps may be an important constrain in monitoring the advance towards achieving the GEnS.

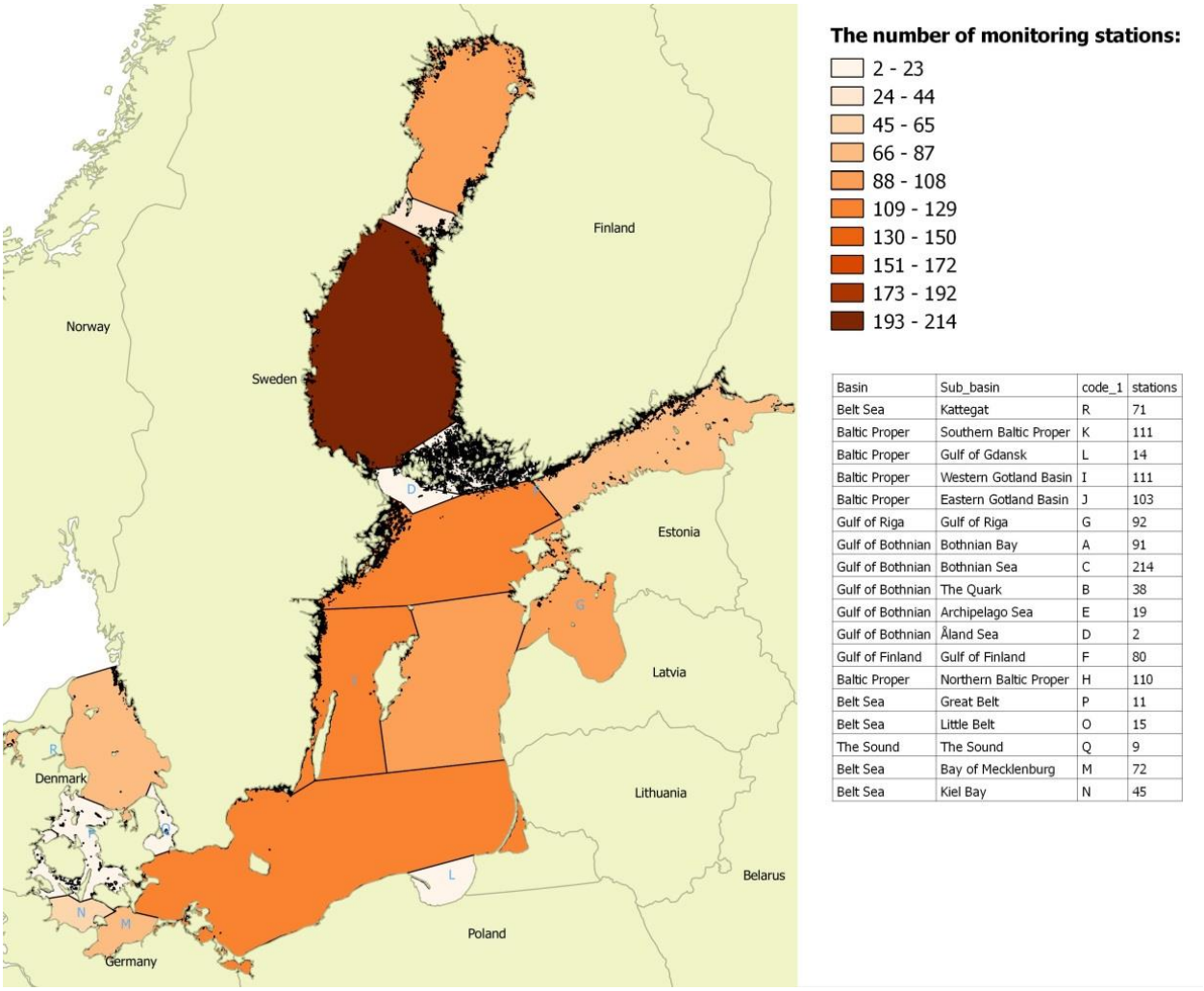
4.2. Baltic Sea

4.2.1. Monitoring Networks - overview

The Baltic Sea is one of the most intensively studied regional seas in the world; some continuous datasets date back to the early 1950s. Despite this, substantial gaps in marine monitoring still occur and some of the pressing issues are discussed below according to the monitoring information obtained during this project and analysis of current HELCOM monitoring programmes (HELCOM MORE, 2013). The Baltic Sea is surrounded by nine coastal countries: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. According to HELCOM the Baltic Sea area is divided into subregions or sub-basins (Figure 23). At least one national marine monitoring programme is ongoing in each Baltic country. National ongoing monitoring programmes of biodiversity components (related to D1, D2, D4 and D6 descriptors) have started differently in each country (e.g. in Lithuania it started since 1980s, while in Germany – since 2008).

Figure 23. The Baltic Sea region map with subregions (blue polygons).

Biological parameters are being monitored in all subregions (Figure 24), however the number of monitoring stations per subregion differs greatly: from two (e.g. Aland Sea) to 214 (i.e. Bothnian Sea), mostly due to the size of the subregion.



Basin	Sub_basin	code_1	stations
Belt Sea	Kattegat	R	71
Baltic Proper	Southern Baltic Proper	K	111
Baltic Proper	Gulf of Gdansk	L	14
Baltic Proper	Western Gotland Basin	I	111
Baltic Proper	Eastern Gotland Basin	J	103
Gulf of Riga	Gulf of Riga	G	92
Gulf of Bothnian	Bothnian Bay	A	91
Gulf of Bothnian	Bothnian Sea	C	214
Gulf of Bothnian	The Quark	B	38
Gulf of Bothnian	Archipelago Sea	E	19
Gulf of Bothnian	Åland Sea	D	2
Gulf of Finland	Gulf of Finland	F	80
Baltic Proper	Northern Baltic Proper	H	110
Belt Sea	Great Belt	P	11
Belt Sea	Little Belt	O	15
The Sound	The Sound	Q	9
Belt Sea	Bay of Mecklenburg	M	72
Belt Sea	Kiel Bay	N	45

Figure 24. Categorized (map) and exact (table) number of marine monitoring stations (where biological parameters are measured) per Baltic Sea subregion. Data source is HELCOM MORE (2013).

There is clear variation in the number of monitoring programmes of relevance to each of the MSFD descriptors. Biological diversity (D1), food webs (D4) and seafloor integrity (D6) descriptors are being monitored in almost all Baltic countries (Figure 25), whereas non-indigenous species (D2) are monitored only in Finland (Table 11).

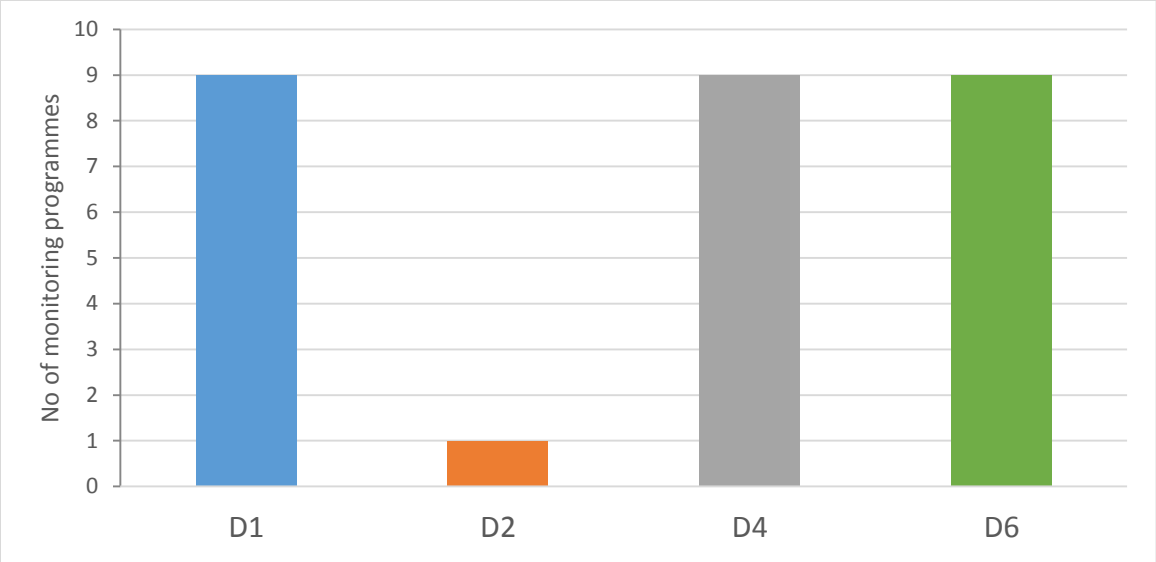


Figure 25. Number of ongoing programmes per MSFD descriptor (D1, D2, D4, D6) in the Baltic Sea, according to the monitoring data obtained during this project and analysis of current HELCOM monitoring data (HELCOM MORE, 2013).

Differences in the number of ongoing programmes are found also among the biodiversity components (Figure 26 and Table 11). Cephalopods and reptiles are not found in the Baltic, therefore there are no special programmes for them. There are only two programmes for microbes; such low number is most likely due to lack of information reported from member countries. Other biodiversity components (i.e. phytoplankton, zooplankton, angiosperms, macroalgae, benthic invertebrates, fish and birds) are being monitored in all Baltic countries, except marine mammals in Estonia, Latvia, Poland and Russia. Relatively small populations or solitary individuals of seals are being reported in these countries, therefore there is no need of monitoring programmes there. Angiosperms are not found in the exposed coast of Lithuania, therefore they are not monitored either. Monitoring data of phytoplankton and zooplankton is absent in the relatively smaller sub-basins of the Baltic Sea (i.e. The Quark and Little Belt).

All biodiversity components listed in the catalogue are associated with quality assurance (QA) protocols, except microbes (in Lithuania) (Table 11).

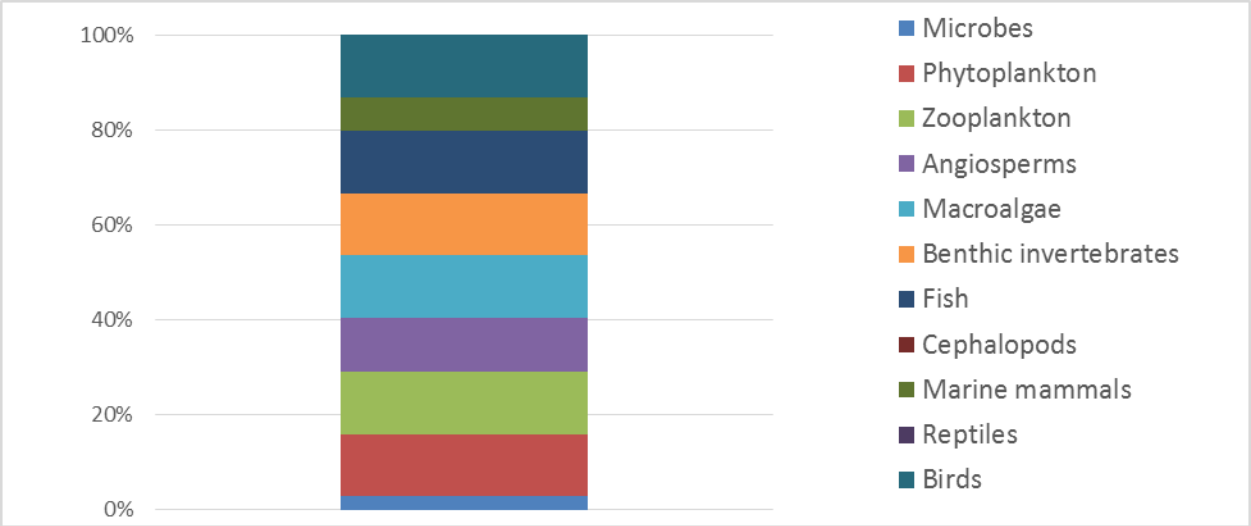


Figure 26. Percentage of monitoring programmes per biodiversity component in the Baltic Sea, according to the monitoring data obtained during this project and analysis of current HELCOM monitoring data (HELCOM MORE, 2013).

Quality assurance protocols associated with the monitored biodiversity components vary per component, monitoring country and research institute, although there is a general guidance proposed by HELCOM COMBINE Programme. It seems that QA of phytoplankton is the most developed. In 1991 HELCOM PEG was established with the main aim to unify methods of collection, counting and identification of phytoplankton species. Other QA schemes, may only apply to a single laboratory. Overall, quality assurance is not associated with all of the monitored biodiversity components, or this information has not been or cannot be provided.

There are nine ongoing monitoring programmes that collect supporting physicochemical parameters (Table 11). The main supporting physical-chemical parameters of the marine environment, including temperature, salinity, waves, currents, turbidity, nutrients, dissolved oxygen, pH, carbon, Chlorophyll a and contaminants, are used for the interpretation of biological data. However, frequency and location of measurements of physical-chemical parameters is generally not sufficient for most biodiversity components. For example, according to HELCOM monitoring data (HELCOM MORE, 2013) out of 270 phytoplankton monitoring stations there are only 101 stations, where additional parameters (including hydrography and water chemistry) are being measured. A similar pattern is found for other biodiversity components: zooplankton – 35 out of 142, zoobenthos – 114/1490, phytobenthos – 133/827, fishes – 19/139, sea birds – 10/48, marine mammals – 10/17.

In total, 16 pressures are covered through monitoring programmes in the Baltic Sea: substratum loss, changes in siltation, thermal regime change (widespread-unmanageable - wu), salinity regime change (wu), emergence regime change (wu), change in wave exposure (wu), introduction of synthetic compounds, introduction of non-synthetic substances and compounds, introduction of radionuclides, introduction of substances - other, nitrogen and phosphorus enrichment, organic matter enrichment, introduction of non-indigenous species and translocations, selective extraction of living resources (active removal of target and non-target species), ph changes (wu), other (Figure 27 and Table 11).

There are thirteen pressures being covered in the southern Baltic proper (mostly of them belong to Lithuania) whereas pressures in other subregions range from five to seven. These results should be consider with caution because most probably the huge difference can explained by the detail of information presented by Lithuania, whereas the data from other subregions were taken from HELCOM (2010). Nutrient inputs and different methods of fishing—pressures causing eutrophication and a decline of biodiversity—were rated the top pressures in all subregions. Despite decreasing during recent decades, inputs of heavy metals are still an issue of concern in all basins. The following concerns should also be highlighted: (1) hunting of seals is an issue in the Bothnian Bay, the Åland and Archipelago Seas, and the Belt Sea, (2) underwater noise from shipping is an issue in the Northern Baltic Proper, the Arkona Basin, Kiel Bight and Mecklenburg Bight, and (3) bottom trawling, including its physical disturbance impact, is a significant issue in the Kattegat, Belt Sea, Kiel Bight, Mecklenburg Bight, Arkona Basin and Bornholm Basin.

Nine different seabed habitats are included within the Baltic Sea monitoring programmes reported (Figure 28 and Table 11): shallow sublittoral rock and biogenic reef, shallow sublittoral coarse sediment, shallow sublittoral sand, shallow sublittoral mud, shallow sublittoral mixed sediment, shelf sublittoral coarse sediment, shelf sublittoral sand, shelf sublittoral mud, shelf sublittoral mixed sediment. Shallow water habitats such as littoral rock and biogenic reef, littoral sediment are not monitored due to reduced littoral zone in the major subregions of the Baltic Sea. Other habitats are not monitored since they are rare or not found at all (e.g. shelf sublittoral rock and biogenic reef).

There are three water habitats monitored in the Baltic Sea (Figure 28 and Table A): variable salinity (estuarine) water, marine water: coastal and marine water: shelf. The reduced salinity water could be found only in the Bothnian Bay.

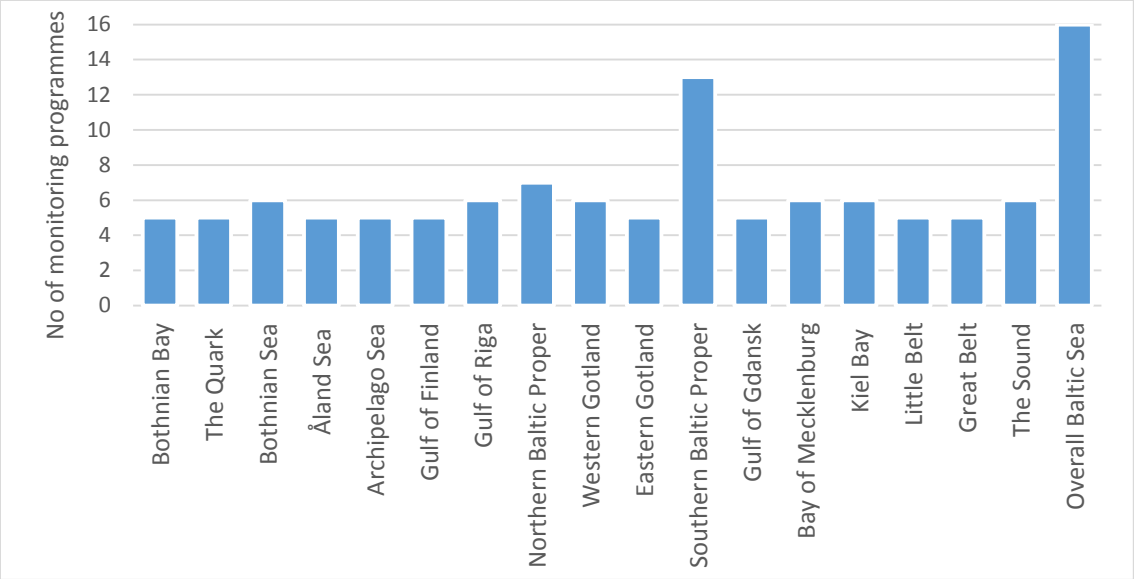


Figure 27. Number of different pressures monitored in each subregion and Baltic Sea region, according to the monitoring data obtained during this project and analysis of current HELCOM monitoring data (HELCOM MORE, 2013).

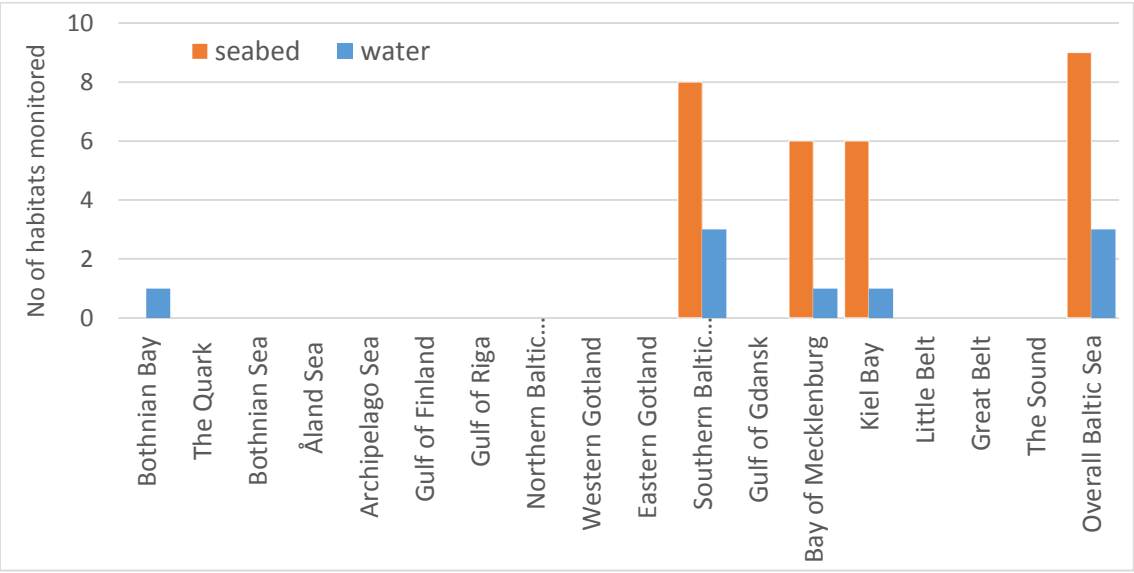


Figure 28. Number of seabed and water habitats monitored in each subregion and Baltic Sea region, according to the monitoring data obtained during this project and analysis of current HELCOM monitoring data (HELCOM MORE, 2013).

