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Technical guidance on monitoring for the Marine Strategy Framework Directive

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Foreword

The Marine Directors of the European Union (EU), Acceding Countries, Candidate Countries and EFTA Countries have jointly developed a common strategy for supporting the implementation of the Directive 2008/56/EC, "the Marine Strategy Framework Directive" (MSFD). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Marine Strategy Framework Directive. In particular, one of the objectives of the strategy is the development of non-legally binding and practical documents, such as this technical guidance on monitoring for the MSFD. These documents are targeted to those experts who are directly or indirectly implementing the MSFD in the marine regions.

The document has been prepared by the Joint Research Centre of the European Commission (JRC) with the contribution of experts from Member States, Regional Seas Conventions and ICES and following consultation of the Working Group on Good Environmental Status.

The Marine Strategy Coordination Group has agreed (in accordance with Article 6 of its Rules of Procedures) to endorse this document as technical guidance developed in the MSFD Common Implementation Strategy that will be published as a JRC Scientific and Policy Report. The participants of the Marine Strategy Coordination Group concluded:

"We would like to thank the experts who have prepared this high quality document. We strongly believe that this and other documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Marine Strategy Framework Directive. This document is a living document that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward on-going implementation work."

The Marine Strategy Coordination Group will assess and decide upon the necessity for reviewing this document in the light of scientific and technical progress and experiences gained in implementing the Marine Strategy Framework Directive.

Disclaimer:

This document has been developed through a collaborative programme involving the European Commission, all EU Member States, the Accession Countries, and Norway, international organisations, including the Regional Sea Conventions and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

Contents

1. EXECUTIVE SUMMARY

<u>Introduction and overarching principles</u>

According to the Marine Strategy Framework Directive (MSFD), EU Member States must establish, by July 2014, monitoring programmes for the ongoing assessment of the environmental status of their marine waters on the basis of the indicative lists of elements set out in Annex III and the list set out in Annex V, and by reference to the environmental targets established pursuant to Article 10. This means that monitoring should provide data which support suitable indicators in order to assess if Good Environmental Status (GES) has been achieved or is maintained, to measure progress towards environmental targets and evaluate the effectiveness of measures to achieve or maintain GES. These programmes have to take into account an indicative list of characteristics, pressure and impacts but also be able to detect and assess emerging issues. They need to integrate existing monitoring programmes and result in assessments that are comparable within and between marine regions and/or sub-regions. There are agreed key principles that monitoring programmes should follow. This includes that monitoring programmes should be adequate, coordinated, coherent and adaptive, they should produce interoperable data, link with assessments, take account of risk considerations, apply the precautionary principle and acknowledge differences in scientific understanding.

<u>State of the art</u>

There is already EU wide existing coastal and/or marine monitoring for the Water Framework Directive (WFD), the Environmental Quality Standards Directive, the Nitrate Directive (ND), the Habitats (HD) and Birds (BD) Directives and the Common Fisheries Policy (CFP) but not all biotic and abiotic elements and pressures of the MSFD are covered and the geographical scope of the MSFD is wider.

Regional Seas Conventions (RSCs) have important experience in coordinated monitoring and an important role in ensuring comparability in the programmes of their EU contracting parties but have also to accommodate the interest of third countries. HELCOM is advanced in agreeing common indicators and associated monitoring and also OSPAR is currently developing an assessment framework based on common indicators. OSPAR is building on the experience of the Joint Assessment and Monitoring Programme and the Ecological Quality Objectives approach to further cover MSFD requirements. In the Southern European Seas monitoring mainly covers physicochemical elements. In the Black Sea biological and physicochemical elements are monitored despite the indicators are not developed for all elements while in the Mediterranean there are efforts and plans for biological monitoring in the near future. Although there are important ecological differences between regional seas, interactions and knowledge transfer between RSCs are possible and valuable but, currently, very limited.

<u>Biodiversity monitoring</u>

Descriptors 1, 2, 4 & 6 are considered as the “biodiversity theme” and can be seen to naturally support each other and be implemented within a same monitoring programme. Data for listed species and habitats are already been collected for the HD and the BD as well as partly in the framework of RSC. Abundance is the most common parameter measured for species. Size and age measurements as well as reproduction and mortality rates are monitored for some species in some areas. Non-indigenous species, food webs and sea-floor integrity monitoring are *per se* introduced ad an EU monitoring requirement for the first time by the MSFD but some related data are already been collected by other monitoring activities. Monitoring in marine protected areas is important for determining reference conditions, defining GES and assessing the effectiveness of measures. There are several operational

models useful in complementing scarce datasets, determining past baseline conditions, predicting the effectiveness of measures and selecting species to monitor. Data availability is critical for the development of models and for the quality and reliability of their outputs.

Hydrographical monitoring

Monitoring for descriptor 7 focuses on permanent alterations and although there are discussions and proposed definitions (such as alterations lasting for more than ten years) a fully agreed definition of permanency does not exist. It is understood that this descriptor concerns mainly future activities with potential hydrological impact at larger scale than the scale of impacts addressed in the WFD. Hydrographical monitoring should cover both the data to assess related indicators as well as basic hydrographical data reflecting long-term changes in ecosystems for interpreting indicators' results. The MSFD hydrographical data requirements include the WFD requirements and some additional ones such as, topography and bathymetry of the seabed, habitat types, ice cover, upwelling, pH and pCO2 and there is considerable potential for using remote sensing, autonomous devices and models.

Eutrophication monitoring

Possible information sources for monitoring and assessment include existing data, models, expert judgement and new data collection with *in situ* measurements and remote sensing. Data requirements should be defined with respect to frequency, spatial resolution, reliability, accuracy and accessibility and there are several related RSCs' guidelines (particularly in the Northern European Seas). The monitoring strategies should take into account general common principles and can be country specific considering the characteristics of different region and sub-regions, e.g. different algal growing seasons and differences in natural variability. Although eutrophication monitoring has a long tradition of international cooperation the development of joint monitoring programmes is slow in some sea regions and there is potential for more integration across Member States.

Monitoring for commercial fish and shellfish

Fisheries related monitoring is already done for the CFP according to the Data Collection Framework (DCF) regulation that specifies 238 stocks in the N.E. Atlantic and the Baltic Sea and 97 stocks in the Mediterranean and the Black Seas. In the Atlantic and the Baltic Sea, management advice is provided by ICES while in the Mediterranean and Black Seas by the Scientific Technical and Economic Committee for Fisheries and the General Fisheries Commission for the Mediterranean. No Member State is currently fully compliant with the DCF but data availability and quality is considerable higher in the Northern European Seas. There is huge potential to combine the EU subsidized DCF monitoring with monitoring for practically all the other MSFD descriptors that currently has not been fully developed.

Contaminants

Contaminant monitoring under the MSFD descriptor D8 is very much linked to assessments of environmental pollution done within the WFD. While contaminant monitoring is supported by numerous guidance documents from the WFD and RSCs, harmonized approaches are needed and should consider the evolution in marine pollution and in technological monitoring developments. Coordinated strategies should be followed for selection and prioritization of substances to be monitored, strategies for sample collection, measurement techniques and assessment approaches. Descriptor 9 regards the monitoring of chemical contaminants in seafood. It appears closely related to Descriptor 8 but targets as endpoint the protection of the human consumer. Opportunities for information exchange and efficient collaboration should be the prime objective when considering specific monitoring for that purpose.

Litter

Monitoring of marine litter is addressed within the MSFD CIS through a dedicated technical subgroup. After having considered the technical options for monitoring, a specific guidance document has been developed which provides protocols for monitoring according to the different indicators for marine litter. The different relevant environmental compartments as seashore, sea surface, seafloor and biota have been considered as well as micro litter specifically. That guidance will provide the opportunity for harmonized approaches for future assessments. Some of the monitoring approaches are still under development, so the implementation and improvement of monitoring will require continuous collaborative efforts.

Noise monitoring

D11 monitoring is extensively addressed by a dedicated technical sub-group that published a detailed report. Concerning impulsive sounds, monitoring will be in the form of a register of activities generating such sounds. The spatial scale of the register is blocks of sea of approximately 10 nautical miles with a temporal scale of a day, approximately the scales of the known effects on individual harbour porpoises. Monitoring of trends in ambient sound requires the establishment of a network of hydrophones. This will require sampling at the scale of regional seas and collaboration between Member States. There are available standards for measurement equipments, standards and definitions for appropriate models and an initial set of rules for the placement of measurement devices that should be considered.

Monitoring of anthropogenic pressures and activities

There are only a limited number of parameters in the national monitoring programmes that monitor directly anthropogenic pressures, such as input of nutrients, organic matter and contaminants. However, a wealth of data on the underlying human activities is available, in principle, and several MS have extensive data collection programmes on activities. Monitoring should take into account spatial (large scale or point like pressures) and temporal (continuous or regular pressures or single events) scales. There are many sources of, frequently scattered, pressure information, such as from the fisheries sector (VMS data), from permitting and inspection authorities and from stakeholders organisations and Member States should aim to compile them into a single dataset.

Quality assurance and control

Quality issues are important for the whole monitoring chain and there are regional and national guidelines that should be taken into account. These guidelines give detailed descriptions of sampling and analytical procedures relating to hydrographic, chemical and biological parameters. In addition there is a large number of national and international standards and specifications available for sampling and further chemical, physical and biological analyses.

Good practices

Monitoring programmes constitute good practices when they take into account as many as possible key principles in their conception, preparation, implementation and reporting. The approaches of HELCOM to agree on common indicators and the steps towards a joint coordinated monitoring system in the Baltic Sea, the use of citizens' observations to complement monitoring data, the Monitoring and Assessment Programme of the Trilateral Cooperation on the Protection of the Wadden Sea and the North Sea Summer Surveys are highlighted as good practices.

Link with the socioeconomic component

The MSFD also requires an economic and social assessment on the use of marine waters and of the cost of degradation of the marine environment. Guidance is provided by the dedicated working group on

economic and social assessment. There is considerable tradition and know-how in collecting and reporting social and economic data for the CFP. Potential sources of socieoeconomic data include DG MARE, European Environment Agency, EUROSTAT, national account and input-output tables, International Maritime Organisation and RSCs.

Outlook

There are many monitoring activities in the European Seas and the MSFD poses an opportunity to review, revise and complement them. Research programmes have already delivered several outputs (e.g. monitoring indicators and tools) and demonstrated the feasibility of innovative monitoring approaches (e.g. acoustic imaging with multibeam sounders for habitat mapping, identification of mammals by remotely obtained sound recordings, airborne hyper-spectral scanners for mapping forests of invasive algae, habitat monitoring with video and photo cameras etc.) but there are still important knowledge deficits and gaps that should be prioritized in future research projects.