In the **DEVOTES Catalogue of Monitoring Networks**, there are no programmes which are being used to assess simultaneously all different biodiversity components/descriptors/pressures/habitats/water column (Table 11). The current version of the catalogue includes solely the Lithuanian and German monitoring programmes. In these two countries, the programmes cover almost all categories.

Table 11. Summary of the information about the ongoing monitoring programmes per marine subregions and entire Baltic Sea region according to MSFD descriptors, biodiversity components, supporting physicochemical (PQ), and number of pressures and habitats covered. Phyto: phytoplankton; Zoo: Zooplankton; Angio: angiosperms; MAlg: macroalgae; BInv: benthic invertebrates; Ceph: cephalopods; Mam: sea mammals; Rep: reptiles. According to the monitoring data obtained during this project and analysis of current HELCOM monitoring data (HELCOM MORE, 2013).

Baltic Sea subregions	MSFD Descriptor				No of pressures	No of habitats		Biodiversity components											Supp. PQ	
	D1	D2	D4	D6		Seabed	Water	Mic	Phy	Zoo	Ang	MacAlg	Binv	Fish	Cep	Mam	Rep	Bir	Yes	No
Bothnian Bay	2	1	2	1	5	0	1	0	2	2	2	2	2	2	0	2	0	2	2	0
The Quark	2	1	2	1	5	0	0	0	0	2	2	2	2	2	0	2	0	2	2	0
Bothnian Sea	2	1	2	1	6	0	0	0	2	2	2	2	2	2	0	2	0	2	2	0
Åland Sea	1	0	1	1	5	0	0	0	1	1	1	1	1	1	0	1	0	1	1	0
Archipelago Sea	1	1	1	1	5	0	0	0	1	1	1	1	1	1	0	1	0	1	1	0
Gulf of Finland	2	1	2	1	5	0	0	0	2	2	2	2	2	2	0	2	0	2	2	0
Gulf of Riga	2	0	2	1	6	0	0	0	2	2	2	2	2	2	0	2	0	2	2	0
Northern Baltic Proper	4	0	4	1	7	0	0	0	4	4	4	4	4	4	0	4	0	4	4	0
Western Gotland	1	0	1	1	6	0	0	0	1	1	1	1	1	1	0	1	0	1	1	0
Eastern Gotland	2	0	2	1	5	0	0	0	2	2	2	2	2	2	0	2	0	2	2	0
Southern Baltic Proper	5	0	5	1	13	8	3	1	5	5	5	5	5	5	0	5	0	5	5	0
Gulf of Gdansk	1	0	1	1	5	0	0	0	1	1	1	1	1	1	0	0	0	1	1	0
Bay of Mecklenburg	1	0	1	1	6	5	1	1	1	1	1	1	1	1	0	1	0	1	1	0
Kiel Bay	1	0	1	1	6	5	1	1	1	1	1	1	1	1	0	1	0	1	1	0
Little Belt	1	0	0	1	5	0	0	0	1	0	1	1	1	1	0	1	0	1	1	0
Great Belt	1	0	1	1	5	0	0	0	1	1	1	1	1	1	0	1	0	0	1	0
The Sound	1	0	1	1	6	0	0	0	1	1	1	1	1	1	0	1	0	1	1	0
OVERALL Baltic *	**9**	**1**	**9**	**9**	**16**	**9**	**3**	**2**	**9**	**9**	**8**	**9**	**9**	**9**	**0**	**5**	**0**	**9**	**9**	**0**

* The overall result is the sum of the programmes of the Baltic countries

4.2.2. Identification of gaps

The current gap analysis is based on the results presented in the previous overview (section 4.2.1.). As previously stated, in the **DEVOTES Catalogue of Monitoring Networks**, the Baltic Sea monitoring programmes are not well represented because only Lithuania and Germany filled in the compilation. Information from Finland, Estonia, Latvia, Poland, Sweden (and Russia) is missing. In order to overcome this weakness, the identification of gaps for the Baltic Sea was based both in the monitoring catalogue and the information given in HELCOM MORE (2013).

The first evidence is that the non-indigenous species (D2) descriptor is not monitored in most of the sub-regions of the Baltic Sea (Table 11).

There are few biodiversity components which are not adequately monitored (i.e. microbes, mammals, phytoplankton and zooplankton). The first two biodiversity components (i.e. microbes and mammals) are poorly monitored, most likely due to incomplete information reported from the Baltic countries. The phytoplankton and zooplankton have low monitoring stations cover in a minor area, such as the Quark and Little Belt areas. According to the monitoring analysis of the Baltic Sea (HELCOM MORE, 2013) there are a smaller number of offshore stations in all relevant biodiversity components compared to coastal stations. Whether this kind of a coast-to-off-shore distribution of the monitoring stations is representative and corresponds, for example, with the natural variability of the two environments and management needs, should be further discussed when adequacy of monitoring is analysed. Some coastal areas also seem underrepresented for some biodiversity components (e.g. phytobenthos). Zoobenthos and seabed habitats are also underrepresented in the offshore areas.

According to HELCOM MORE (2013) macrophytobenthos (i.e. angiosperms and macroalgae) in most of the stations (695) is monitored every year (Figure 29), whereas in the Estonian and Lithuanian coast it is monitored every three years (36 and 9 stations, respectively) and in Germany - every two years (93 stations). Possible gaps in the distribution of phytoplankton monitoring stations are in the Northern Baltic Proper, Bornholm Basin, Western Gotland Basin and Eastern Gotland Basin. There are areas without stations along some parts of the coasts of Finland and Sweden (except in the Kattegat), which contrasts with the larger number of stations along the coasts of Denmark, Germany, Lithuania and Estonia (532, 111, 9 and 48, respectively). The zoobenthos monitoring is greatly biased to coastal areas whereas the offshore areas, especially in the central Baltic Proper are monitored at a small number (<100) of stations. Moreover, the offshore monitoring stations do not overlap with the shallow water areas (<40 m), which are the main feeding areas of the diving seabirds and many benthic fish species. The spatial coverage of zooplankton monitoring is poor in a number of sub-basins: Gulf of Bothnia – five monitoring stations and the Bornholm Basin - nine, the Western Gotland Basin and Arkona Basin – two. No monitoring is undertaken in a Kiel Bay and Bay of Meckelburg. Many coastal areas also lack monitoring stations (i.e.

Sweden and Finland). The frequency of monitoring varies between sub-basins: stations in the Kattegat and Estonian coast, for example, are monitored more often than the rest of the sub basins. Offshore bird winter monitoring lacks coordination and is geographically not representative. As wintering offshore birds are highly mobile, assessments of some species such long-tailed duck or common scoter are not possible with the current monitoring. Experts have suggested improvements in offshore monitoring but also emphasized the use of migration statistics for species staying in the Baltic Sea during the winter.

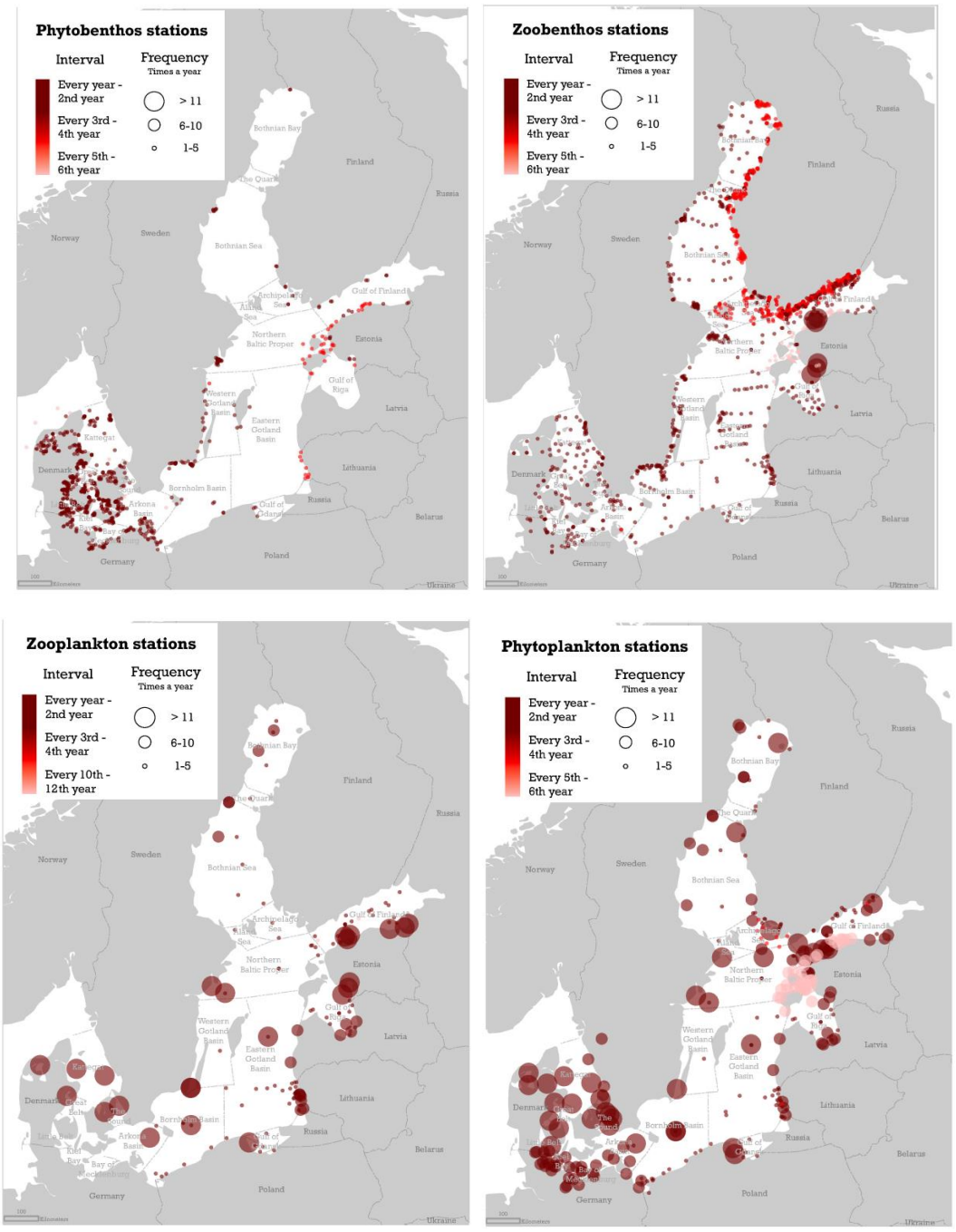


Figure 29. Distribution of monitoring stations of macrophytobenthos, zoobenthos, zooplankton and phytoplankton in the Baltic Sea and its subregions according to HELCOM MORE (2013). Sampling interval and frequency in the monitoring stations is given by intensity of red colour and size of bubble size respectively.

It is worth noting that for most biodiversity components, quality assurance is non-existent (or unreported), therefore this aspect should be considered in future monitoring programmes.

Despite extensive monitoring of the main pressures of the Baltic Sea, there are pressures which are poorly monitored in all subregions (i.e. marine litter and noise). It is also worth noting that even where underwater noise is monitored, the impact of noise on many biodiversity components is not well understood and the outputs of such monitoring cannot be used effectively at the present time. The introduction of non-indigenous species and translocations is also insufficiently monitored.

Monitoring of mixed bottom habitats is still unsatisfactory in many subregions. Rare seabed habitats, such as shelf sublittoral rock and biogenic reef, are also poorly monitored.

4.2.3. SWOT analysis – Baltic Sea

Strengths S

- Almost all GEnS descriptors and biological components are addressed through monitoring programmes within the the Baltic region.
- At least nine national monitoring programmes of each Baltic country address GEnS Descriptors 1, 4 and 6.
- All ongoing monitoring programmes simultaneously address more than one descriptor. This catalogue only focuses on the four biodiversity-related descriptors relevant to the MSFD; therefore, it is likely that the catalogued monitoring programmes will also be suitable to address more descriptors of the MSFD.
- Major subregions of the Baltic Sea have an extensive system of monitoring programmes (i.e. Bothnian Sea, Eastern and Western Gotland Basins, Northern and Southern Baltic Propers, Kattegat).
- In general, the proportions of monitoring programmes for the different biological components are similar across the different subregions.
- A higher proportion of monitoring programmes address phytoplankton, zooplankton, angiosperms, macroalgae, benthic invertebrates, fish and birds.

Weaknesses W

- Collating monitoring programme information at the subregion scale masks information about the spatial extent and distribution of monitoring within that subregion. Within each subregion of the Baltic Sea, monitoring programmes address a specific focus (e.g. habitat, species, pressure etc.), resulting in an uneven distribution of spatial monitoring stations/sites, sampling interval and frequency and monitored components. Coverage of monitored attributes (e.g. descriptors, biological components, habitats and pressures) may therefore be shown as addressed at a subregion level; however, in reality monitoring may only take place in a small number of specific subregion sub-sections.
- In the Baltic region the number of monitoring programmes that address Decriptor D2 is limited, compared to programmes which address D 1, 4 and 6.
- There seem to be gaps in geographical distribution of monitoring stations, sampling interval and frequency in the monitoring stations. These gaps of monitoring design over many subregions may underestimate GEnS of major biodiversity components, especially in the offshore areas, macrophytobenthos, zoobenthos and birds.

Strengths S

- In contrast with other subregions, the proportions of monitoring programmes for all biological components, except microbes, reptiles and cephalopods, are higher in the Northern Baltic Proper and Southern Baltic Proper.
- The monitoring programmes of fishes and mammals seem to be without any serious drawbacks.
- The collection of physicochemical data in conjunction with biodiversity component monitoring is a common practice in monitoring programmes undertaken in the Baltic Sea.
- Overall, monitoring programmes undertaken within the Baltic region address all pressures, especially the major ones: eutrophication and extraction of living resources.
- All water habitats and most of seabed habitats (e.g. hard and soft bottoms) are addressed within the monitoring programmes of the Baltic Sea.

Weaknesses W

- Although there is general guidance of quality assurance (QA) associated with the monitored biological components in the Baltic Sea, however its development highly varies among biological components. This has implications for the standardisation (within and between institutes) of data collection techniques, laboratory analysis methods and data handling, treatment and presentation methods. There is therefore high potential for poor comparability between data sets where QA procedures are not in place.
- Absence of regional methodology on monitoring marine litter, noise and introduction of non-indigenous species and translocations may result in underestimation of impact by these pressures to GEnS in almost all subregions of the Baltic Sea.
- There are no reported monitoring programmes covering benthic habitats, mixed bottom, sublittoral rock and biogenic reef, in the Baltic region.
- In general, absence of regional uniform monitoring system results in uneven coverage of stations, simultaneous assessment intervals and frequency for many biological components, habitats and pressures. There is a need for monitoring programmes to become more efficient and robust, integrating data of biological components, habitats and pressures through simultaneous monitoring. Reduction of overlapping measurements and/or changing their distribution and sampling frequency may also improve the efficiency of regional monitoring.

Opportunities O

- The existing long-term monitoring programmes (including relatively dense cover of monitoring stations and frequency of measurements) in the Baltic Sea and implementation of the MSFD by each member state make a great platform for the further development of GEnS and their monitoring methods, which should be harmonized within the Baltic region.
- The obtained data during monitoring programmes within the Baltic Sea may have scientific value in the regional and inter-regional scale, where different comparisons and predictions could be performed.
- Although marine litter and noise pressures have not been well monitored, many research activities have recently started concerning these topics.
- Regionally coordinated (by HELCOM) and obtained long-term monitoring data may serve good database for online information system on the aquatic non-indigenous species (AquaNIS), which is being developed in the framework of EU project VECTORS. AquaNIS seeks to ensure the long-term maintenance and reliability of the database by continuous update and scientific validation of its data, making it useful for risk assessments of bioinvasions and decisions of measures.

Threats T

- Recently the monitoring programmes have not been fully harmonized among the Baltic countries, most likely due to the differences in size of national budgets, assigned to the marine monitoring programmes. Therefore this problem may remain in the future, highly depending on the national policy and/or economic status.
- The policy of non-EU country (Russia) may have evident impact on the monitoring system at least in the subregional scale.
- There could be potential effect on some vulnerable and rare species or habitats by intensive monitoring activities, especially using destructive methods such as nets, trawls, grabs and frames.

4.3. Black Sea and the Sea of Marmara

4.3.1. Monitoring Networks - overview

The Black Sea monitoring networks are analysed in this section as two geographical areas: EU and non-EU waters (Figure 30). This geographical division is used as there are no defined MSFD subregions within the Black Sea. In addition, the monitoring networks covering the Sea of Marmara (currently included in the non EU Seas) are also included in this analysis (Figure 30). The Sea of Marmara connects two EU Seas (the Black Sea and the Mediterranean Sea) and is under the sovereignty of Turkey (a candidate EU country). It is therefore deemed relevant within this deliverable to consider and assess the marine monitoring undertaken in the Sea of Marmara in association with monitoring undertaken in the Black Sea.

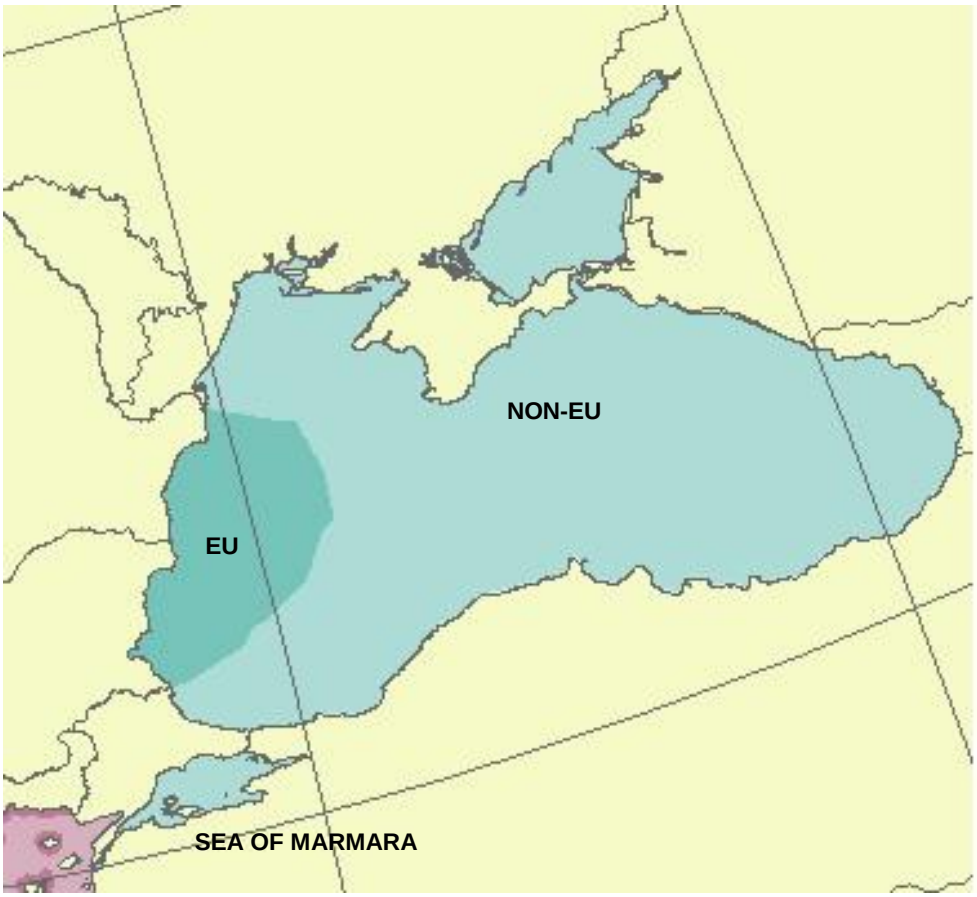


Figure 30. Black Sea (EU, non-EU waters) and the Sea of Marmara: (Source: Connor, 2012).