2. INTRODUCTION

2.1 Policy context and aims of the guidance document

The Marine Strategy Framework Directive[1] (MSFD) is the environmental pillar of the Integrated Maritime Policy[2]. It requires that EU Member States take the necessary measures to achieve or maintain Good Environmental Status (GES) by 2020. For this purpose Member States should regularly, every six years, assess the environmental status (Art.8), define GES (Art.9) and set environmental targets (Art.10). Monitoring programmes (Art.11) should be established and operational by 2014 and updated at least every six years. Programmes of measures (Art.13) should be set by 2015, become operational by 2016 and follow the six years cycle. Figure 1 from Claussen et al. (2011) shows the management cycle of the MSFD.

The MSFD Annex I includes a set of 11 descriptors on the basis of which GES should be determined. The descriptors address:

1. Biodiversity
2. Non-indigenous species
3. Commercially exploited fish
4. Marine food webs
5. Human-induced eutrophication
6. Sea floor integrity
7. Hydrographical conditions
8. Concentration of contaminants
9. Contaminants in fish & seafood
10. Marine litter
11. Energy

Commission Decision 2010/477/EU[3] includes 29 agreed criteria and 56 indicators on which GES could be defined. The Decision was supported by Task Groups established for descriptors 1, 2, 3, 4, 5, 6, 8, 9, 10 and 11 that published respective task group reports (Cochrane et al., 2010; Olenin et al, 2010; Piet et al, 2010; Rogers et al., 2010; Ferreira et al., 2010; Rice et al., 2010; Law et al., 2010; Swartenbroux et al., 2010; Galgani et al., 2010; Tasker et al., 2010) as well as a management group report (Cardoso et al., 2010) summarizing the state of the art and proposing the criteria and indicators related to the descriptors.

For monitoring programmes, Art. 11 MSFD states that they should be established and implemented on the basis of the initial assessment (Article 8(1)) and on the basis of the indicative lists of elements set out in Annex III and the list set out in Annex V, and by reference to the environmental targets (Art. 10). As monitoring programmes also serve to assess the effectiveness of measures, this aspect has to be taken into account as well - though not totally convertible in the first cycle as the establishment of measures follows after the establishment of monitoring programmes. They should also be compatible within marine regions or subregions and shall integrate and complement the monitoring requirements imposed by other EU legislation, such as the Water Framework Directive (WFD)[4], Habitats Directive (HD)[5] and Birds Directive (BD)[6] and international agreements, such as the Regional Seas Conventions

[1] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy.

[2] http://ec.europa.eu/maritimeaffairs/policy/

[3] Commission Decision 2010/477/EU of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters.

4 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

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

(RSCs). Consistency, coherence and comparability within marine regions and subregions should be ensured by coordination of monitoring programmes and methods in the framework of RSCs taking also into account transboundary features and impacts. According to the document "Monitoring under MSFD- Recommendations for implementation and reporting"[7]:

"Coherent" (Art 5.2 – 11.2 – 12 – 13.4 – 16) could be applied where monitoring programmes established for the national part of a marine (sub-)region are compared to those within the whole marine (sub-)region or across the EU.

"Compatible" (Art 11.1) could be applied for monitoring programmes established for the national part of a marine (sub-)region within areas with the assessments and monitoring of other Community legislation.

"Consistent" (Art 8 – 9.3) could be applied for monitoring and assessment methods to be designed so as to facilitate comparability of monitoring results, hence providing data fit for aggregation across Member States sharing the same marine (sub)region and across different scales (see also Recommendation 7).

A JRC report (Zampoukas et al., 2012) related the MSFD monitoring requirements with those of other EU legislation and identified some initial considerations for the establishment of monitoring programmes. The document "Monitoring under MSFD- Recommendations for implementation and reporting" was agreed in the MSFD common implementation strategy (CIS) and forms the basis for this guidance document. It relates monitoring with reporting, it summarizes the outcomes of and the gaps identified in the two 2012 JRC workshops[8] on contaminants/eutrophication and biodiversity and includes seven recommendations for the implementation of monitoring programmes.

The MSFD has the ambition to ensure that a certain level of protection will be granted for all EU marine waters allowing for a comparable level of GES despite differences in abiotic and biotic conditions, know-how, pre-existing policies and traditions in the different regions and countries. These differences, however, are significant and could justify different monitoring approaches. Establishment of monitoring programmes should be based on the best available science and technology.

This guidance aims to frame monitoring for MSFD before the establishment of the first monitoring programmes by bringing together experts across the EU and agreeing on some minimum standards to be followed and concepts to be considered and, in particular, applying the already agreed recommendations in specific monitoring issues.