The Black Sea is surrounded by six countries (i.e. Bulgaria, Romania, Turkey, Ukraine, Russia, Georgia) and each of them are obliged to control the state of the marine environment in a relevant sea sector as per implementation of the ratified Bucharest Convention (http://www.blacksea-commission.org/_table-legal-docs.asp). All countries have their own national programmes concerning the monitoring of particular ecological components of the Black Sea environment. These programmes are structured in coherence with the Integrated Monitoring and Assessment Program (BSIMAP), which was adopted in 2006 under the umbrella of the Black Sea Commission (BSC). BSIMAP aimed to compile existing data from national monitoring and integrate datasets to improve the assessment of the chemical and ecological status of the Black Sea. The EU member states of the region also implement EU directives, programs and policies such as the Water Framework Directive, Marine Strategy Framework Directive, Habitats Directive, Birds Directive, NATURA 2000, Bathing Water Directive and Common Fisheries Policy.

The catalogue includes the list of monitoring programmes undertaken by Ukraine, Bulgaria and Turkey only. For this reason, the monitoring networks overview covers approximately 77% of the Black Sea region by coastline length.

There are 18 monitoring programmes reported for the three countries that filled in the catalogue. Thirteen of these programmes are undertaken within EU waters of the Black Sea (four of which are ongoing), three ongoing programmes are reported in the non-EU waters of the Black Sea (Figure 31) and one ongoing programme is undertaken in the Sea of Marmara.

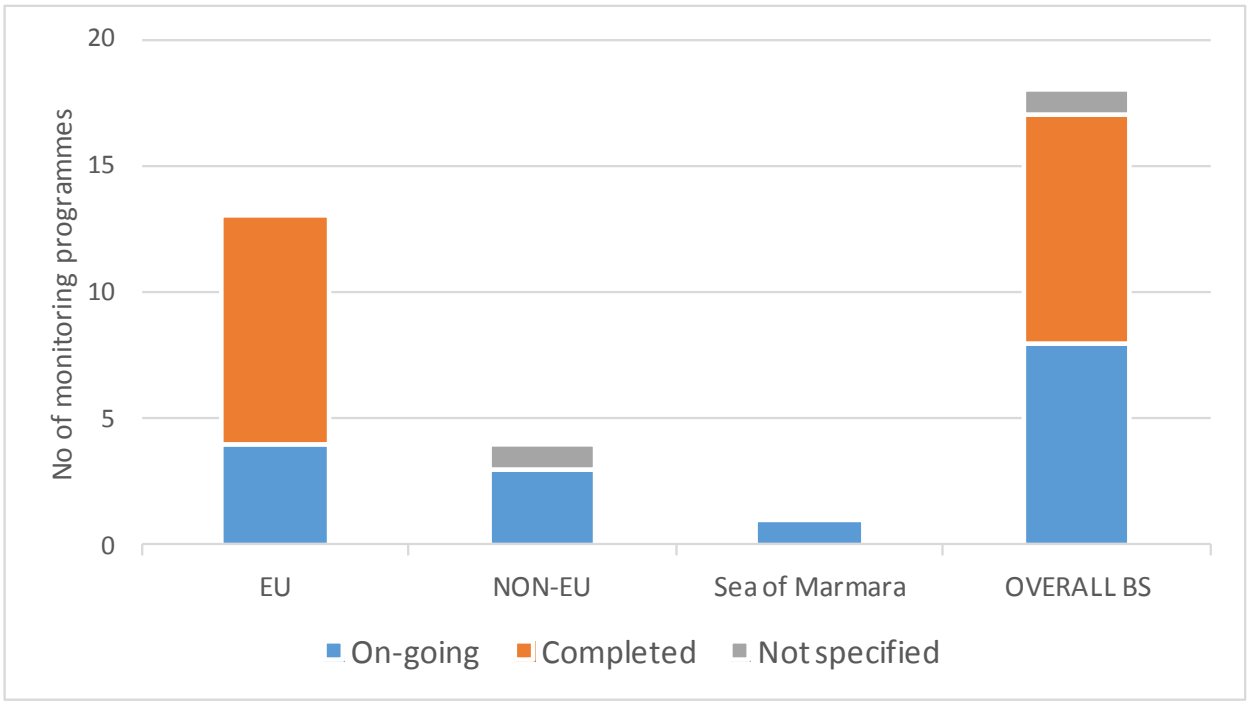


Figure 31. Number of ongoing and completed monitoring programmes in the EU and non-EU waters of the Black Sea and the Sea of Marmara.

The descriptor biological diversity (D1) is addressed through all eight of the ongoing monitoring programmes undertaken in the Black Sea (both EU and non-EU waters) and Sea of Marmara (Figure 32). In EU Black Sea waters the descriptors non-indigenous species (D2) and seafloor integrity (D6) are monitored simultaneously with descriptor D1 (biological diversity) in one ongoing marine monitoring program. In non-EU Black Sea waters the descriptor seafloor Integrity (D6) is addressed simultaneously with biological diversity (D1) in one programme, whilst in the single monitoring programme listed in the Sea of Marmara this descriptor (biological diversity D1) is addressed simultaneously with the descriptor

non-indigenous species (D2). No monitoring programmes in the Black Sea (EU or non-EU waters) or Sea of Marmara address the descriptor food-webs (D4) (Figure 32 and Table 12).

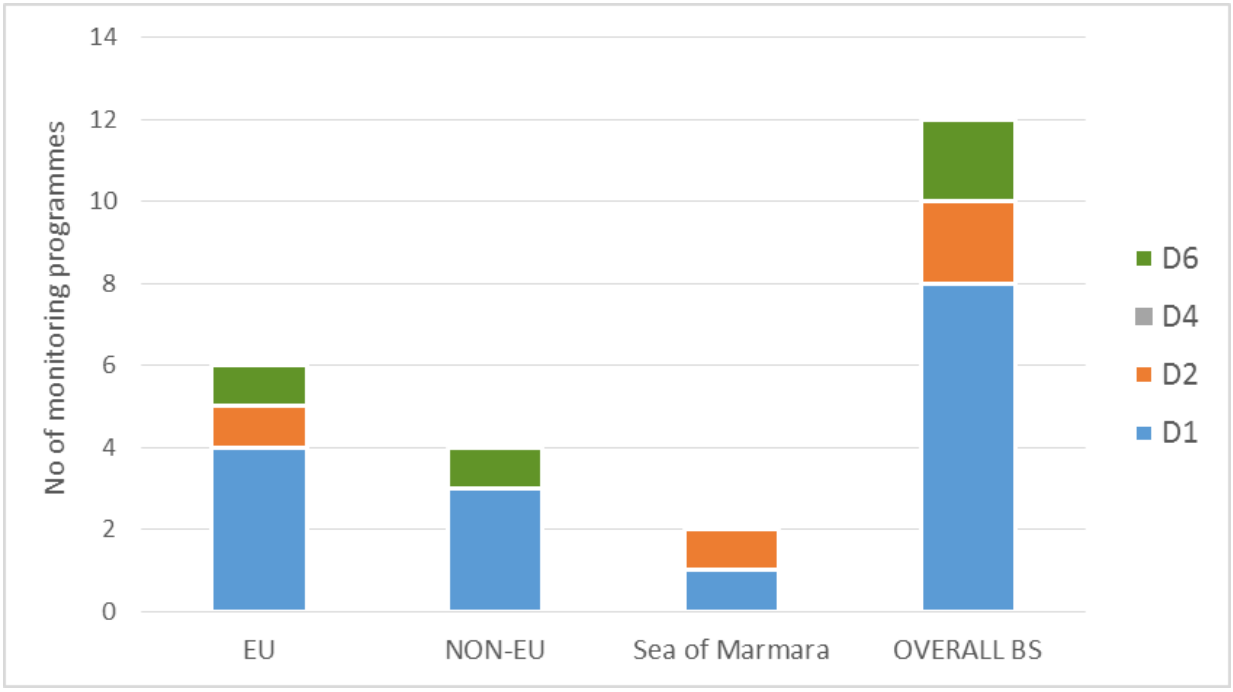


Figure 32. Ongoing monitoring programmes per descriptor in the EU and non-EU waters of the Black Sea (BS) and the Sea of Marmara (D1: Biological diversity, D2: Non-indigenous species, D4: Food webs, D6: Seafloor integrity).

As there are no cephalopod or reptile species recorded in the Black Sea, microbes are the only biodiversity component not currently monitored in the ongoing marine monitoring programmes (EU and non-EU waters). Eight biodiversity components are monitored in EU Black Sea waters (i.e. Phytoplankton, zooplankton, angiosperms, macroalgae, benthic invertebrates, fish, marine mammals and birds), compared to six biodiversity components monitored in non-EU waters (i.e. phytoplankton, zooplankton, angiosperms, macroalgae, benthic invertebrates and fish). Three biodiversity components (i.e. phytoplankton, zooplankton and benthic invertebrates) are monitored in the Sea of Marmara (Figure 33 and Table 12).

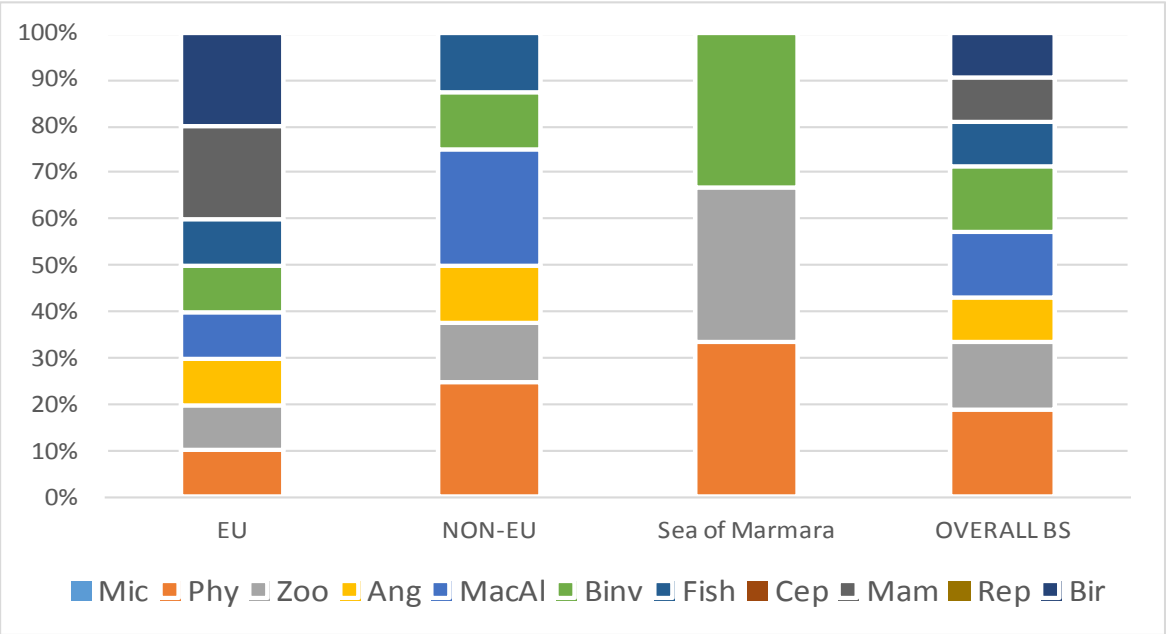


Figure 33. Percentage of each biodiversity component monitored in the ongoing programmes in the EU and non-EU waters of the Black Sea (BS) and the Sea of Marmara.

Half of the monitoring programmes recorded in the Black Sea marine region do not collect any supporting physicochemical parameters in conjunction with biodiversity component monitoring (Figure 34).

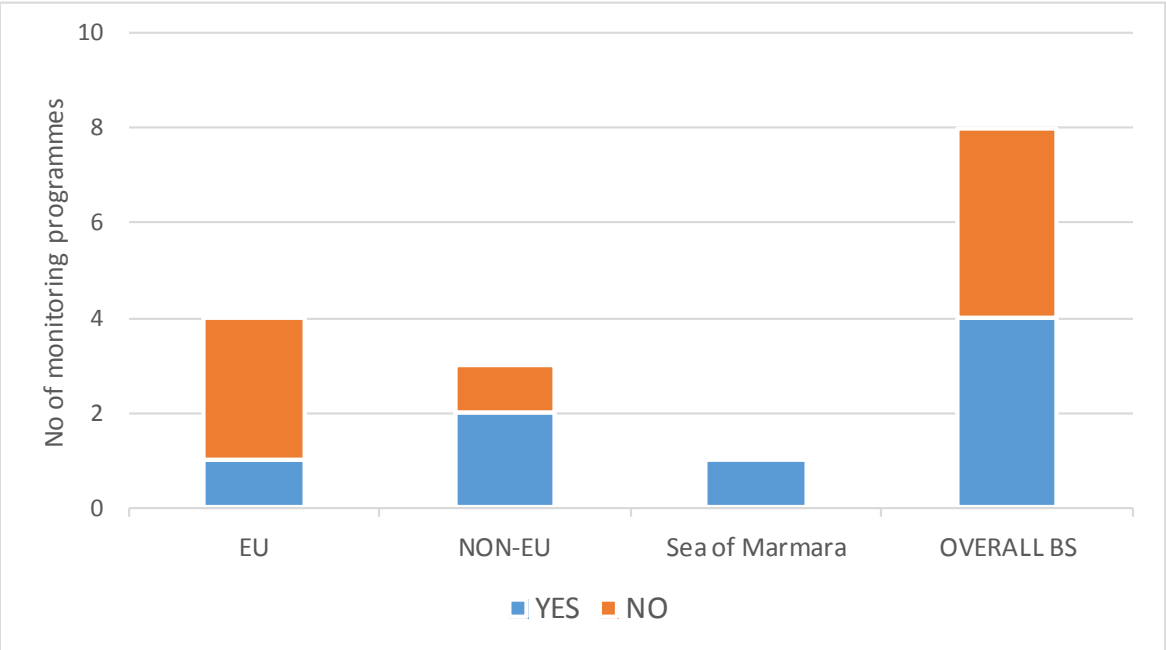


Figure 34. Number of ongoing programmes collecting supporting physicochemical parameters in the EU and non-EU waters of the Black Sea (BS) and the Sea of Marmara.

In EU Black Sea waters, only one out of four ongoing monitoring programmes collects supporting physicochemical data, compared to two out of three programmes in the non-EU Black Sea region (Figure 34). The single recorded monitoring programme in the Sea of Marmara collects supporting physicochemical parameters in conjunction with biodiversity component monitoring (Figure 34). Where supporting parameters are collected, these mainly relate to the physical (e.g. temperature, salinity, density, Secchi disk) and/or chemical state of the ecosystem (e.g. nitrates, nitrites, dissolved oxygen, phosphates, silicates, pH, metals, organic pollutants, PAHs).

Out of the 31 pressures identified in the catalogue of monitoring networks, only nine are addressed through monitoring programmes in the Black Sea and Sea of Marmara (Figure 35). The pressures 'nitrogen and phosphorus enrichment' and 'organic matter enrichment' are simultaneously addressed through one monitoring programme in both EU and non-EU Black Sea waters. The pressures 'local thermal regime change', 'local salinity regime change', 'introduction of synthetic compounds', 'introduction of non-synthetic substances and compounds', 'introduction of other substances', 'nitrogen and phosphorus enrichment', 'organic matter enrichment' and 'manageable pH changes' are addressed simultaneously through a single monitoring programme in the non-EU waters of the Black Sea (eight pressures; Figure 35).

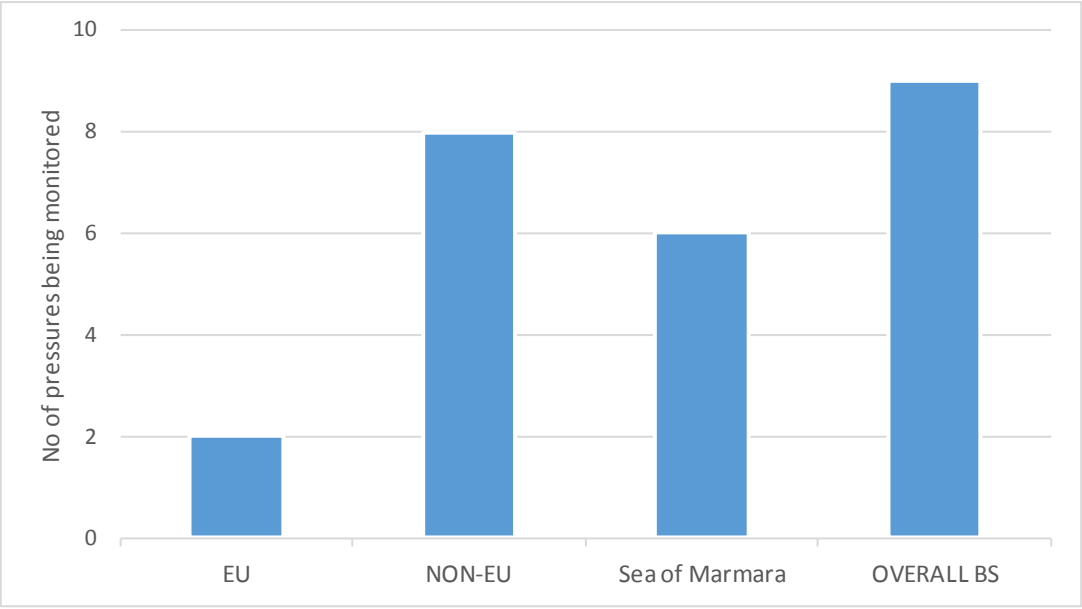


Figure 35. Number of ongoing programmes monitoring pressures monitored in the Black Sea (BS) and the Sea of Marmara regions.

The pressures 'thermal regime change', 'salinity regime change', 'local water flow rate changes', 'nitrogen and phosphorus enrichment', 'organic matter enrichment' and 'manageable pH changes' (six pressures) are simultaneously addressed through the single monitoring programme in the Sea of Marmara (Figure 35). Whilst some of these pressures are measured in EU Black Sea waters, they are not related to the monitoring of biodiversity components and thus in the MSFD context are not included in the **DEVOTES Catalogue of Monitoring Networks**.