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

[7] https://circabc.europa.eu/w/browse/6902dba0-53e4-4cf4-8483-689fc1daffdb

[8] https://circabc.europa.eu/w/browse/a6496791-a677-488e-bd8f-bb255b6dea89; https://circabc.europa.eu/w/browse/b6242e8d-e0e7-4982-8df0-6b41527e76af

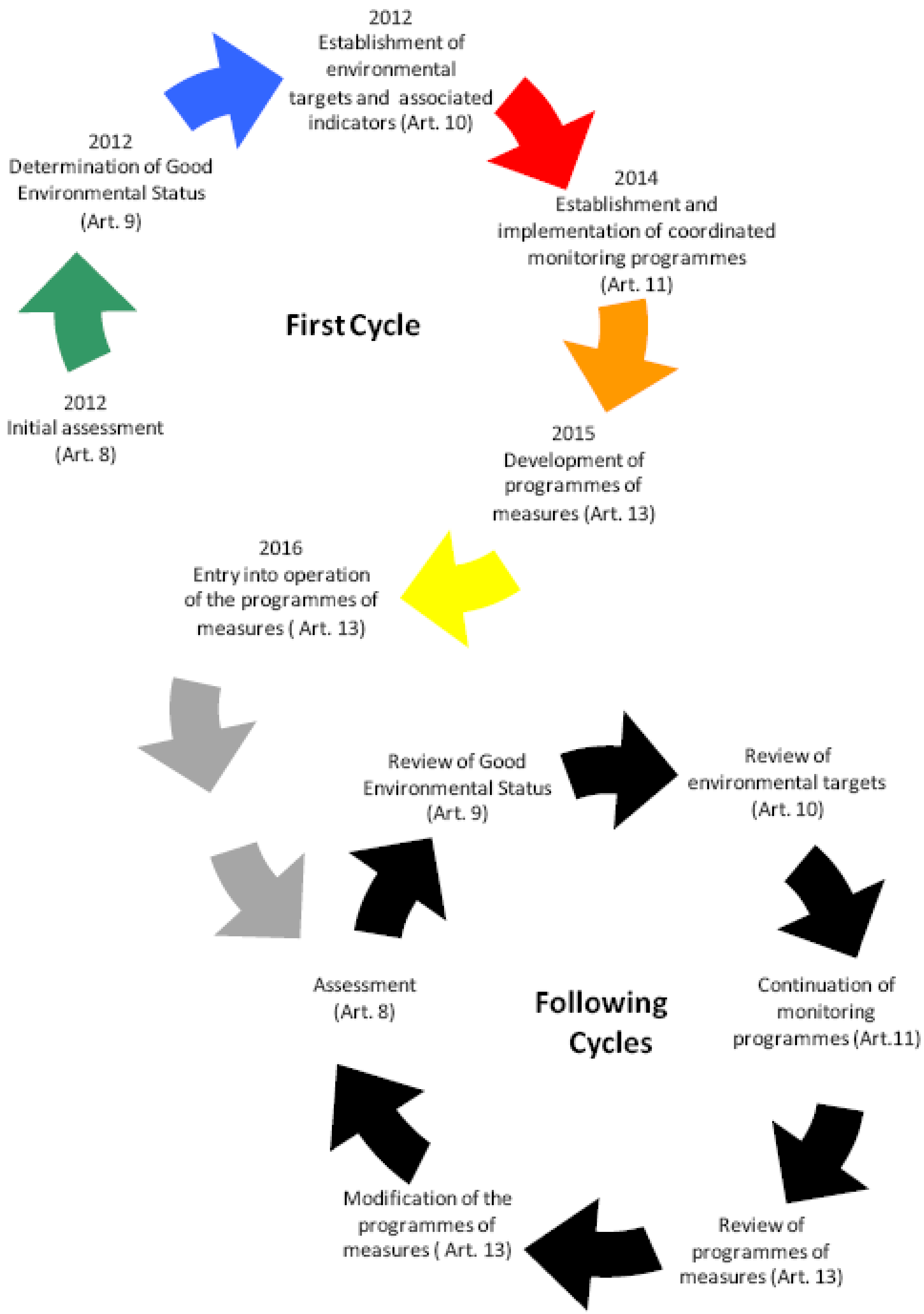

Figure 1. MSFD management cycle (from Claussen et al., 2011)