Eleven littoral and sublittoral seabed habitats (including rock and biogenic reef, sand, mud and coarse and mixed sediment) and three water column habitats (coastal, shelf and oceanic marine waters) are monitored in the EU waters of the Black Sea (Figure 36 and Table 12). Due to missing information in the monitoring networks catalogue, only littoral sediment is listed as monitored in non-EU Black Sea waters, in additional to coastal and shelf marine water column habitats (Figure 36). The catalogue provides no information on the type of seabed monitored In the Sea of Marmara monitoring programme, however the water column habitat addressed is identified as coastal marine. (Figure 36). The number of seabed and water column habitats monitored may increase in the future as the catalogue develops and more inputs are added, as it currently contains a number of missing inputs in regards to monitored habitats, particularly for the non-EU Black Sea waters and the Sea of Marmara. As outlined in Annex 3, the Black Sea basin-wide habitat inventory, based on EUNIS classification, has not yet been completed for the entire marine area, which creates difficulties in the assessment.

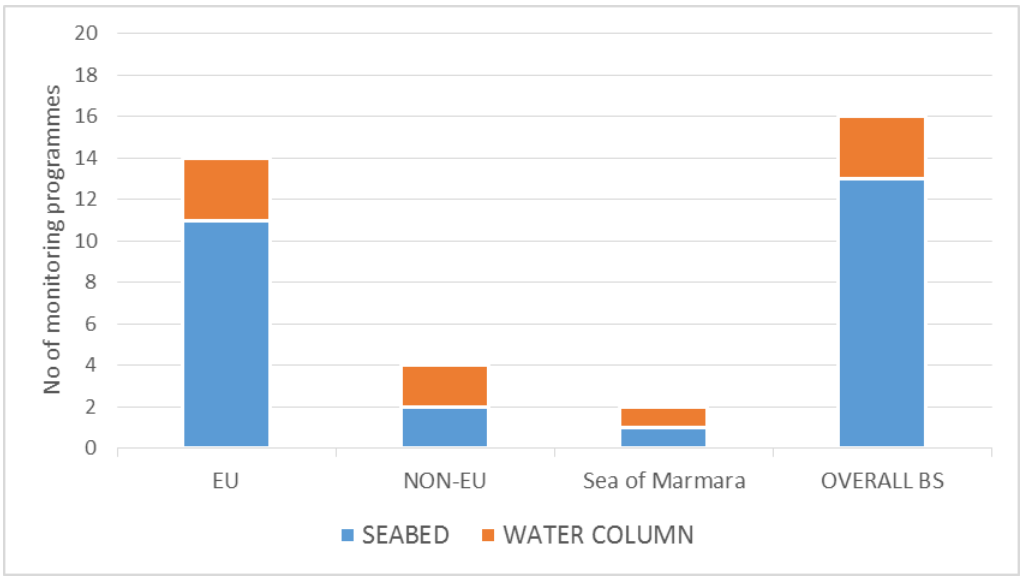


Figure 36. Number of ongoing monitoring programmes addressing seabed and water column habitats in the EU and non-EU waters of the Black Sea (BS) and the Sea of Marmara.

Table 12. Summary table of ongoing monitoring programmes in the EU and non-EU waters of the Black Sea (BS) and the Sea of Marmara. MSFD: Marine Strategy Framework Directive; PQ: physicochemical.

Black Sea and Sea of Marmara regions	MSFD Descriptor				No of pressures	No of habitats		Biodiversity components											Supp. PQ	
	D1	D2	D4	D6		Seabed	Water	Mic	Phy	Zoo	Ang	MacAlg	Binv	Fish	Cep	Mam	Rep	Bir	Yes	No
EU waters	4	1	0	1	2*	11	3	0	1	1	1	1	1	1	–	2	–	2	1	3
non-EU waters	3	0	0	1	8	2	2	0	2	1	1	2	1	1	–	0	–	0	2	1
Sea of Marmara	1	1	0	0	6	1*	1*	0	1	1	0	0	1	0	0	0	–	0	1	0
OVERALL BS	**8**	**2**	**0**	**2**	**9**	**11**	**3**	**0**	**4**	**3**	**2**	**3**	**3**	**2**	**0**	**2**	**–**	**2**	**4**	**4**

* information incompletely reported in the catalogue; – biodiversity components not present in the EU and non-EU waters of the Black Sea and Sea of Marmara regions.

All biodiversity-related marine monitoring programmes currently ongoing in the EU waters of the Black Sea are those undertaken by Member States (Bulgaria) in relation to implementation of EU directives, programmes and policies (listed above). This monitoring is undertaken, at a regional level, through the Bucharest Convention (BSIMAP) and, at a national level, through the national institutes (Institute of Oceanology and Institute of Biodiversity and Ecosystem Research- Bulgarian Academy of Sciences and Institute of Fishery Resources – Agricultural Academy) and NGOs.

The ongoing monitoring programmes included in the catalogue of monitoring networks include the Bulgarian National Black Sea Monitoring Program, which is the responsibility of the Ministry of Environment and Water. According to the National Water Act (state gaz. 61/6.08.2010) the responsible authorities include the Executive Environment Agency and the Black Sea Basin Directorate, Executive Agency for Exploration and maintenance of the Danube River, Institute of Hydrometeorology – BAS (IHM-BAS) and the Institute of Oceanology – BAS (IO-BAS). Between 2006 and 2011 the National Black Sea Monitoring Program consisted of a number of fragmented campaigns. However the legitimate programme commenced in 2012 and is mainly related to the Water Framework Directive and some descriptors of Marine Strategy Framework Directive with a focus on biodiversity components and physicochemical parameters, while pollutants are not fully addressed (responsible IO-BAS). IHM-BAS is in charge of monitoring of complementary hydrometeorological parameters. The MSFD related monitoring is limited to six stations located in the coastal, shelf and open sea with four surveys undertaken per year (May-November).

Two monitoring programmes undertaken in EU Black Sea waters and listed in the catalogue monitor marine mammals (Ministry of Environment and Water - MOEW) and birds (NGOs). Fish biodiversity monitoring as part of a fish stock assessment program commence in 2007 and is under responsibility of

the Executive Agency of Fish and Aquaculture, Ministry of Agriculture, however the programme was not funded in 2013.

The pressures addressed concurrently with biodiversity component monitoring are limited to eutrophication. Microbial contamination is monitored and reported under the Bathing Water Directive.

Bulgaria is obliged to report monitoring data to the European Environment Agency (EEA) and EU (as a Member State) and to the Black Sea Commission (Bucharest Convention). IO-BAS hosts the National Oceanographic data Centre, but a National Monitoring data Center to manage a national database does not exist.

Ukrainian State Marine Environmental Monitoring (MEM) is legally regulated by Council of Ukraine Ministers (the resolution № 815 from 20.07.1996 'On the Procedure of the state monitoring of water environment'). According to the 'National program for the protection and restoration of the environment of the Azov and Black Seas' (Law of Ukraine of 22.03.2001, № 2333-III) Ukrainian state marine monitoring is related to two habitats (i.e. water column and seabed) and mainly aimed to control the quality of coastal and offshore waters and sediments from chemical pollution, eutrophication and hypoxia. Some indicators related to plankton and benthic faunal states are measured at stations (possibly those affected by eutrophication and hypoxy events) a few times per year. The Ukrainian Scientific Center of Ecology of the Sea is responsible for this monitoring.

The remaining monitoring programs included in catalogue are carried out in the framework of National Research Programmes. They are related to seabed habitat and aim to assess the status/trends of macroalgae, angiosperm and plankton in Ukrainian coastal waters. These monitoring activities are carried out by the Institute of Biology of Southern Seas (NASU, in Sevastopol, http://ibss.nas.gov.ua/?page_id=285&lang=en) and its Odessa branch. The databases from these national programmes are stored in an international metadata bank - the European Network of Marine Research Institutes and Stations (http://www.marsnetwork.org/).

Ukrainian marine monitoring in the Black Sea has limited geographical coverage. Regular plankton monitoring has been carried out in Sevastopol Bay and inshore waters off Crimean coast. Macroalgae and angiosperm monitoring has been carried out along the Crimean coastline over different seasons but not

regularly. The Ukrainian monitoring has been designed to address pressures related to pollution and eutrophication: ‘nitrogen and phosphorus enrichment’, ‘organic matter enrichment’ and ‘introduction of synthetic and non-synthetic substances and compounds’.

The Turkish monitoring programme is performed according to the BSIMAP of the Black Sea Commission. The national responsible authority for the programme is the Ministry of Environment and Urbanization. Like Ukrainian monitoring, Turkish monitoring can also be assessed as pollution and eutrophication monitoring since the parameters monitored are mainly physicochemical, rather than biological. Annual data is collected across 22 transects, at 66 stations along the Turkish Black Sea coast. Eight out of 22 sites are evaluated as hotspots for the Black Sea Action Plan. The Turkish monitoring programme also contains three sites in the Sea of Marmara to monitor the effects of the Danube River input. The results are reported to the Black Sea Commission every year.

Data for 26 categorized parameters are collected from the sea and bottom sediment environments. Some of the parameters are related to coastal bathing waters and some others represent some biota of the Turkish Black Sea coasts. There are studies to enhance Turkish marine monitoring programmes, especially to structure them according to the EU directives in the accession period. Some ministries have been re-organized in the last three years; legislative arrangements are continuing and a national project was completed by the end of 2013 which will be the basis for re-structuring the monitoring programmes in the next years, according to MSFD, WFD and other EU directives.

4.3.2. Identification of gaps

As mentioned in the previous subsection, the Black Sea monitoring networks catalogue covers the monitoring activities of three of the six countries in this region. Thus, this cataloguing has a geographic gap of around 23% of the region represented by coastline length. The gaps are listed for descriptors, biodiversity components, habitats and pressures, which are not covered by the ongoing monitoring programmes identified in the catalogue of monitoring networks.

Among the four descriptors that DEVOTES addresses, monitoring programmes associated with MSFD descriptor food webs (D4) are completely lacking in the region or are not reported in the current version of the catalogue. The descriptors non-indigenous species (D2) and seafloor integrity (D6) are also only

addressed through a small number of monitoring programmes in the Black Sea (EU and non-EU waters) and Sea of Marmara. The descriptors food webs (D4) and seafloor integrity (D6) are not addressed in the Sea of Marmara monitoring programme. According with the catalogue current version, the descriptors non-indigenous species (D2) and food-webs (D4) are not addressed in monitoring programmes in non-EU waters and descriptor D4 (food-webs) is also not addressed in EU Black Sea waters.

The biodiversity component microbes are not monitored in the Black Sea (EU and non-EU waters) or Sea of Marmara (Table 12). Marine mammals and birds are monitored within EU Black Sea Waters, but are not monitored in non-EU Black Sea waters or the Sea of Marmara. Angiosperms, macroalgae and fish are not monitored in the Sea of Marmara (Table 12).

Among the seabed habitat types considered in the catalogue, the presence of the habitat 'upper bathyal rock and biogenic reef' in the Black Sea region is scientifically debated due to a lack of data and information. The habitats 'upper bathyal sediment', 'lower bathyal rock and biogenic reef', 'lower bathyal sediment', 'abyssal rock and biogenic reef' and 'abyssal sediment' are mainly lacking in the Black Sea (no biota) due to the presence of H_2S (Todorova, 2013: BG Initial Assessment Report). With reference to the relevant habitats for this region, shelf sublittoral rock and biogenic reef and upper bathyal rock and biogenic reef (if existent) are not addressed in EU waters; only littoral sediment is addressed in non-EU Black Sea waters (likely due to a lack of information in the catalogue) and there is no information available (i.e. not specified) regarding the seabed habitats covered by the ongoing monitoring programme in the Sea of Marmara (see Table 13).

The water column habitat types 'reduced salinity water' and 'variable salinity (estuarine) water' are not valid for the Bulgarian marine environment, but are present in the North-Western EU areas (Romania), which are not included in the Catalogue of Monitoring Networks. Coastal, shelf and oceanic marine waters are addressed in EU Black Sea waters and coastal and shelf marine waters are addressed in non-EU waters (see Table 13). The single ongoing marine monitoring programme in the Sea of Marmara addresses coastal marine water column habitats.

Table 13. Gaps of ongoing monitoring programmes for habitat types in the EU and non EU waters of the Black Sea and Sea of Marmara.

	SEABED HABITATS																	WATER COLUMN HABITATS				
Black Sea and Sea of Marmara regions	Littoral rock and biogenic reef	Littoral sediment	Shallow sublittoral rock and biogenic reef	Shallow sublittoral coarse sediment	Shallow sublittoral sand	Shallow sublittoral mud	Shallow sublittoral mixed sediment	Shelf sublittoral rock and biogenic reef	Shelf sublittoral coarse sediment	Shelf sublittoral sand	Shelf sublittoral mud	Shelf sublittoral mixed sediment	Upper bathyal rock and biogenic reef	Upper bathyal sediment	Lower bathyal rock and biogenic reef	Lower bathyal sediment	Abyssal rock and biogenic reef	Abyssal sediment	Reduced salinity water	Variable salinity (estuarine) water	Marine water: coastal	Marine water: shelf	Marine water: oceanic
EU waters	1	1	1	1	1	1	1	0	1	1	1	1	0*	–	–	–	–	–	0§	0§	1	1	1
non-EU waters	0	1	0	0*	0*	0*	0*	0	0	0	0	0	0*	–	–	–	–	–	0	0	1	1	0
Sea of Marmara	---------- NOT SPECIFIED ----------																						
OVERALL	**1**	**2**	**1**	**1***	**1***	**1***	**1***	**0**	**1**	**1**	**1**	**1**	**0***	**–**	**–**	**–**	**–**	**–**	**0§**	**0§**	**2**	**2**	**1**

* information uncertain or not present in the current version of the catalogue (Jan 2014); – habitat type not present in the Black Sea (EU and non-EU waters); § habitats missing from Bulgarian waters but present in North Western EU waters (i.e. Romania)

In accordance with the Catalogue for Monitoring Networks, a total of 29 pressures are not monitored in the EU waters of the Black Sea. A greater number of pressures are monitored in the non-EU waters of the Black Sea (although there are still 23 unmonitored pressures). Twenty-five pressures are not monitored in the Sea of Marmara: substratum loss, smothering, abrasion, selective extraction of non-living resources, underwater noise, marine litter, changes in siltation, widespread thermal regime change, widespread salinity regime change, local emergence regime change, widespread emergence regime change, local change in wave exposure, widespread change in wave exposure, electromagnetic changes, introduction of synthetic compounds, introduction of non-synthetic substances and compounds, introduction of radio-nuclides, introduction of other substances, introduction of microbial pathogens, introduction of non-indigenous species and translocations, selective extraction of living resources, widespread pH changes, barrier to species movement and death or injury by collision.

The most significant gap in the reported monitoring programmes is the lack of an integrated monitoring strategy with relevant frequency and spatial coverage which would allow a better understanding of the changes in the pelagic and benthic communities to construct a relevant assessment system aimed at achieving GEnS.

4.3.3. SWOT analysis – Black Sea and the Sea of Marmara

Strengths S

- The major strength in the Black Sea monitoring is the regional cooperation of all six countries. At Regional Sea level in the framework of the Bucharest Convention (Convention on the Protection of the Black Sea Against Pollution, Black Sea Commission), there is the regional monitoring programme BSIMAP (Black Sea Integrated Monitoring and Assessment Program) based on national monitoring programmes and financed by the Black Sea States.
- Five programmes monitor three or more biodiversity components simultaneously.
- The descriptor Biological diversity is monitored in all areas by eight programmes, and EU Black Sea waters is the most monitored area, with four programmes.
- Among the biodiversity components, phytoplankton, zooplankton and benthic invertebrates are monitored in all areas, being monitored by 4 (EU waters), 3 (non-EU waters) and 3 (Sea of Marmara) programmes.
- Nitrogen, phosphorus and organic matter enrichment are the pressures covered by highest proportion of monitoring networks in the region.
- Monitoring programmes in the EU Black Sea waters address the most types of habitats: 11 seabed habitats and three water column habitats.
- Most of the activities are based on EU/NATO/UNDP funded projects.
- Manuals on sampling and analysis, including guidelines on equipment, site selection, abundance, biomass, blooms and taxonomic identification have been developed and used for soft-bottom macrozoobenthos (Todorova & Konsulova, 2005), zooplankton (Korshenko & Alexandrov, 2006) and phytoplankton (Moncheva, 2010; Moncheva & Parr, 2010). There has been significant recent progress in compiling monitoring manuals for meiobenthos and microzooplankton (not finalized), for harmonization of assessment methodologies, analytical techniques, reporting formats, application of unified set of indicators (protocol of 17th Meeting of Advisory group for Biodiversity Conservation).

Weaknesses W

- Poor geographical coverage: the catalogue does not reflect all monitoring activities being carried out by the six countries (Bulgaria, Romania, Ukraine, Russia, Georgia, Turkey) surrounding the Black Sea. All countries have their own national programmes concerning monitoring of particular biodiversity; only Bulgaria, Ukraine and Turkey reported for the catalogue.
- The Food webs (D4) descriptor is not covered in the region. Non-indigenous species (D2) and seafloor integrity (D6) are missing in the non-EU Black Sea waters and descriptor D6 is not monitored in the Sea of Marmara.
- The proportion of monitoring programmes that address a single descriptor is high.
- Microbes are not addressed by the Black Sea monitoring programmes. Monitoring of mammals and birds is not well developed for the non-EU waters and the Sea of Marmara region.
- The monitoring activities are not planned to cover all seabed and water column habitats of the region especially for the non-EU waters and the Sea of Marmara.
- The catalogue lacks information for the habitat types monitored in the non-EU waters. The monitoring is underdeveloped for “shallow sublittoral mixed sediment”, “lower bathyal rock and biogenic reef”, “lower bathyal sediment” and “abyssal rock and biogenic reef” seabed habitat types.
- Several Black Sea specific habitats (i.e. gas seepages, mud volcanoes, oxic/anoxic layer, deep-sea oceanic waters) are insufficiently monitored and studied.
- The regional programmes do not adequately address pressures except for nitrogen, phosphorus and organic matter enrichment and there is poor simultaneous monitoring of pressures within monitoring programmes.
- According with the information reported in the catalogue, the EU Black Sea waters are the least well covered by pressure related monitoring activities. Although pressure related data are collected, the link with the biodiversity components is not clear and the monitoring is not carried out in the MSFD context.

Strengths

S

- Several inter-comparison exercises have been organized and collaboration within recent WFD/MSFD supporting projects (SESAME, PERSEUS, CoCoNet, MISIS, EMBLAS) contribute to generating new data and advance application of harmonized approaches and indicators.
- A regional database (known as Mnemiopsis) hosted by the Black Sea Commission was developed in 2008 (BlackSeaScene infrastructure Project) but needs further updating. An interoperable GIS enabled Regional Pollution Data Base, hosted by Regional Activity Centre (RAC) Pollution Monitoring Assessment (PMA) is being developed in the framework of Baltic2Black (BSC and HELCOM) Project. A common tool for assessment of eutrophication (BEAST) has been adopted (Baltic2Black Project).