2.2 Definition of terms

Coastal waters	Surface waters on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters (from the WFD Art. 2(7)).
Cost effective programme	Among decision alternatives, the one whose cost is lower than its benefit. The most cost effective programme would be the one whose cost-benefit ratio is the lowest among various programmes competing for a given amount of funds. (Siegel et al, 1987**)**
Data requirements	Data requirements relate to frequency, locations, reliability, accuracy, continuity (what is maximum acceptable period that a planned measurement can be postponed or that a measurement does not take place) and data availability (how long may the period be between collection of data and making the data available to the user). They are determined by the expected use of information.
Descriptors	Annex I MSFD provides a list of eleven qualitative 'Descriptors' which constitute the basis for the assessment of GES, and provide a further refinement of aspects of the definition of GES in Art. 3(5) MSFD. These descriptors are substantiated and further specified in the COM Decision 2010/477/EU through a set of 29 criteria and 56 indicators (from Claussen et al., 2011).
Dominant pressure	The direct effect of a driver (for example, an effect that causes a change in flow or a change in the water chemistry) that prevails amongst the direct effects of other drivers affecting the same system (based on Roni et al., 2005)
GES	'Good Environmental Status' means the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations (MSFD Art. 3(5), abbreviated).
Indicator	An indicator is a parameter, or a combination of parameters, chosen to represent (indicate) a certain situation or aspect and to simplify a complex reality. In the context of the implementation of the MSFD, indicators are specific attributes of each GES criterion that can be measured to make such criteria operational and which allow subsequent change in the attribute to be followed over time (from Claussen et al., 2011).
Information collection strategy	A concrete predefined plan on how to gather data in order to efficiently assess environmental status, progress on environmental targets and efficiency of measures. It could include use of existing data, model outputs, new data collection and/or research.
Marine Monitoring	Monitoring can be defined as 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 GES (based on Zampoukas et al., 2013 and further developed).
Marine waters	(a) Waters, the seabed and subsoil on the seaward side of the baseline from which the extent of territorial waters is measured extending to the outmost reach of the area where a Member State has and/or exercises jurisdictional rights, in accordance with the UNCLOS, with the exception of waters adjacent to the countries and territories mentioned in Annex II to the Treaty and the French Overseas Departments and Collectivities. (b) coastal waters as defined by Directive 2000/60/EC, their seabed and their subsoil, in so far as particular aspects of the environmental status of the marine environment are not already addressed through that Directive or other Community legislation. Art. 3 (1) MSFD
Metric	A metric quantifies some aspects of the biological population's structure, function or other measurable characteristic that changes in a predictable way with increased human influence (from the WFD intercalibration guidance[9]).
Modelling parameters	Parameters included in models to simulate ecological processes and/or parameters estimated from ecological models that generate data and/or develop future scenarios.
Monitoring guidelines	A technical guidance on methods and standards for sampling, analysis and quality control/assurance, complement monitoring strategies.
Monitoring manual	A detailed document including pragmatic advices, specific methodologies, tools and approaches for parameter collection, indicator calculation and interpretation to support a monitoring programme.
Monitoring parameter	Quantitative physical, chemical, or biological property, such as water temperature or biota abundance, whose values describe the characteristics or behavior of an individual, a population, a community, or an ecosystem (Roni et al., 2005).
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. For the purposes of the MSFD, a differentiation is made between monitoring programme (structured along MSFD Descriptors) and sub-programmes (addressing status/impacts, pressures, activities, measures, investigative activities). Monitoring programmes include a number of scheduled and coordinated activities to provide the data needed for the on-going assessment of environmental status and related environmental targets.

[9] https://circabc.europa.eu/sd/d/61fbcb5b-eb52-44fd-810a-63735d5e4775/IC_GUIDANCE_FINAL_16Dec2010.pdf

Monitoring requirements	Characteristics (including, state, pressures and impacts) for which data collection is needed according to legislation and scientific perspectives.
Monitoring strategy	A concrete plan on how to collect the data specified in a monitoring programme. It is a function of: • Objectives • Size and characteristics of area to be assessed • Existing monitoring • Number and types of parameters • Specificity, sensitivity of monitoring techniques • Sampling frequency and duration and spatial resolution • Magnitude of natural variability (e.g. higher in an isolated water body, lower in the open sea) and local seasonal cycle. • Available resources (€, manpower, schedule) (based and further developed from US Environmental Protection Agency) [10]
Monitoring sub-programme	Sub-programmes are the monitoring strategies for aspects of status/impacts, pressures, activities, measures, that contribute data for the assessments in relation of GES and targets for MSFD Descriptors.
Monitoring surveys	A regular procedure using a standard methodology undertaken to provide a series of observations over time. In OSPAR, the term 'survey' is meant to be a time-limited monitoring activity, whereas regular other monitoring is indeterminate in forward time.
MSFD information and monitoring cycle	Relevant aspects of the information and assessment cycle of the MSFD include: • identification, specification of the questions to be answered, need of information • information collection strategy • determination of data requirements • monitoring strategy • monitoring implementation • data storage • assessment • evaluation of the assessment, possibly leading to the conclusion that the required information, data requirements or other steps in the information cycle should be modified, leading to a new information cycle

2.3 What is included and what is out of the scope

The chapters and issues addressed in this guidance were highlighted in the JRC 2012 workshops or/and proposed by Member States in the MSFD CIS. They do not include all possible monitoring issues and the guidance is, by no means, exhaustive. The guidance is limited to marine monitoring for the MSFD and does not include other data collections for the purposes of the MSFD. However, the link between MSFD and the requirements of other Directives is important, especially in relation to the pressures which originate on land.

[10] http://www.epa.gov/apti/video/083111webinar/3MonitoringStrategyv2.pdf

This guidance addresses the design of monitoring programmes by discussing and recommending principles on how to prioritize and chose what to monitor and not necessarily the explicit parameters to monitor. Detailed suggestions for each Member State are out of the scope of the monitoring guidance. However, good practices at the regional and national level are highlighted.

Assessment, GES definition, target setting and measures are also out of the scope. However, some considerations on these issues are included as long as they are needed for establishing monitoring. Aggregation rules, i.e. how to combine assessment of different descriptors/indicators/areas to one assessment and classification are of paramount importance for all the stages of MSFD implementation although the MSFD itself only specifies that assessment should be done at the level of region or subregion. However, this guidance is not about aggregation issues as it is expected that they will be addressed by a dedicated group.

2.4 The role of the RSCs in monitoring

The MSFD clearly recognizes the important role of the RSCs in most steps of its implementation. RSCs should be the fora where regional coordination, coherence, consistency and comparability in relation to monitoring and data generated from monitoring is ensured. Additionally, cooperation across RSCs is needed to allow, to the extent possible, interregional comparability and coherence. The drafting group of this document includes experts from RSCs as well as experts from Member States that are actively participating and are well aware of the developments in all RSCs, namely OSPAR for the North-Atlantic Ocean, HELCOM for the Baltic Sea, Barcelona Convention for the Mediterranean Sea and Bucharest Convention for the Black Sea.

It seems possible that comparability and consistency could be more achievable and meaningful at the lowest technical level (sampling and analysis methods and quality assurance and control), whereas at programme level they can be coordinated or coherent but should also be adapted to differences in natural conditions and environmental problems.

The level of maturity in the development and agreement of monitoring programmes differs between RSCs. In some RSCs there is long standing experience in monitoring including in offshore areas and their Contracting Parties have agreed common monitoring requirements and related guidelines, which are currently under revision. This *acquis* has been taken into account in drafting this guidance document.

Regional work will also need to take account of interests of third countries participating in RSCs and ensure that inclusive agreements are achieved. The importance of reaching a certain degree of coherence and consistency between EU Member States in each RSC and between the RSCs should be highlighted. The RSCs covering the marine waters of the EU Member States provide, within the Commissions established by them, fora for the organisation, between EU and third countries, of internationally coordinated environmental monitoring and assessment for each sea basin. Each of these RSC Commissions are undertaking monitoring and assessment activities in relation to their regional specificities, taking account of the objectives of the regional Convention and of their regionally agreed strategies. EU Member States are bound by the MSFD Art. 6 to coordinate their actions with third countries and to build, as far as possible, on relevant existing programmes and activities. In order to avoid duplication of efforts and ensure coherence, RSCs are being requested to address how to maximise the mutual organisation and use of monitoring. The MSFD applicability to all EU Member States' marine waters also provides a basis for extending the dialogue on effective monitoring organisation across sub-regions and regions. This implies a concrete invitation to RSCs to contribute to achieving coherence within and across the regional seas around Europe.

3. OVERARCHING PRINCIPLES OF MONITORING

3.1 Adequacy (recommendation 1)

Monitoring programmes should be able to provide the data needed to assess whether GES, as established by reference to the initial assessment, has been achieved or maintained, the distance from and progress towards GES and progress towards achieving environmental targets cf. MSFD Art. 9 and 10.

Consequently, monitoring should cover relevant biotic and abiotic elements included in MSFD Annex III, table 1 as well as the dominant pressures and activities (MSFD Annex III, table 2) in order to quantify pressures associated with activities and assess effectiveness of measures in relation to the targets set. Monitoring should provide the data in support of the relevant criteria and indicators of the COM Decision 2010/477/EU or its successor. Some of these criteria and indicators require biotic (e.g. indicator 5.3.1 Abundance of perennial seaweeds and seagrasses) some abiotic data (e.g. 1.6.3 Physical, hydrological and chemical conditions of the habitat) while others require pressures' data (e.g. 10.1.1 Trends in the amount of litter washed ashore and/or deposited on coastlines). Additional data collection on socioeconomic elements - mostly of statistical information and modelling rather than environmental sampling - is needed for the proper implementation of Art. 8c (assessment), Art. 13 (measures) and possibly also for Art. 14 (exceptions). Ideally, the acquisition of all relevant data should be done in the most cost-efficient manner.

3.2 Coordination and coherence (recommendation 2)

Member States should, as much as possible, follow agreed monitoring approaches, particularly within the same subregion and/or region. Ideally, they monitor a common regional set of elements, following agreed frequencies, comparable spatial resolution and agreed sampling methods (e.g. bottles, nets, sonars). Joint specifications and use of other observation data in the region, such as satellite imagery, also contribute to coordination. Such coordinated approaches would also result in coherence, i.e. the same biotic and abiotic components would be monitored in similar habitats and points in time. It would also facilitate comparable assessment results and associated classification of the state of similarly impacted areas belonging to different Member States. Ultimately, coherent monitoring programmes will facilitate the application of coherent mitigation measures so that measures taken by one Member State would facilitate and not prevent the achievement of GES in other Member States. Ideally, differences in monitoring strategies would only be justified by demonstrating important differences in the biological and physicochemical characteristic (e.g. species, habitats and pressures) between two or more marine areas.

3.3 Integration of existing monitoring (recommendation 3)

It is obvious that, in order to minimize additional costs, Member States should define the MSFD monitoring requirements relevant for their marine areas and check them against existing monitoring efforts (i.e. programmes aiming to fulfil the requirements of other EU legislation, of RSCs agreements and recommendations and of national initiatives). This would allow them to identify the additional requirements of the MSFD and develop monitoring programmes only for those additional requirements.

However, existing programmes may need to be adjusted in order to be more coherent with neighbouring countries as well as in the subregional and regional level. Adjustments should be balanced against the need for continuity of current monitoring, in particular with a view to long time series which

are required for trend assessments. Any adjustment of monitoring methods (e.g. in terms of devices, planning in time and space, analysis of the samples etc.) should be accompanied with a period of simultaneous application of both the old and the new approach in order to allow for intercalibration.

In reviewing existing monitoring, Member States should seek opportunities for cooperation on monitoring activities with neighbours and through joint regional data products from other observation platforms (e.g. Copernicus[11], formerly GMES) to enhance coherence and reduce costs.