Weaknesses

W

- Although, monitoring data are used in Ukrainian legislation for the designation of MPAs for integrated coastal zone management, the data are poorly used in legislation regarding the identification of operational objectives and development of measures for marine management. The Ukrainian marine policy is currently being reformed in line with MFSD.
- There is insufficient financial support of monitoring and poor coordination between responsible authorities.
- Despite the Black Sea regional initiatives such as Black Sea GOOS (ARGO floats and other drifters in the Black Sea), as well as participation in the MyOcean program, the bio-ecological operational oceanography is still poorly developed. Infrastructure improvements and effective introduction of less applied approaches (such as remote sensing, underwater video surveys, Continuous Plankton Recorders, side-scan sonar techniques for habitat mapping, Ship of opportunity / FerryBox system) should be considered as overarching and critical issues for implementation of the MSFD.
- Lack of advanced genetic and genomic methodologies for taxonomic revisions including microbes and viruses.
- Lack of a fixed network of sampling stations with regular and long-term observations.
- Lack of efficient data exchange and integrated outputs (intercalibration between different networks) stands as an obstacle for data management and quality issues in inter-governmental levels.

Opportunities O

- The catalogue provides evidence for various sampling frequencies within the Black Sea monitoring networks. This points to the necessity to address scales (temporal and spatial) as a crucial issue for adequate monitoring efforts.
- The catalogue assesses the gaps of existing QA/QC procedures and thus provides opportunities to further addressing the issue towards improving the reliability of the assessments.
- Among the six Black Sea countries, only Bulgaria and Romania are EU Member States. Turkey, with almost 35% of coastline length coverage, is a candidate state and proceeds efforts to reorganize its monitoring activities to be integrated with the EU directives.
- There is increasing cooperation between the Black Sea countries and progress on the integration of monitoring with EU directives. This opportunity enhances the state-of-art of monitoring in the region.
- The Sea of Marmara, although not an EU Regional Sea, is the connection between the Mediterranean and Black Sea (EU seas). Integrating the local ongoing monitoring programmes within the regional networks will improve the MSFD implementation in the neighbour regional seas.

Threats T

- The Black Sea has a catchment drainage area of 2,000,000 km^2 and suffers from land-based sources through river inputs. This large drainage area obliges the involvement of states without direct connection with the Black Sea in the monitoring and management programmes.
- For the non-EU Member States, Russian Federation, Ukraine, Georgia and Turkey, which have 86% of the Black Sea's coastline length, the EU directives are not obligatory, which is a potential threat for the integrated regional monitoring activities. The lack of integrated monitoring could generate difficulties in identifying the most adequate cause/effect relationships and formulation of proper management options.
- In spite of accomplished standardizations in data collection, analysis and assessment methods and representativeness of different water bodies of the Black Sea, a serious deficiency in spatial and temporal resolutions in the areas monitored is apparent.
- The deficiency of D4 (food -web) monitoring affects the level of knowledge that might be crucial for adequate understanding of the ecosystem processes.
- Integrating the Sea of Marmara monitoring activities in the international networks it is not straightforward because it is an inland sea of Turkey.

4.4. Mediterranean Sea

4.4.1. Monitoring Networks - overview

A formal analysis of the current situation, structure, spread and coverage of monitoring programmes in the Mediterranean and its four subregions (Figure 37) was done. The Mediterranean analysis of the catalogue reports on numbers and types of monitoring programmes for four biodiversity components and several habitats addressed by ongoing monitoring programmes overall and by subregion.

A total of 48 biodiversity related monitoring programmes have been registered in the Mediterranean Sea, nine of which were completed by 2013, and the remaining 39 are reported to run to date (Figure 38). With the exception of four programmes aiming at reporting the environmental condition of impacted sites (all in the Eastern Mediterranean) the rest are surveillance programmes. Special mention should be made to two programmes, namely MEDITS and MEDPOL, which have been running across the Mediterranean Region following the same sampling protocol.

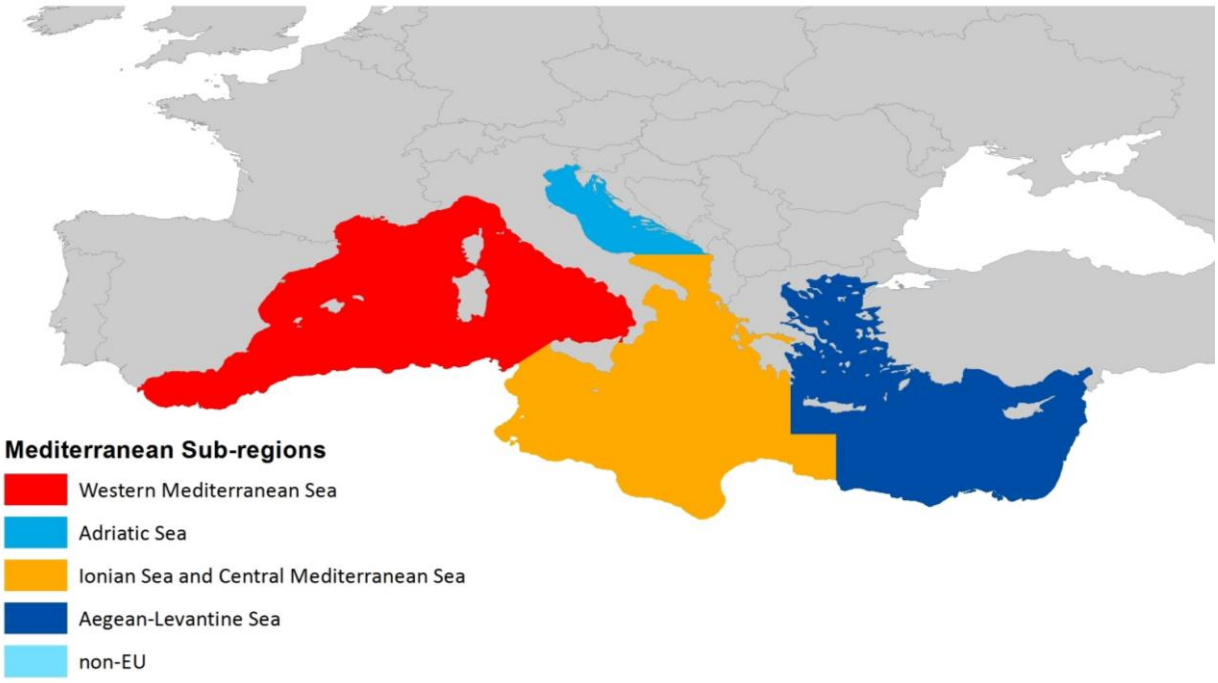


Figure 37. Mediterranean Sea marine subregions used in DEVOTES Catalogue of Monitoring Networks.

MEDITS is the International Bottom Trawl Survey in the Mediterranean, a programme running since 1994 in Spain, France, Italy, and Greece. In 1996 the area was enlarged to cover almost all of the Adriatic Sea (including Slovenian, Croatian, and Albanian Waters).

The south of the Alboran Sea has been included in the survey programme since 1999 (Moroccan contribution), the waters around Malta have been surveyed since 2000, and those around Cyprus since 2006. Since 2002, the MEDITS survey is included in the European regulation related to the collection of fishery data (DCF).

The MEDPOL Programme (the marine pollution assessment and control component of MAP) is responsible for the follow up work related to the implementation of the LBS Protocol, the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (1980, as amended in 1996), and of the dumping and Hazardous Wastes Protocols. MEDPOL has been conducted at irregular intervals in 16 Mediterranean countries (see Annex 4)

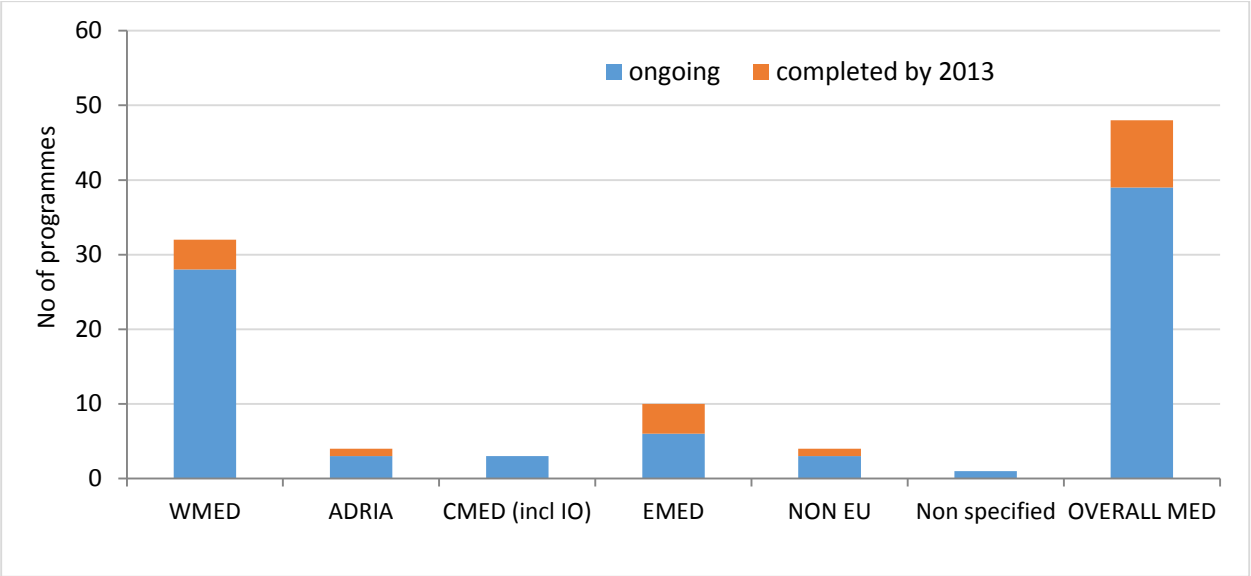


Figure 38. Number of ongoing and completed monitoring programmes in the Mediterranean region and subregions. WMED: western Mediterranean; ADRIA: Adriatic Sea; CMED: central Mediterranean; EMED: eastern Mediterranean (Aegean & Levantine Seas).

The vast majority of ongoing monitoring programmes (29 programmes) are carried out in the Western Mediterranean (WMED) followed by the Eastern Mediterranean (EMED) (six programmes) (Figure 38, Table 14). Only four programmes are included in the catalogue for the Ionian Sea and three for the Adriatic. However, this estimation is likely to be biased as only Italy (of the different countries surrounding the Adriatic) has reported on monitoring activities in this subregion. In Croatia, Slovenia and Albania for example the implementation of the Convention on Biological Diversity and the need for harmonization with the Habitats Directive, WFD and MSFD has created a demand for the recognition of areas of high biodiversity. As a result a relatively large amount of funding has been targeted at the development of NGO capacities to help develop nature protection and monitoring in parallel with institutional bodies (Henkens *et al.*, 2010; Mackelworth *et al.,* 2011; http://www.grida.no/enrin/biodiv/biodiv/national/albania/home.htm).

Compliance with the Barcelona Convention has also motivated non-EU countries across the Mediterranean to establish monitoring networks focusing on certain taxa such as marine mammals. These however are not reflected in Figure 38.

Table 14. Summary information on ongoing monitoring programmes by MSFD descriptor, number of pressures, number of habitat types and biodiversity components covered by subregion. N/I has been counted as a positive entry. Mic: microbes; Phy: phytoplankton; Zoo: zooplankton; ANG: angiosperms; MacAlg: macroalgae; BInv: benthic invertebrates; Cep: cephalopods; Mam: sea mammals; Rep: reptiles; Bir: birds.

Mediterranean subregions	MSFD Descriptor				No of pressures	No of habitats		Biodiversity components										
	D1	D2	D4	D6		Seabed	Water	Mic	Phy	Zoo	Ang	MacAlg	Binv	Fish	Cep	Mam	Rep	Bir
Western Mediterranean (WMED)	29	10	22	8	20	14	5	2	6	5	4	5	5	7	1	5	6	6
Adriatic Sea (ADRIA)	2	0	2	2	13	12	2	0	2	0	0	1	2	1	0	0	0	0
Central Mediterranean including the Ionian Sea (CMED incl IO)	4	0	1	3	13	9	4	0	1	1	0	1	2	N/I	0	0	0	0
Eastern Mediterranean (EMED)	3	2	1	2	16	7	2	0	1	0	0	0	1	1	0	0	0	0
NON EU	3	2	0	0	8	0	0	N/I	N/I	N/I	0	0	N/I	N/I	0	0	0	0
N/I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

With regard to the four studied descriptors (Figure 39), approximately 75% of the programmes monitor Biological Diversity (D1), 66.7% Food Webs (D4), 38.5% Seafloor Integrity (D6), and 35% Non-Indigenous Species (D2). Only two programmes in the WMED (France) monitor all four descriptors. These are: *REBENT-DCE - Benthic survey for the WFD* and *RESOMAR PELAGOS - Marine stations French network - Plankton diversity survey - Slack mouth.*

Interestingly, though expected, is the coupling of D2 and D4 descriptors in 59 % of the programmes (23 out of 39 cases). The same but to a lesser extend is valid for Sea Floor Integrity which is usually coupled with Biological Diversity. With the exception of the monitoring of alien species in Rhodes Island, Greece, monitoring of Non Indigenous species is not a primary aim of any other monitoring study but a by-product of 33% of them. The Adriatic mirrors this finding by pointing out both the lack of consistent monitoring under D2 but also the lack of sharing data collected for other descriptors (e.g. for phytoplankton and macrofauna under D1) or for certain uses only (e.g. monitoring on harmful algal blooms does not link or report back formally on non-indigenous species issues).

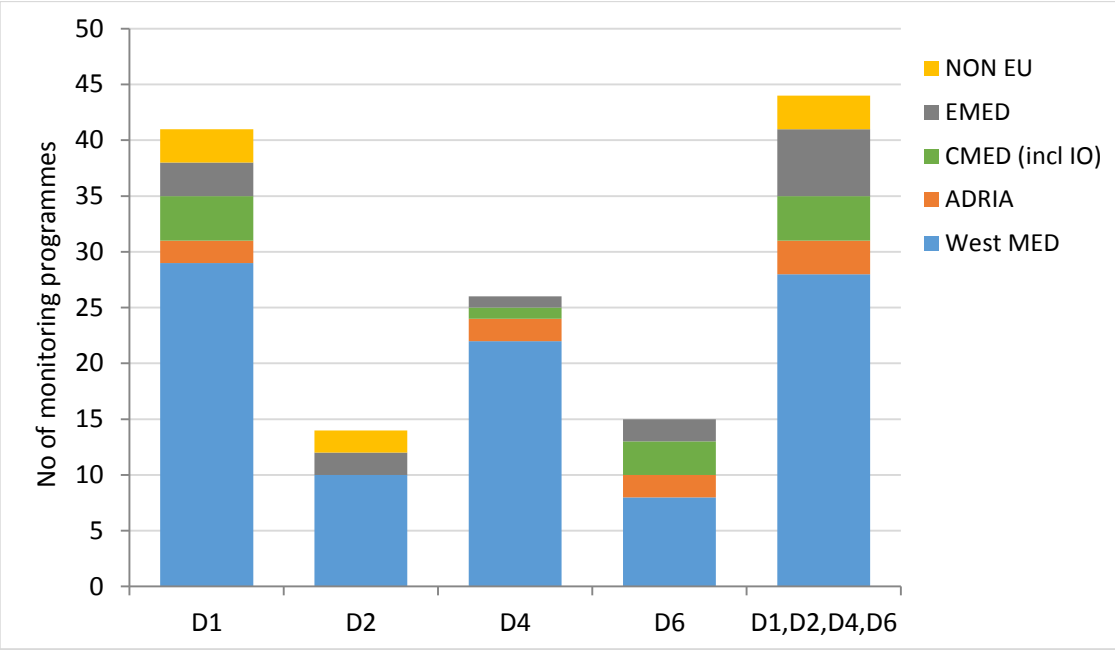


Figure 39. Number of ongoing monitoring programmes covering the D1, D2, D4 and D6 Marine Strategy Framework Directive descriptors to achieve GEnS in the Mediterranean region and subregions.

Note: *The number of programmes addressing all biodiversity issues is not the sum of the separate descriptors as many programmes conduct integrated monitoring.*

Many of the monitoring activities have been conducted under the context of broader programmes such as Natura 2000 and the Habitats Directive, the WFD, the fisheries Data Collection Regulation (DCR) and Data Collection Framework (DCF) programme under the Common Fisheries Policy, and other policy drivers such as the Barcelona Convention. In addition a few programmes have been undertaken in the framework of European Research projects. Consequently, in approximately 60% of them, biodiversity data are complemented by physicochemical data.

The seabed habitats covered, vary among geographical sectors (Figure 40). In the WMED it appears that most habitats from Littoral to the Abyssal zone (soft and hard substrata) are monitored (14 habitats in total) with the exception of the upper and lower bathyal, as opposed to the EMED (Aegean Sea) where monitoring is being carried out in the shallow sublittoral to shelf sublittoral zone mostly on soft substrata (seven habitats in total). (Figure 40). In the Adriatic, the programme 'Monitoring the quality of coastal marine waters' is carried out at the shallow sublittoral zone, whereas the 'Network for the Conservation of Cetaceans and Sea Turtles in the Adriatic' monitors a wide range of habitats (nine in total). Six seabed habitat types are not monitored in the Adriatic but two of these do not exist in the area, namely abyssal rock and biogenic reef and abyssal sediment. Four water column habitat types are not monitored in the Adriatic but one of these does not exist in the area, namely ice-associated habitats. In the Ionian Sea

(CMED), although there is less scientific effort than in the Aegean Sea, monitoring appears to include more habitats. This is mostly attributed to the monitoring of the MEDITS programme.

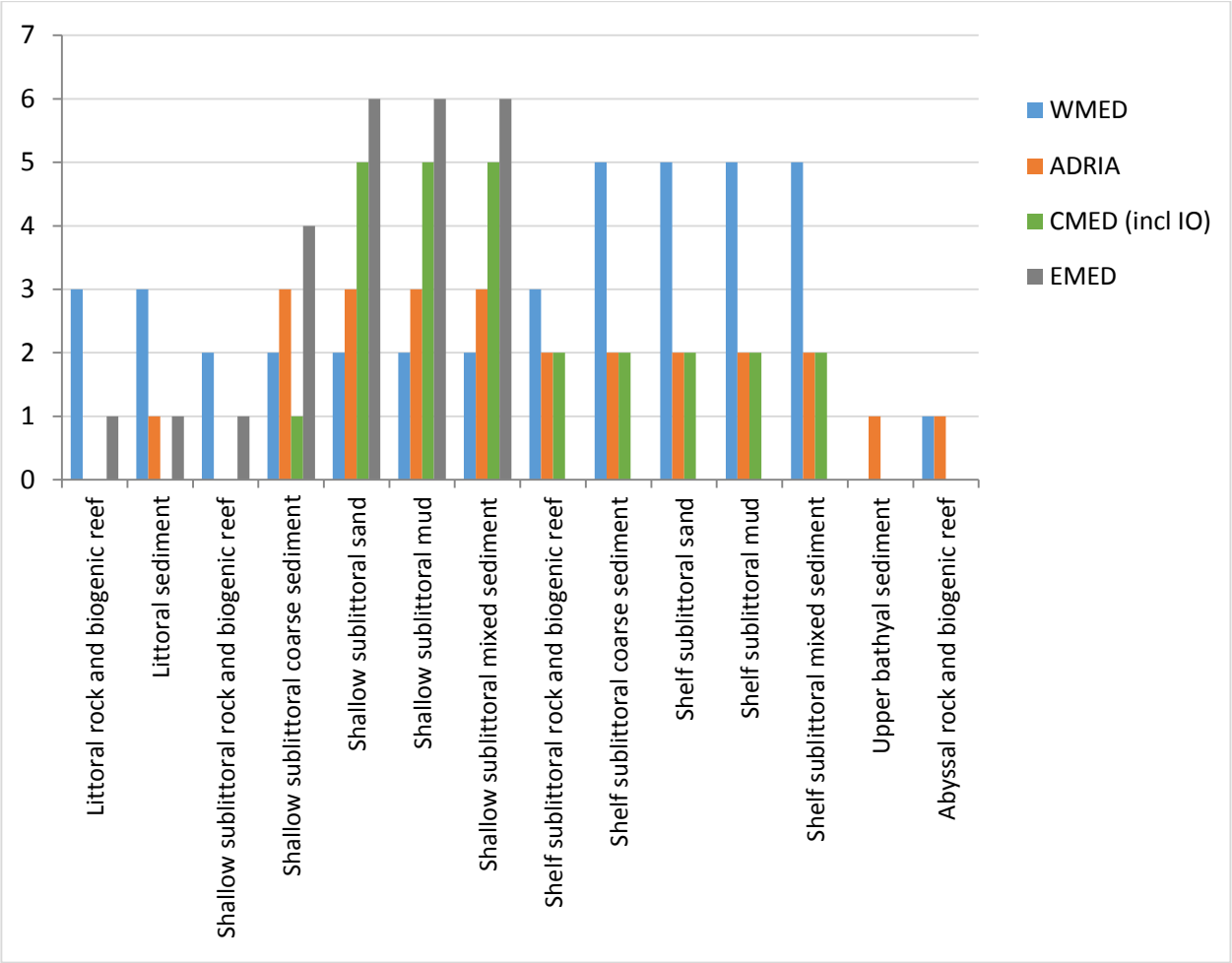


Figure 40: Sea bed habitats covered in monitoring in the Mediterranean region and subregions.

The biodiversity components covered vary among geographical sectors (Figure 41 and Table 14). With the exception of the WMED the coverage by all other regions is less comprehensive and the coverage of the components cephalopods, reptiles, mammals, birds and microbes is non-existent. Some spatially and temporally fragmented information exists for example in the Adriatic for mammals and birds while information collected for microbes in the context of the bathing water directive (e.g. in Italy and Greece) does not fit the needs of the MSFD under D1.

The pressures covered vary among geographical sectors (Figure 42 and Table 14). The WMED has the most comprehensive list of pressures (20); even so a number of pressures are missing including for example underwater noise, barrier to species movements, electromagnetic changes, and a number of locally

managed salinity-temperature-emergence regime changes. The Aegean-Levantine subregion is reported to provide data and/or to monitor 16 pressures, with again a considerable number of pressures missing. The monitoring programmes of the Adriatic and Central Mediterranean (including the Ionian Sea) subregions are reported to cover 13 pressures. In the Adriatic a number of locally managed and climate related unmanaged pressures are missing along with pressures missing from other subregions (e.g. substrate loss, underwater noise, electromagnetic changes, death or injury by collision). The reported coverage by all other regions is in reality less comprehensive than required in terms of data quality and spatial and temporal spread as well as in terms of providing data relevant to state pressure relationships (wherever these might exist). A number of pressures are missing: underwater noise, emergence regime change WIDESPREAD-unmanageable, Change in wave exposure WIDESPREAD-unmanageable, electromagnetic changes, and introduction of radionuclides. Major regional pressures are not monitored in all the subregions (e.g. habitat loss is only monitored in the WMED) while some pressures are reported to be monitored in all subregions. Among these are the introduction of non-synthetic substances and compounds, nitrogen and phosphorus enrichment, organic matter enrichment and marine litter. Surprisingly this also includes the introduction of NIS when the gap analysis for monitoring for Descriptor 2 highlights the less than perfect coverage of the data collected in at least two subregions. There are no programmes targetting simultaneously all different biodiversity components, descriptors, habitats and pressures.

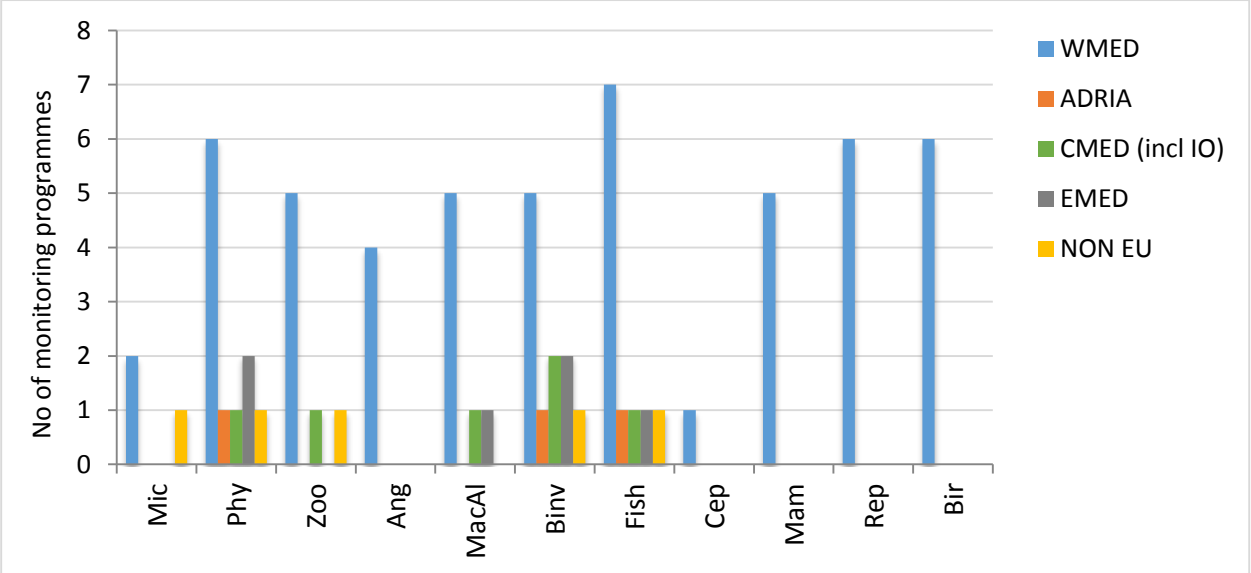


Figure 41: Biodiversity components covered in monitoring in the Mediterranean region and subregions.

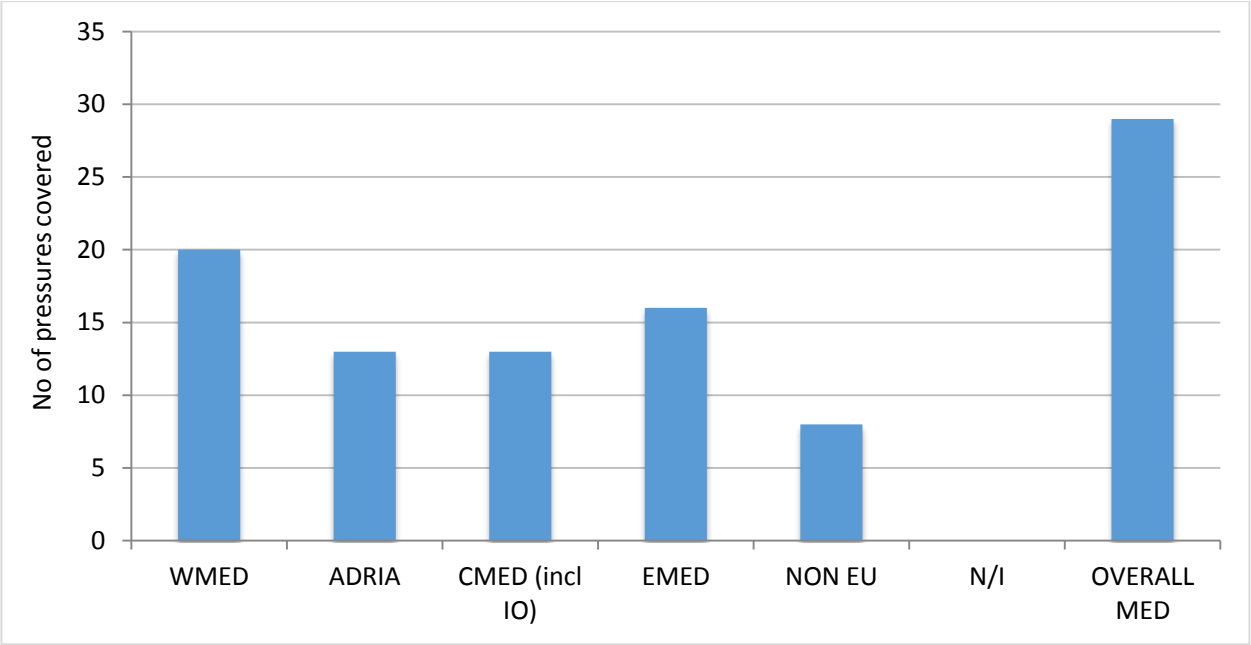


Figure 42: Number of pressures covered in monitoring in the Mediterranean region and subregions.

D1 - Biodiversity

Higher Trophic level biodiversity components (marine mammals, reptiles and birds) appear to be monitored exclusively in the WMED. However, as the DEVOTES monitoring catalogue includes mostly institutional programmes, NGO's activities in the Adriatic, Ionian and Aegean Sea, targeted mostly on these taxa that are missing. For example beach monitoring of *Caretta caretta* in the National Marine Park of Zakynthos (Ionian Sea) has been fully undertaken since 1984 by the Sea Turtle Protection Society, NGO ARCHELON (Margaritoulis, 2005). Similarily, the Mediterranean monk seal, which has been categorized as critically endangered on the IUCN Red list is monitored not only in the WMED but across all subregions (EMED: National Marine Park Alonnisos, Northern Sporades: Dendrinos *et al.,* 2007). The best studied groups are in decreasing order fish, phytoplankton, zooplankton, macroalgae and benthic invertebrates. This stems from the implementation of the DCF (fish), WFD (macroalgae, benthic invertebrates) and eutrophication. Surprising is the lack of monitoring programmes in the Aegean (EMED) and Ionian Sea on *Posidonia oceanica*, identified as a priority habitat type species in the Mediterranean. Although its distribution has been mapped in the framework of NATURA 2000, the habitat is not monitored by any programme in the Greek Aegean and/or Ionian Sea.

D2 - Non-Indigenous species

The introduction of alien species appears to be relatively well monitored (by ten programmes) in the western Mediterranean. However, on looking closer at the ongoing programmes only one of them focuses on introduced species per se, namely the invasive macroalgal *Caulerpa taxifolia*. Of the remaining species, Jellyfishes operation, Jellywatch CIESM and jellywatch PACA are expected to record non-indigenous pelagic species, whereas monitoring for the MSFD will shed more light to on the issue. Nevertheless, the habitats and the target groups studied in the framework of the relative DEVOTES listed programmes are not ideal for collection of qualitative data/impact assessment attributed to non indigenous species. In the eastern Mediterranean, for example, efforts should be channeled to data collection in the framework of the Common Fisheries Policy (Data Collection Framework Regulation) for fisheries and in the western Mediterranean and in the Adriatic Sea in aquaculture sites where alien species are thriving (Zenetos *et al*., 2012). Considering the significance of shipping as a pathway/vector for species introductions in the Mediterranean (Figures 43 and 44), hotspot habitats such as ports should be permanently monitored.

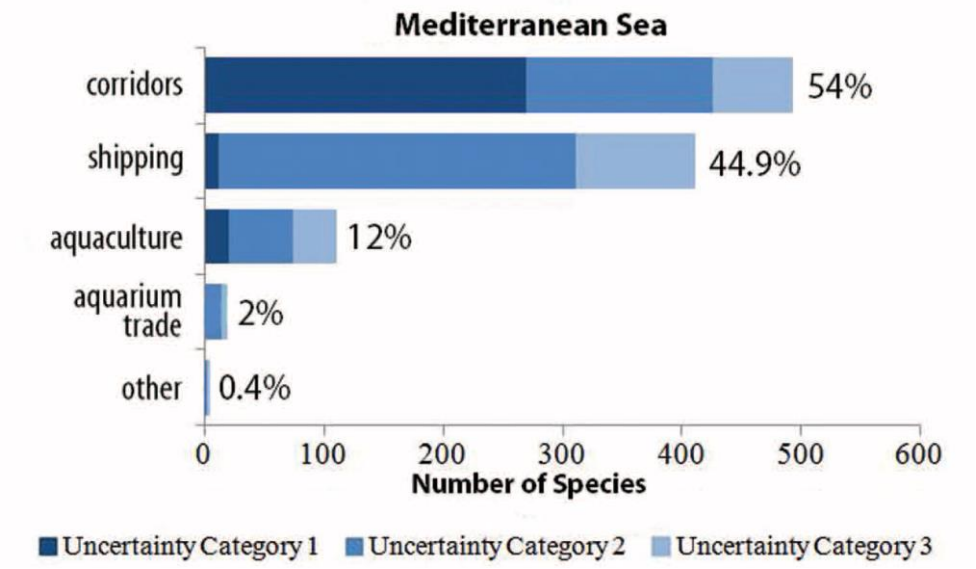


Figure 43. Number of Non-Indigenous Species (NIS) known to be or likely to be introduced by each of the main pathways. Percentages add to more than 100% (i.e. 113%) as some species are linked to more than one pathway. source: Zenetos *et al*., 2012.

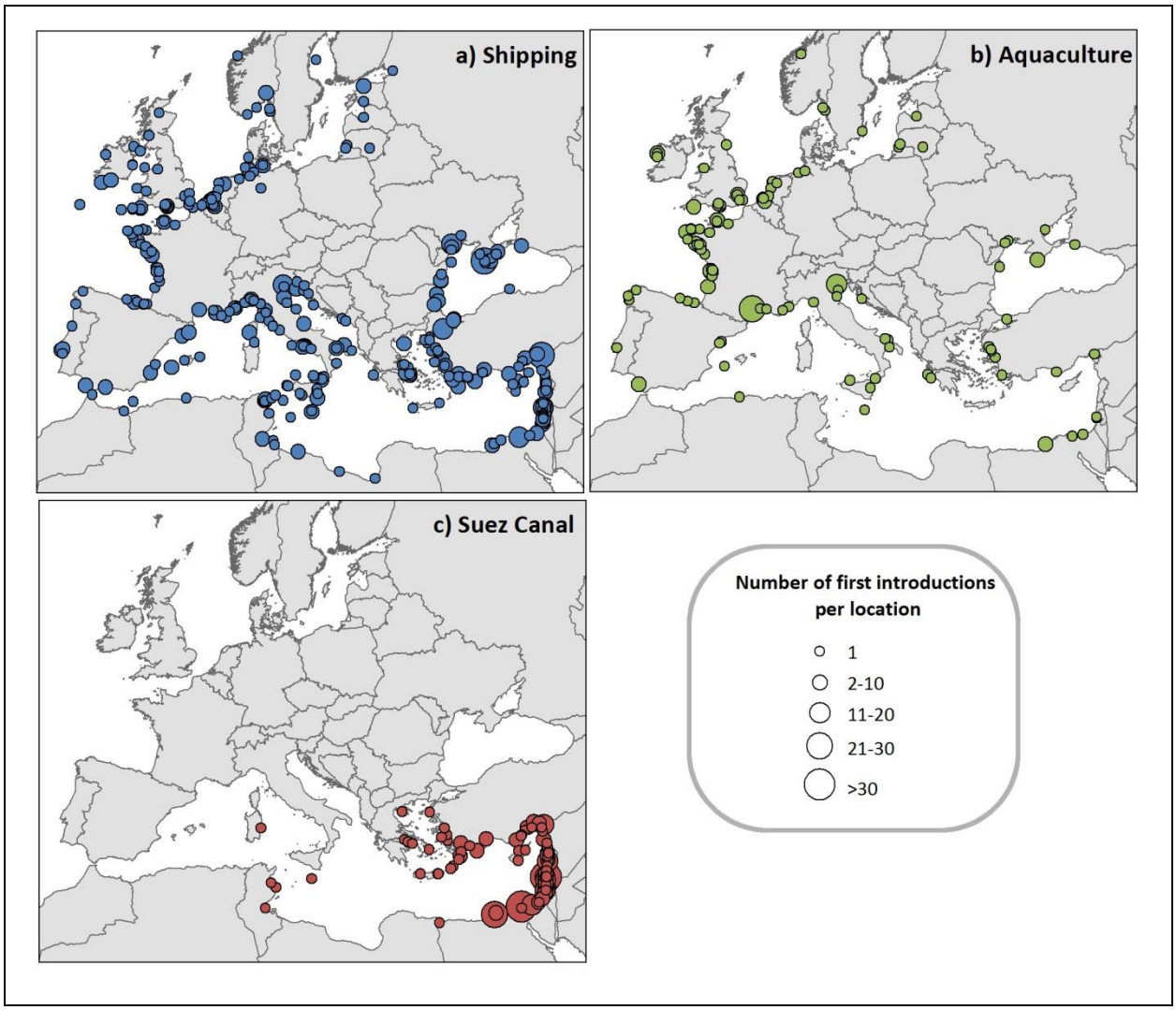


Figure 44. Maps illustrating locations of new alien species introductions in European waters, for the three main pathways of introduction: (A) Shipping (619 records); (B) Aquaculture (183 records); and (C) the Suez Canal (435 records). The circle size represents the number of new species introduced per location, arriving through a specific pathway. Source: Nunes *et al.*, in press.

Once an alien species is established it is almost impossible to remove it from its new habitat, not to mention its spreading. Thus, the more sensible way is to remove it at its very early stage. Early warning and early detection are the best ways as indicated by the recent EU Regulation.

Besides the MSFD, the introduction of non-indigenous species is directly addressed by the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean and the Action Plan concerning species introductions and invasive species in the Mediterranean Sea. To this end, UNEP/MAP RAC/SPA has developed MAMIAS: Marine Mediterranean Invasive Alien Species database (mamias.org,), which includes a tool for extracting trends in introductions at country and MSFD level. In addition,

Mediterranean countries are developing their own systems/networks for archiving alien species [Italy: Si.Di.MAr., Greece: ELNAIS].

Biological invasions are almost always large-scale processes, so tracking their onset followed by their subsequent spread is certainly challenging for the scientific community. To overcome this difficulty, one effective solution is to involve citizen-scientists and NGOs in the monitoring of NIS or in reporting historical information through national, regional, and European networks such as the CIESM JellyWatch Program and MAMIAS (UNEP-MAP-RAC/SPA, 2012). Recently, participative actions have started to be experimented with in the Mediterranean Sea and at European level (COST 1209: Aliens Challenge). The establishment of networks has been very rewarding in terms of new data (see Boero *et al*., 2009; Azzurro *et al.,* 2013; Zenetos *et al*., 2013).

D4 - Food-webs

With respect to D4, a total of 23 programmes and 43 activities (i.e. entries) have been considered. The vast majority of the studies have been carried out in the Western Mediterranean, whereas in the Central and Eastern parts of the basin, there is currently no focus on D4 in the programmes (Figure 45). Among programmes that have been conducted and completed in the areas of the Aegean and Ionian Seas, only the phytoplankton and zooplankton components were examined.