The monitoring results may also provide a contribution to a better understanding of ecosystem functioning, being responsive to broader considerations identified in an application of the ecosystem-based approach. Information gathered through a programme of monitoring should be made available to science to foster this wider aim.

3.4. Data architecture and interoperability (recommendation 4)

Coherent monitoring programmes would ideally result in the collection of data for a regional set of common parameters. In order to achieve common datasets and interoperability of data, data sources will need to ensure that they are capable to deliver data using the same interface format. To achieve common data sets and to avoid duplication of work, existing databases and data flows (e.g. ICES) at international or regional level should be taken into account as they already provide a valuable pool of regionally interoperable data. The specifications of INSPIRE[12] should be followed and additional and more explicit common specifications may be needed. Interoperability means that it should be possible that data collected and stored by one Member State can be compared and combined with the data collected and stored by other Member States in regional (or ideally in European) assessments. This would require agreement in the classification of habitats, taking into account the EUNIS approach. Data products should match with the needs of the MSFD. Interoperability is more meaningful and can be better managed at the RSC level. The Working Group on Data, Information and Knowledge Exchange (DIKE) is currently discussing towards an agreement on information standard and data infrastructure to make available info for EEA according to MSFD Art. 19(3).

3.5. The concept of adaptive monitoring programs (recommendation 5)

New or previously unknown pressures may emerge in a marine area and/or existing pressures may decrease or be eliminated. Climate change, a pressure itself, is affecting the intensity and impact of other pressures and can change the structure and functions of marine ecosystems. Environmental state may degrade in an area, requiring investigative monitoring to identify causes. The frequency, intensity and the whole rational of monitoring programmes may need adjustment to better respond to a changing situation. An acute pollution event (oil spill) for example will require more intense monitoring in the years following the event and introduction of a non-indigenous species may require additional and targeted monitoring. New off –and near- shore activities (e.g. oil-gas installation, windfarms) will also require investigative monitoring as part of the Environmental Impact Assessment that will also generate data (usually owned by the project operator) and publically available information. Also technical progress may require adjustment of monitoring programmes (e.g. new sampling devices). MSFD has a six years cycle but more frequent adjustment of monitoring programmes may be needed.

[11] http://copernicus.eu/pages-principales/services/marine-monitoring/
[12] http://inspire.jrc.ec.europa.eu/

For the adaptation of monitoring programmes all the rest of recommendations (e.g. coherence, interoperability) should also apply.

3.6. Linkage between monitoring and assessment needs, including the use of risk-based approach and, where appropriate, the precautionary principle (recommendation 6).

Resources are never infinite and are usually very limited. Member States are required by MSFD Article 11 to establish monitoring programmes on the basis of the initial assessment. They do not have to monitor everything, everywhere and with the same frequency. Based on the initial assessment, they should prioritize their monitoring efforts in areas under higher pressures that are at risk not to achieve or maintain GES and in the biota that are known to be more sensitive. Furthermore, increased monitoring effort may be needed in areas that are close to the boundary of GES in order to increase confidence in assessment and, consequently, in the decision to take measures. Additionally, monitoring in areas with special ecological value should be prioritised.

Where there is reasonable ground for concern that achieving or maintaining GES is at risk, but where scientific evidence is not sufficient to establish the causes and/or the risk, the precautionary principle should apply and monitoring and research should be carried out with a view to revising/adjusting the monitoring programmes.

3.7. Consideration of the differences in scientific understanding for each descriptor (recommendation 7).

It is widely acknowledged that for some descriptors the level of scientific knowledge is more developed than for others. Eutrophication, fisheries and contaminants for example are already addressed, to some extent, by other EU legislation and some specifications exists on what GES is for these descriptors. For some descriptors such as noise, marine litter and biodiversity much less knowledge exists and they have not been previously addressed by EU law. The limited knowledge for some descriptors should trigger specific monitoring efforts, starting from investigative monitoring that will be built on the state of the art scientific developments.

4. STATE OF THE ART IN MARINE MONITORING

4.1 Characterisation of MSFD monitoring

The objective of monitoring is the on-going assessment of environmental status and related environmental status. The WFD mentions three types of monitoring, i.e. operational, investigative and surveillance. The thinking of the WFD which encapsulates risk considerations in a simple manner can be applied to MSFD monitoring, not as a rigid typology but as a means to describe the different monitoring purposes in such a way as to help justifying differences in monitoring effort in national waters both in terms of parameters/indicators needed and the spatial and temporal resolution of monitoring. Consequently, the MSFD monitoring is compatible and complementary to WFD monitoring and can draw on relevant WFD guidance[13]. Additionally, important work on defining different types of monitoring has been done by Elliott (2011).

Within the requirements of the MSFD, monitoring programmes may differ in their monitoring strategy and set up, due to differences in ambition, knowledge gaps, available budgets and other national or regional differences. In particular, prospected monitoring programmes may differ in the extent to which they enable to relate pressures to impacts. For clarity and as a basis for working towards comparable or joint monitoring programmes, Member States preferably accurately describe the goals and rationale behind their monitoring programs, to what extent their monitoring programmes may link pressures to impacts and make explicit, if possible, which knowledge gaps are an impediment to include that in the monitoring programme. Member States may use the list below to characterize their monitoring programmes.