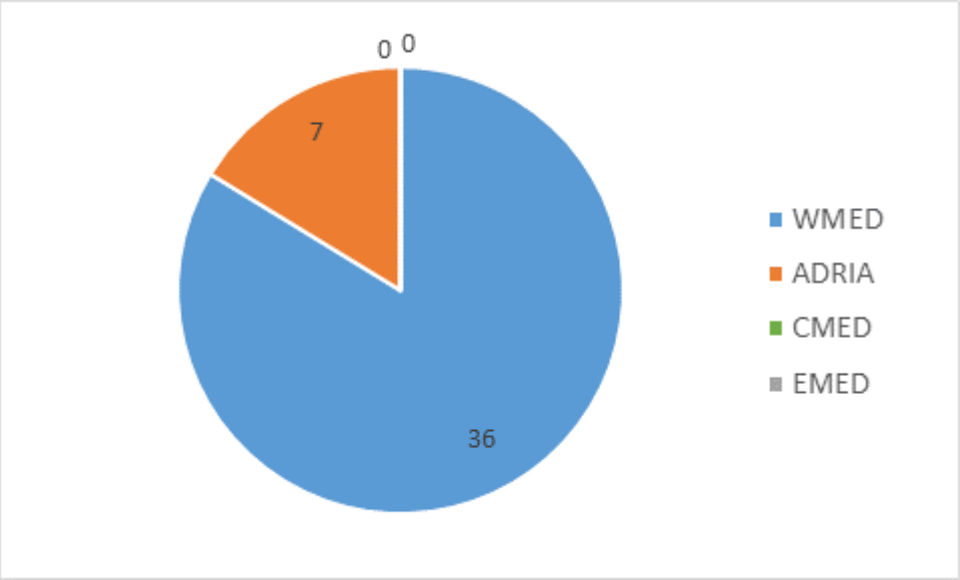


Figure 45. Spatial distribution of the current programmes dealing with the MSFD Descriptor 4 (food webs).

The 11 biodiversity components (i.e. microbes, phytoplankton, zooplankton, angiosperms, macroalgae, benthic invertebrates, reptiles, fish, cephalopods, marine mammals, and birds) were grouped into two major classes: those of low trophic level (LTCs) (i.e. microbes, phytoplankton, zooplankton, angiosperms, macroalgae, benthic invertebrates, and reptiles) and those of high trophic level (HTCs) (i.e. fish, cephalopods, marine mammals, and birds). For this classification, the trophic levels of each individual taxon, as provided in TrophLab (Pauly *et al*., 2000) were used.

None of the 23 programmes takes into account all biodiversity components. The maximum number of components that appear in a single programme is four (Project REBENT-DCE - Benthic survey for the WFD). As far as LTCs are concerned, they are examined in 31 out of the 43 activities. Out of those 31 activities, 21 take into account solely LTCs and disregard the HTCs. Correspondingly, HTCs are examined in 21 activities out of the total of 43. In eleven of the 21 activities, only HTCs are being examined and LTCs are excluded. Additionally, only eleven out of the 43 monitoring activities span both LTCs and HTCs.

Finally, there is no programme that is restricted to the sole examination of one group (i.e. only LTCs or only HTCs) that takes into consideration all the components of the group.

Large monitoring programmes applied in the Mediterranean, such as MEDITS and MEDIAS as well as sampling on board commercial vessels, which are actions incorporated in the Data Collection Framework (DCF), provide information on the abundance of megafaunal organisms (fish, cephalopods, and large crustaceans). Specifically, the MEDIAS programme provides abundance indices for small pelagic fish, the MEDITS programme for demersal species while sampling on board commercial vessels provides data on landings and by-catch. This information is crucial and useful for estimating and testing of indicators related to D4, such as the "Large fish (by weight)" indicator as well as "abundance trends of functionally important selected groups/species", which are explicitly stated in the Commission Decision 2010/477/EU as indicators 4.2.1 and 4.3.1, respectively. In addition, biological sampling performed in the framework of DCF as well as stock assessments are important sources of information on the productivity of high trophic level species (4.1).

Furthermore, biological traits and abundance indices estimated in the framework of these programmes have been used as input information for the construction of food web models. Such models integrate biological, ecological (e.g. feeding habits) and fisheries information and can be useful to identify key trophic groups/species as well as, more importantly, to provide estimates of more complex metrics (e.g. flow ratios, abundance ratios of groups of species, simulation trends) related to D4. Several food web models have been used to explore trophic flows and the structure of the food webs in all four Mediterranean subregions defined by the MSFD (WMED: e.g. Coll *et al.,* 2006, Banaru *et al.,* 2013; Adriatic: e.g. Coll *et al.,* 2007; CMED: e.g. Piroddi *et al.,* 2010, Hattab *et al.,* 2013, Moutopoulos *et al.,* 2013; EMED: e.g. Tsagarakis *et al.,* 2010), however, not covering all subdivisions.

D6 - Seafloor integrity

Generally the MSFD D6 is covered by overlapping parameters of the WFD, which is literally the criterion 6.2. "condition of benthic communities". Indicators (Criteria) 6.2.1. “presence of particularly sensitive and/or tolerant species” and 6.2.2. “multi-metric indexes assessing benthic community condition and functionality” are fully covered by indices applied under the WFD or by indices or schemes that are derived secondarily from the benthic species taxonomy provided under the WFD work for benthic macroinvertebrates Environmental Quality Standards assessment. Indicators 6.2.3 “Proportion of biomass or numbers of individuals in the macrobenthos above some specified length/size” and 6.2.4 “Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community” related to size parameters are mostly applied in transitional waters.

For the Criterion 6.1. regarding physical damage of the seafloor substrates, information is more scarce and scant and may be derived indirectly through bottom trawl surveys (assessing the fisheries pressure inflicted on the sea floor) or by habitat mapping surveys which seem to be mostly related to sea grass bed (*Posidonia*) mapping or other natural reserves monitoring (Habitats Directive, MPAs) also providing information for D1. Both methodological gaps and data gaps are reported for this criterion by a number of EU MS (Laroche *et al.,* 2013).

In Spain, the active monitoring relates to *Posidonia oceanica* meadows and D6 is covered in relation to this habitat and related benthic communities (6.2.). Hence the criterion 6.1. regarding physical damage of the seafloor substratum characteristics may also be assessed (depth extend of Posidonia meadows). CNRS covers D6 under the Benthic survey for the WFD addressing presumably the biological quality elements of benthic macroinvertebrates, seagrasses and macroalge under the WFD. Bottom trawling surveys also address epifaunal benthic macroinvertebrates and presumably provide an aspect of the criterion 6.1. of D6 in relation to criterion 6.1. and specifically the indicator 6.1.2. “extent of the seabed significantly affected by human activities for the different substrate types”. The French natural reserves monitoring, relating to the Habitats Directive provides some habitat mapping and probably also assesses criterion 6.1.1. regarding “type, abundance, biomass and areal extent of relevant biogenic substrate”.

Most of the Adriatic Sea countries have data from their regional monitoring programmes, and some of them have already developed the infrastructural and operational monitoring needs and actions within the WFD and the Habitats Directive and their implementation. The analysis of the spatial cover of monitoring programmes along the Adriatic subregion reveals that, overall, the Northern sector of the Adriatic Sea is covered much better than the southern sector with good monitoring practices. A similar gradient in the efficiency of monitoring coverage applies to the transition from the west to the east coasts of the Adriatic Sea, also partly because some Member States entered the Community very recently (e.g. Croatia). Despite the spatial-temporal fragmentation of the data collected, large sectors of the Adriatic subregion are

subject to the monitoring of D1 (Biological diversity), D4 (Food webs), and D6 (Seafloor integrity) descriptors (6.2. criteria).

In the Aegean Sea and Levantine, Greece and Cyprus (although not reported in the catalogue) cover D6 through the monitoring program of the WFD for coastal and transitional waters i.e. 6.2. benthic communities condition (benthic macroinvertebrates and macroalgae as WFD biological quality elements) addressing diversity and sensitivity indices pertaining to indicators 6.2.1., 6.2.2. However size indicators (6.2.3., 6.2.4.) are only applied in transitional waters. For coastal waters more localized monitoring programmes address the same parameters as the WFD for coastal waters. Bottom trawl surveys (MEDITS) may also give an aspect of the damage inflicted by fisheries on the sea floor (6.1.) and a number of seafloor integrity studies on potential indicators are underway (Simboura *et al*., 2012). Along the Turkish coast, D6 is covered by the monitoring of Izmir Bay addressing benthic communities and macroalgae condition.

4.4.2. Identification of gaps

The analysis of the reported monitoring programmes of the Mediterranean Sea, allowed the identification of the following gaps:

- Insufficient Mediterranean coverage of monitoring networks.
- Country data deficiencies in a number of networks.
- Uneven habitat coverage (Figure 40). Monitoring in the Western Mediterranean addresses a wide range of habitats from the littoral zone to abyssal sediments. In the Eastern Mediterranean monitoring is channeled to soft/mixed substrata in the sublittoral zone. Only one programme is studying hard substrata in the littoral zone.
- Uneven study of biodiversity components (Figure 41). Fish, benthic invertebrates and phytoplankton are monitored in all four subregions. Reptiles, mammals, birds and microbes are not monitored at all although some fragmented but unavailable data do exist.
- Uneven study of pressures. Data on a number of pressures are missing. This includes a few unmanageable pressures (e.g. emergence regime widespread change) along with underwater noise, electromagnetic changes and Introduction of radionuclides. Major regional pressures are not monitored in all subregions (eg habital loss) and/or seemingly complete regional coverage (eg for marine litter and aliens) is in reality very patchy and sub-optimal at the subregional level.
- All seabed and water habitat types appear to be monitored although the coverage is very patchy and far from adequate. Looking at finer resolution habitat types (e.g. EUNIS level 5 or more) and at habitats protected by EU legislation or regional policies (Habitats Directive, Mediterranean Regulation, UNEP MAP), a number of habitats including Posidonia and maerl habitats are not monitored in some subregions (and mapping is far from comprehensive). No data are reported for the ice-associated habitats although this is not relevant in the Mediterranean region.
- Data gaps, knowledge gaps and the need for further development of assessment methodologies (e.g. D4) and monitoring networks (e.g. D2) have been reported by a number of EU Member States in their initial assessments. Lack of methodological standards (e.g. for D6) and lack of common or harmonized methodologies (e.g for D1) have also been reported.

4.4.3. SWOT analysis – Mediterranean Sea

Strengths S

- The prior experience gained through the WFD (especially for D1 and D6)
- The role of NGOs is increasingly important in recording and monitoring native and alien biodiversity (especially for D1 and D2).
- Joint efforts by different policy instruments acting on different scales i.e. MSFD, UNEP MAP and individual countries enhance recording and monitoring capabilities
- Joined up efforts and support in data collection through other EU policies, for example, through incorporating additional marine litter data collection to so far purely fisheries data collection and monitoring schemes under the CFP such as MEDITS
- Support by citizen science and associated established networks in recording and monitoring biodiversity components

Weaknesses W

- Misreporting: The level of reporting in the monitoring catalogue has not always been ideal. These shortcomings are detailed in Patrício *et al*. (2013) although use of expert knowledge in D1.4 report has remedied some of these issues.
- Under-reporting: Although the WMED is sufficiently covered, at least its European area, reporting was limited for the Ionian and Central Mediterranean (lack of input for Malta, Italy); the Adriatic (input only from Italy); and the EMED (input only from Greece).
- Whilst some countries reported programmes carried out by NGOs, others did not. Thus, even well-known existing information derived from projects such as MEDPOL is not analysed herewith (however MEDPOL covers a number of non-DEVOTES partner countries).
- Data on most descriptors are limited in space and time. Moreover, it is not debatable whether any of the projects addressing descriptor D4, are indeed examining prey-predator relationships and the structure of the food webs
- There is a deficiency of data concerning pressures. However, the lack of monitoring programmes dealing with pressures should not be considered as a full lack of data about most of them. Many data about pressures can be mined from multiple sources, under the premises of specific research or monitoring actions but with spatially and temporally fragmented and multiple purposes designs. Mismatch of scales between for example data collection needs for biodiversity components and pressures can be an issue.

Opportunities O

- Long-term studies and successful monitoring programmes reported significant modifications of the environment conditions (e.g. in the Northern Adriatic Sea), due to climatic fluctuations and changes of the anthropogenic pressure (e.g. Danovaro *et al.,* 2009; Conversi *et al*., 2010).
- Previous studies also reported warming of surface waters at the Adriatic regional scale and acidification of dense waters due to the increase of atmospheric CO_2 (Giani *et al*., 2012; Russo *et al*., 2002).
- Major regional and subregional reviews are making use of historical data trends and findings of existing successful monitoring programmes to enhance our understanding of how the whole ecosystem can respond to these pressures and environmental changes.
- There is an opportunity to learn (and build on) from past and recent experiences and very recently through the first cycle of the implementation of the WFD. This can be used to highlight areas of attention for MSFD such as harmonization of methods, data sharing and to identify potential hot spot areas for additional monitored parameters. Good practice examples (e.g. MEDITS) could be replicated for other components and/or expand its spatial and temporal spread to fit the needs of MSFD and more than one descriptor/pressure.
- There is an opportunity to build synergies and formal communication and data sharing channels between policies to support wider monitoring of components-habitats-pressures.
- There is an opportunity to fully align and support the regional seas programme with the MSFD by providing both the science base and a structured and standardised approach to assessment and monitoring.

Threats T

- Limited power to detect GEnS because of the few ecosystem components monitored, biodiversity indicators are still under development, monitoring is not standardized in terms of methods of sampling, policy and use of the available data require optimization.
- Since monitoring has not necessarily been designed to address specific pressures, there is currently insufficient information to adequately address pressure-impact relationships (D1.3, Patrício *et al*., 2013).
- Type and frequency of sampling and the sampling scales of the monitoring programmes are often constrained by available expertise, limited number of, human and other resources and/or insufficient financial support to identify the potential changes in biodiversity.
- Data collected are not easily available and this hampers a wider control and an appropriate utilization of information. Data on monitoring details, scales, methods, sampling and statistical power as well as spatial data and maps are not readily available. Open Access data are still limited and access is usually restricted
- Even good examples of monitoring networks in terms of countries participating and/or standardised protocols (e.g. MEDITS and MEDPOL) suffer from data gaps in years missed in their data collection due to budgetary constraints. Adequate funding is required for EU member states to maintain ambition levels (not to back-down to minimums, and for non-EU member states to be able to access funding whether it is national or international. A sustainable funding scheme and a rapid response/intervention framework is necessary for a successful monitoring scheme.
- Knowledge and data gaps might not be addressed if not backed up by a sufficient research budget (e.g. with dedicated proposal calls) or if priority shifts from environmental concerns to blue growth initiatives and for example mapping and monitoring needs give way to employment and growth and development needs.

5. Concluding Remarks

5.1. Overall Gap analysis

***GEnS Descriptors*:** Monitoring programmes which address the descriptors D1 'Biological Diversity' and D4 'Food webs' are the most numerous in all regional seas when taken as a whole, whereas monitoring associated with D2 'Non-indigenous species' and D6 'Seafloor integrity' are the least numerous. The distribution of monitoring programmes that address these descriptors however varies both within and between regional seas. In the Mediterranean for example, most of the 23 catalogued programmes addressing descriptor D4 'Food webs', have been carried out in the West Mediterranean, whilst no monitoring currently addresses this descriptor in the East Mediterranean. In the Black Sea, monitoring associated with this descriptor is completely lacking. Monitoring addressing descriptor D2 'Non-indigenous species' is lacking or the scope of the monitoring is of concern in all regional seas with the exception of the North Eastern Atlantic.

Some of the above highlighted gaps were expected. For example, monitoring for non-invasive species was not explicitly required by EU law before the MSFD entered into force although some EU MS have been collecting data on non-invasive species and using them for coastal water quality assessment. The lack of D2 monitoring is in line with the finding of Vandekerkhove and Cardoso (2010) that most existing monitoring programmes fail to detect some indicative non-indigenous species. Zampoukas *et al.* (2014) recommended that existing monitoring programmes (e.g. for the WFD) should be complemented to explicitly record non-indigenous species and to include high priority samplings sites.

Biodiversity components: In general, monitoring programmes which address high trophic level (HTC) biodiversity components (including cephalopods, reptiles, mammals and birds) are lacking or limited in all regional seas (North Eastern Atlantic, Baltic Sea, Black Sea and Mediterranean Sea).

Monitoring programmes which address fish were not identified as lacking or limited in any regional sea; however, monitoring for this biodiversity component is not evenly distributed throughout the sub-categories, with monitoring for deep sea fish, deep sea elasmobranchs and ice-associated fish lacking or limited to a small number of programmes; a pattern which is mirrored in the habitats which lack or have limited monitoring (i.e. deep sea and ice-associated habitats). In addition, most of the fish monitoring focuses on commercial species and less in non-commercial or focussed on the fish in transitional waters as dicatated by the WFD. Considering there are also few indicators for these biodiversity components (**DEVOTES Deliverable 3.1**, Teixeira *et al*., 2014), it is likely that a significant effort may be required to monitor these components once indicators are developed.

The lack of monitoring for reptiles, mammals and birds was not expected since, as presented in chapter 2.2.2, such monitoring requirements are already included the Habitats and Birds Directives. The same applies to the identified gaps in cephalopods monitoring that it would be expected to be already operational for the Common Fisheries Policy. If these gaps are not due to incomplete reporting they may indicate that the implementation of the EU environmental and fisheries related *acquis* has been limited. Contrary to cephalopods, it seems that CFP monitoring is better implemented for fish.

Monitoring programmes which address microbes are lacking or limited in all regional seas. With the exception of microbes, biodiversity components that belong to low trophic levels (LTCs) are generally well addressed by monitoring programmes in all regional seas. The exception to this is in the Baltic Sea, where monitoring programmes addressing phytoplankton and zooplankton are limited in offshore areas.

The rather good coverage of LTC monitoring could be related to the long European tradition of eutrophication monitoring and to the similar requirements of the WFD (see chapter 2.2.2). The lack of microbial diversity monitoring is expected as, with the exception of pathogens in the Bathing Water Directive, it was not previously addressed at the European level.

Quality Assurance and Supporting physicochemical data: For a number of biodiversity components Quality Assurance is lacking and in some regional seas (e.g. North Eastern Atlantic and Black Sea) around half of the monitoring activities do not collect supporting physicochemical data.

Habitats: Monitoring programmes that address bathyal and abyssal habitats (e.g. sediment, rock and biogenic reef) are lacking or limited in all regional seas in which they occur (i.e. North Eastern Atlantic, Mediterranean Sea, Black Sea EU waters). Mixed sediment habitats are also reported as having no or limited only monitoring in the Baltic and Black Seas, along with rare seabed habitats (such as shelf sublittoral rock and biogenic reef) in the Baltic Sea. The uneven coverage of habitat types monitored is also reported as problematic both within and between marine regions. In the Mediterranean Sea for example, monitoring in western subregions addresses a wide range of habitats from the littoral zone to abyssal sediments, whilst in eastern subregions monitoring is channelled to soft/mixed substratum in the sublittoral zone. Monitoring programmes addressing ice-associated habitats are recorded as completely lacking in all regional seas, however this is most likely a relic of the inadequacies of the current catalogue (lack of input from more Northern countries, particularly in the North Eastern Atlantic).

Pressures: Monitoring programmes addressing the pressure 'underwater noise' are lacking or limited in all regional seas. It is of note that even where underwater noise is monitored, the impact of noise on many biodiversity components is not well understood and the outputs of such monitoring cannot be used effectively at the present time. Monitoring programmes addressing the pressures 'introduction of radionucleides', 'electromagnetic changes', 'marine litter' and 'introduction of non-indigenous species and translocations' are also lacking or limited in most regional seas.

5.2. Overall SWOT analysis

5.2.1. Strengths

In most regional seas, current monitoring practices are built on a strong foundation of scientific knowledge (i.e. good-practice, standardised techniques and methodologies) through a long history of national and international monitoring programmes and networks, policies and EU Directives. For example the collection of supporting physicochemical data (essential to explain changes in the biological parameters or indicators) is generally common practice in monitoring programmes and biodiversity component monitoring is associated with formal Quality Assurance guidelines in a number of cases. This significant record of marine monitoring has resulted in an extensive system of monitoring programmes and networks in most regional seas and/or subregions. This provides a good foundation for implementation of the MSFD with the aim to achieve good GEnS, as overall (i.e. in all regional seas) monitoring programmes address all descriptors, biodiversity components, habitats and pressures. Additionally, nearly all monitoring programmes address more than one descriptor, with descriptor D1 and D4 (Biological diversity) particularly well addressed through a large number of monitoring programmes.

In most regional seas, the 11 biodiversity components are being covered and several are monitored simultaneously. Similarly, most monitoring programmes address more than one seabed and water column habitat at the same time, optimizing the sampling efforts.

In general, most monitoring programmes address more than one pressure. Although these are exeptions some monitoring activities assess 18-20 pressures at once (e.g. Celtic Seas subregion), suggesting the potential for monitoring programmes to become more efficient.

A full breakdown of the strengths of current marine monitoring in all regional seas is shown in the Overall SWOT table (Table 15).

5.2.2. Weaknesses

The major weakness found within this catalogue is that it is currently under development and is therefore not a complete representation of all monitoring programmes operating within the regional seas. In proposing that this exercise was undertaken, it was assumed, wrongly, that all Member States readily knew their monitoring and so this merely required collating. The catalogue also currently provides no indication of the intensity or adequacy (i.e. methodologies) of monitoring and only provides information on spatial coverage. The analysis in this report has highlighted the fact that in order to assess the adequacy

of the monitoring programmes and networks in addressing pressures on biodiversity components, it is necessary to have information on specific details of methodological procedures (i.e. sampling design, frequency, temporal and spatial scales, standardized procedures between Member States). This information is currently not contained within the monitoring networks catalogue.

Despite the strengths listed above, one of the main weaknesses of using current monitoring programmes in the implementation the MSFD is the spatial variability of current monitoring and the robustness of current monitoring programmes. In a number of subregions, monitoring programmes address a specific focus (e.g. habitat, species, pressure, etc.) resulting in an uneven distribution of spatial (e.g. sites) and temporal (e.g. sampling interval and frequency) monitoring scales and monitored components (i.e. not all components are monitored in all subregions). At the spatial scale required for implementation of the MSFD (region and subregion), the uneven spatial and temporal scales of individual monitoring programmes are masked and monitoring (the descriptors, components, habitats and pressures) is shown to occur, however in reality, monitoring may only take place in a small number of specific subregion sub-sections.

The number of monitoring programmes that address simultaneous biodiversity components, descriptors, habitats and pressures (managed and unmanaged) is used in this report as a measure of the robustness of ongoing monitoring to potentially meet the requirements of the MSFD (to achieve GEnS) in all regional seas. A number of monitoring programmes both within and between regional seas address single or a limited number of components, habitats and pressures and although not explicitly investigated within the catalogue, may be limited in terms of spatial (e.g. geographic area, sampling locations) and temporal (time-series, sampling frequency) scale. There is a need for monitoring programmes to become more efficient and robust, integrating several biodiversity components, habitats and pressures through simultaneous monitoring. Additionally, despite the extensive system of monitoring programmes that exist in most regional seas, a number of biodiversity components (e.g. microbes), descriptors (e.g. non-indigenous species), habitats (e.g. ice or deep sea habitats) and pressures (e.g. noise, introduction of radionuclides, selective extraction of living resources such as seaweed and maerl) are poorly or not addressed.

In addition, quality assurance (QA) protocols associated with the monitored biodiversity components vary per component, monitoring country and institute. Overall, QA is not associated with all of the monitored biodiversity components or this information has not been or cannot be provided.

A full breakdown of the strengths of current marine monitoring in all regional seas is shown in the Overall SWOT table (Table 15).

5.2.3. Opportunities

This report has highlighted a number of inadequacies in the monitoring currently undertaken in the regional seas. This presents a number of opportunities to develop new monitoring programmes or to modify and/or expand existing ones and to collaborate with Member States both within and between regional seas to develop collaborative, harmonised and robust monitoring programmes and networks that maximise use of the best available data. This would mean the introduction and/or integration of validated external Quality Assurance protocols, standardised verification of analyses and species identification and a focus on upgrading the spatial and temporal resolution of monitoring and inter-calibration procedures. It would also mean increasing the robustness of monitoring by introducing the simultaneous monitoring of descriptors, biodiversity components, habitats and pressures within single, large monitoring programmes and ensuring that monitoring is designed to address specific pressures. This may also lead to an oppurtunity to create an online bank of all monitoring programme data accesable to all EU Member States.

Implementation of the MSFD also provides the opportunity for collaborative work with non-member states to address actions to improve and/or develop monitoring programmes to achieve GEnS in some regional seas (i.e. the Black Sea). For example, through the Black Sea Commission, non-EU member states of the Black Sea may be encouraged to develop more EU-integrated monitoring programmes (especially for the descriptors related to biodiversity monitoring). Regional cooperations with non-member states may prove essential for achieving GEnS in regional seas that border non-EU nations. It is of note that as of January 2014 some countries are already carrying out public consultation exercises on the monitoring currently performed and that required to fulfil the demands of the MSFD (e.g. for the UK see https://consult.defra.gov.uk/marine/msfd-proposals-for-uk-marine-monitoring-programmes). It is expected that such consultations will both indicate monitoring programmes and their adequacy for the MSFD.

Our findings regarding the inadequacies in the monitoring currently undertaken in the European regional seas form the basis of further research requirements.

A full breakdown of the strengths of current marine monitoring in all regional seas is shown in the Overall SWOT table (Table 15).

5.2.4. Threats

The most obvious and significant threat to monitoring is budgetary constraints within EU Member States (e.g. Borja and Elliott 2013). For example, even good examples of countries participating in monitoring networks with standardised protocols (e.g. MEDITS and MEDPOL) suffer from data gaps from years missed

due to budgetary constraints. As identified above, in order to implement the MSFD and achieve GEnS, it is necessary to improve the current and future monitoring of marine biodiversity in all regional seas. In order to achieve this, it is important to increase the number of ecosystem components monitored and to develop specific monitoring programmes to analyse pressures and pressure-impact relationships. In some regional seas it may also be necessary to increase sampling frequency, intensify sampling design and standardize sampling methods. A sustainable funding scheme and/or research budget and a rapid response/intervention framework may be necessary ensure successful integrative monitoring schemes within and between regional seas. In the current economic climate, it is difficult to envision which, if any, EU Member States would be able to provide an appropriate budget for this.

Each EU Member State has a long history of monitoring which has been expanded, modified and developed over time. As a result of these developments, together with methodological differences between nations, integration and holistic assessment of the data (at a regional sea level) may be difficult, time consuming and economically restrictive. Furthermore, Member States may be reluctant to generate new monitoring programmes and so rely on existing programmes; however, those may have been designed for other purposes and so may be inadequate for fulfilling the MSFD needs.

Whilst implementation of the MSFD requires collaborative regional cooperation between Member and Non-Member States, Non-Member States are under no legislative requirement to achieve GEnS in their respective regional seas. Achieving this cooperation may put undue additional pressure on Member States and if agreements with Non-Member States are not in place, or infractions (i.e. pressure impacts) cannot be prosecuted, GEnS in the regional sea may not be achieved.

A full breakdown of the strengths of current marine monitoring in all regional seas is shown in the Overall SWOT (Table 15).

Table 15. Overall SWOT analysis: Strengths of the existing monitoring networks across the four European Regional Seas (North Eastern Atlantic, Baltic Sea, Mediterranean and Black Sea) and the Sea of Marmara, based on the monitoring activities reported in DEVOTES Catalogue of Monitoring Networks.

STRENGTHS

GEnS Descriptors

- In all Regional Seas, GEnS Descriptor 1 (biological diversity) is addressed through the greatest number of ongoing monitoring programmes.
- The GEnS Descriptor 4 (food-webs) is addressed through a considerable number of monitoring activities in the North Eastern Atlantic, Baltic Sea and in the Mediterranean Sea (particularly in Western Mediterranean subregion).
- Most ongoing monitoring programmes simultaneously address more than one GEnS descriptor.
- In the Mediterranean Sea, NGOs are increasingly involved in recording and monitoring native and alien species biodiversity (especially for D1 and D2).

Biological Components

- In most regional seas, all eleven biodiversity components identified in the DEVOTES Catalogue of Monitoring Networks are monitored, and several are monitored simultaneously.

Supporting physicochemical data

- The collection of supporting physicochemical data (essential to explain changes in the biological parameters or indicators) is generally common practice in monitoring programmes (around half of the activities in the North Eastern Atlantic, Black Sea and Mediterranean Sea, the vast majority in the Baltic Sea) although is not always associated with all biodiversity components.

Pressures

- Most monitoring programmes address more than one pressure.
- Overall, monitoring undertaken within the North Eastern Atlantic address all pressures considered in the catalogue.
- Some monitoring activities assess 18-20 pressures (e.g. Celtic Sea subregion), demonstrating the potential more efficient and integrated monitoring programmes.
- Nitrogen, phosphorus and organic enrichment are the main pressures covered.

Habitats

- Most monitoring programmes address more than one seabed and water column habitat simultaneously.
- All five water column habitats considered in the catalogue are all addressed by the ongoing monitoring activities.

Others

- In most regional seas, and in particular in the NEA and Baltic Sea, current monitoring practices are built on a strong foundation of scientific knowledge (i.e. good-practice, standardised techniques and methodologies) through a long history of national and international monitoring programmes and networks, policies and EU Directives.
- There is some degree of regional cooperation, supported by RSCs and other international initiatives.
- There are synergies between different policies and instruments operating on different scales (i.e. EU Directives, RSC agreements, and national legislation and initiatives) that enhance recording and monitoring activities.

Table 15. Overall SWOT analysis: Weaknesses (I) of the existing monitoring networks across the four European Regional Seas (North Eastern Atlantic, Baltic Sea, Mediterranean and Black Sea) and the Sea of Marmara, based on the monitoring activities reported in DEVOTES Catalogue of Monitoring Networks.

WEAKNESSES (I)

Geographical coverage

- The major weakness of the catalogue is that it is currently under development and is therefore not a complete representation of all monitoring programmes operating within the regional seas.
- In the analysed version of the catalogue, the Baltic Sea monitoring programmes are not well represented, with contributions from only Lithuania and Germany. Information from Finland, Estonia, Latvia, Poland, Sweden (and Russia) is missing. Further efforts are underway to fill this critical gap.
- The catalogue does not reflect monitoring activities carried out by all six countries that surround the Black Sea. Only Bulgaria, Ukraine and Turkey provided information for the catalogue, therefore, 23% of the region represented by coastline length is not covered.
- Under-reporting in several subregions and detailed reporting in others has contributed to a lack of coherence in the information provided in the catalogue.
- The catalogue currently only provides information on spatial coverage but no indication of the intensity or adequacy (i.e. methodologies) of monitoring.

Spatial aggregation

- The lowest spatial unit of the catalogue is the subregion. Consequently, coverage of monitored attributes (e.g. descriptors, components, habitats and pressures) may be shown as addressed in a subregion, in reality, monitoring is only taking place in a small number of specific sub-sections.

GEnS Descriptors

- In all Regional Seas, GEnS Descriptor 2 (non-indigenous species) is addressed by the lowest number of ongoing monitoring programmes
- The number of monitoring programmes that address Descriptor 6 are limited, particularly in the NEA, Black Sea and Mediterranean Sea. In the Sea of Marmara, this descriptor is not addressed at all.
- The GEnS Descriptor 4 (food-webs) is not addressed through monitoring programmes in the Black Sea and the Sea of Marmara.

Biological Components

- A number of monitoring programmes address single biodiversity components. There is a need for monitoring programmes to become more efficient and robust, integrating several biodiversity components through simultaneous monitoring.
- In all Regional Seas, microbes are the biodiversity component monitored through the lowest number of programmes. Microbes are not addressed at all in the Black Sea and the Sea of Marmara.
- In addition to microbes, marine mammals, birds, angiosperms, macroalgae and fish are not monitored in the Sea of Marmara.
- Cephalopods are addressed through a small number of monitoring programmes in the North Eastern Atlantic and Mediterranean Sea (they are not present in the Baltic Sea and the Black Sea, and for that reason there are no monitoring activities with them as targets).

Table 15. Overall SWOT analysis: Weaknesses (II) of the existing monitoring networks across the four European Regional Seas (North Eastern Atlantic, Baltic Sea, Mediterranean and Black Sea) and the Sea of Marmara, based on the monitoring activities reported in DEVOTES Catalogue of Monitoring Networks.

WEAKNESSES (II)

Pressures

- Monitoring programmes addressing the pressure 'underwater noise' are lacking or limited in all seas.
- Monitoring programmes addressing the pressures 'introduction of radionuclides', 'electromagnetic changes', 'marine litter' and 'introduction of non-indigenous species and translocations' are also lacking or limited in most regional seas.

Habitats

- Monitoring programmes addressing ice-associated habitats are recorded as completely lacking in all regional seas.
- Monitoring programmes that address bathyal and abyssal habitats (e.g. sediment, rock and biogenic reef) are lacking or limited in all regional seas in which they occur (i.e. North Eastern Atlantic, Mediterranean Sea, Black Sea EU waters).
- Mixed sediment habitats are reported as having no or limited monitoring in the Baltic and Black Seas, along with rare seabed habitats (such as shelf sublittoral rock and biogenic reef) in the Baltic Sea.
- The uneven coverage of habitat types monitored is also reported as problematic both within and between marine regions.
- There are no reported monitoring programmes covering the seabed habitats in the Macaronesian biogeographic region
- In the Sea of Marmara, the monitoring programmes do not specify the type of habitat covered.

Quality assurance (QA)

- QA protocols associated with the monitored biological components vary per component, monitoring country and institute. Overall, QA is not associated with all of the monitored biodiversity components or this information has not been or cannot be provided. There is therefore considerable risk for poor comparability between datasets where QA is not standardised or not included.

Others

- Across all European Seas, there are very few (if any) reported monitoring programmes simultaneously targeting all descriptors, biodiversity components, habitats and relevant pressures.
- Whilst some countries reported programmes carried out by NGOs, others did not.

Table 15. Overall SWOT analysis: Opportunities of the existing monitoring networks across the four European Regional Seas (North Eastern Atlantic, Baltic Sea, Mediterranean and Black Sea) and the Sea of Marmara, based on the monitoring activities reported in DEVOTES Catalogue of Monitoring Network

OPPORTUNITIES
▪ By highlighting inadequacies in the monitoring currently undertaken in the regional seas, this analysis identifies a number of opportunities to develop new monitoring programmes or to modify and/or expand existing ones and to foster collaboration between countries both within and across regional seas to develop coordinated, harmonized and robust monitoring programmes and networks.
▪ MSFD monitoring requirements considerably overlap with the requirements of other EU legislation and international agreements, therefore the ongoing programmes should already provide some of the data required for MSFD monitoring.
▪ Introduction and/or integration of validated external Quality Assurance protocols, standardized verification of analyses and species identification and a focus on upgrading the spatial and temporal resolution of monitoring and inter-calibration procedures ongoing or to be implemented.
▪ This catalogue demonstrates that single, large monitoring programmes can simultaneously address different descriptors, biological components, habitats and pressures with adequate specificity and thus there is potential for existing monitoring programmes to widen their scope and improve integration of activities.
▪ There is a lack of monitoring associated with microbes in the context of MSFD but microbial quality of shellfish and bathing waters is routinely monitored. There is an opportunity to expand and adapt this monitoring, learning from past experience.
▪ An online database of all monitoring programme data accessible to all EU Member States seems feasible.
▪ There is considerable potential to increase synergies, communication and data sharing between policies to support wider monitoring of components-habitats-pressures
▪ There is an opportunity to fully align and support the regional seas programmes with the MSFD by providing both the science base and a structured and standardised approach to monitoring.
▪ The implementation of the MSFD provides the opportunity for collaborative work between EU and non-EU contracting parties to improve and/or develop monitoring programmes to achieve GEnS in some regional seas (i.e. the Black Sea).
▪ The Sea of Marmara, although not an EU Regional Sea, is the connection between the Mediterranean and the Black Sea (EU seas). Integrating the local ongoing monitoring programmes within the Mediterranean and Black Sea networks will improve coherence in MSFD implementation.
▪ The findings regarding the inadequacies in the monitoring currently undertaken in the European regional seas form the basis of further research requirements.

Table 15. Overall SWOT analysis: Threats of the existing monitoring networks across the four European Regional Seas (North Eastern Atlantic, Baltic Sea, Mediterranean and Black Sea) and the Sea of Marmara, based on the monitoring activities reported in DEVOTES Catalogue of Monitoring Networks.

THREATS
▪ The most obvious and significant threat to monitoring is budgetary constraints within EU Member States. A sustainable funding scheme and/or research budget and a rapid response/intervention framework may be necessary to ensure successful integrative monitoring schemes within and across regional seas. In the current economic climate, it is difficult to envision which, if any, EU Member States would be able to provide an appropriate budget for this.
▪ Each EU member state has a long history of monitoring which has been expanded, modified and developed over time. As a result of these developments, together with methodological differences between countries, integration and holistic assessment of the data (at a regional sea level) may be difficult, time consuming and economically restrictive.
▪ Member States may be reluctant to generate new monitoring programmes and so rely on existing programmes.
▪ Lack of Quality Assurance protocols in monitoring programmes may hinder harmonization and comparability across the EU.
▪ Certain descriptors, biodiversity components, pressures, habitats and even subregions have limited monitoring programmes; such gaps may be an important constrain in monitoring the advances towards achieving the GEnS.
▪ Intensive monitoring activities, that use destructive methods (e.g. nets, trawls, grabs and frames), can have a negative impact on vulnerable and rare species or habitats.
▪ Data collected are often not easily available and this might limit their appropriate utilization. Data on monitoring details, scales, methods, sampling and statistical power as well as spatial data and maps are not readily available. Open Access data are still limited.
▪ Cooperation between EU and non-EU countries is often based on agreements that are non-binding or binding but non enforceable and thus achievement of GEnS in the regional sea may not be particularly difficult.
▪ Integrating the Sea of Marmara monitoring activities into the European networks it is not straightforward because Turkey is, currently, a non-EU country.

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Website links:

DEVOTES link project website: http://devotes-project.eu/

EMIS-EU-bathymetry-maritime boundaries-borders: http://emis.jrc.ec.europa.eu/4_1_gismap.php)

European Network of Marine Research Institutes and Stations: http://www.marsnetwork.org/

7. List of annexes

Annex 1 – DEVOTES Catalogue of Monitoring Networks

Annex 2 – Interactive .pdf files (‘*Marine Region Overviews’* and ‘*Marine Region and subregion Summaries’*)

Annex 3 – Ecosystem Overview of the European Regional Seas

Annex 4 – Supporting Gap and Monitoring Tables