- State monitoring (relating to Art. 8, 9 MSFD) which compares to WFD surveillance monitoring: It aims at long-term monitoring and at surveillance monitoring for an overview of the state of the environment and is the backbone of MSFD monitoring. It is sufficient where GES is achieved for the individual ecosystem component. State monitoring includes the features, activities and pressures relevant for GES. It includes monitoring of additional parameters under Annex III MSFD to assess the extent and intensity of human activities and resulting pressures and their changes as well as changes in natural conditions.
- Target and measure monitoring (relating to Art. 10 and 13 MSFD) which compares to WFD operational monitoring: This requires additional monitoring (in terms of indicators/parameters, sampling frequency and stations) in those areas and for those ecosystem components for which GES has been failed and for those pressures, which are responsible for failing GES and for which environmental targets have been set. Monitoring should enable to assess progress towards GES and achieving targets and the efficiency of measures.
- Investigative monitoring (relating to Art. 8, 9 and 10 MSFD) which compares to WFD investigative monitoring: targeted monitoring to investigate causes for failing GES and the degradation of state, and to answer specific questions (e.g. in relation to pollution events).

[13] Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance document no 7. Monitoring under the Water Framework Directive. https://circabc.europa.eu/sd/d/63f7715f-0f45-4955-b7cb-58ca305e42a8/Guidance%20No%207%20-%20Monitoring%20(WG%202.7).pdf

4.2 Elements that are already monitored in each RSC, including what is monitored for other EU legislation.

The existing EU legislation more closely related to the MSFD includes the following:

a. WFD (2000/60/EC)

b. EQS (Environmental Quality Standards Directive; 2008/105/EC) and its amendment (2013/39/EC)

c. Habitats Directive (92/43/EEC)

d. Birds Directive (2009/147/EC)

e. Common Fisheries Policy (CFP)

f. Commission Regulation (1881/2006) setting maximum levels for certain contaminants in foodstuffs and its amendments (Commission regulation Nº 835/2011)

g. Nitrates Directive (91/676/EC)

Also related to the MSFD is the proposed Framework Directive on Maritime Spatial Planning (MSP) and Integrated Coastal Management (ICM)[14].

Zampoukas et al. (2013) summarized the characteristics, pressures and impacts of MSFD Annex III and checked them against monitoring requirements under other EU legislation. Table 1 shows that few additional physicochemical elements (ice cover, mixing, residence time, siltation, pH) and pressures (abrasion, extraction, sealing, litter, energy, non-indigenous species) are not covered at all by already required monitoring. However, additional monitoring is also needed for elements that are partly covered since different pieces of legislation have different geographical scope. The WFD applies to coastal waters, up to 1 nautical mile from the baseline from which territorial waters are defined, for the ecological status and to territorial waters up to 12 nautical miles for the chemical status for priority substances (cf. EQS Directive). The HD and BD apply to all waters under national jurisdiction including the Exclusive Economic Zone (EEZ) but they may not cover all species and habitat types that Member States may find worth protecting. For instance, the Netherlands have designated the oystergrounds an area protected under the MSFD because of the high benthic biodiversity associated with a presence of silty sediment, rich in organic matter. Another example are the ecological protected zones designated, according to UNCLOS, by France and Italy in the Gulf of Lion and the Tyrrhenian Sea, respectively. CFP applies to the management of fish stocks and fishing activities. The MSFD has a much wider geographical scope than other directives as it covers all marine waters under the sovereignty and jurisdiction of Member States of the EU (including territorial waters, EEZ as well as continental shelf beyond 200nm).

RSCs in EU Seas have coordinated marine monitoring programmes which have ensured that similar sampling and analysis methods are being used by several countries within a marine region. The MSFD requirement to coordinate the implementation of the Directive within the marine regions has strengthened this role of the RSCs and also given an option for Member States to report the monitoring programmes to the EC via RSCs. The role of RSCs in the marine monitoring may vary across Europe, but it is likely that a majority of the monitoring can be carried out in a coordinated way, ensuring comparable or even shared assessment results. Countries being parties to two RSCs may play a role of facilitating coordination also across RSC borders. Nevertheless, it is clear that Member States have

[14] COM(2013) 133 final; 2013/0074 (COD).Proposal for a Directive of the European Parliament and of Council establishing a framework for maritime spatial planning and integrated coastal management. Brussels, 12.3.2013.

special natural characteristics which are not shared by neighbouring countries and therefore some monitored parameters will be left out of the coordinated monitoring. This may be especially true for the 'risk-based monitoring', where high pressure areas or species or habitats of special conservation status will be monitored in more detail than in neighbouring waters where other pressures and habitats may require priority attention.

In this document a summary of RSCs monitoring activities is included. From this summary it is already apparent that all RSCs cover, to some extent, contaminants and eutrophication related monitoring. However, there is much less agreed and coordinated monitoring for biodiversity elements and for pressures such as litter and noise. HELCOM seems to be much advanced in including the whole range of MSFD requirements in its revised strategy and OSPAR also has developed plans to include more elements related also to the progress in developing and agreeing Ecological Quality Objectives (EcoQOs). In the Southern European Seas (Mediterranean and Black Seas), issues related to monitoring of elements additional to contaminants and eutrophication seem to be open. Interaction and sharing of know-how between RSCs are clearly needed and currently do not seem to have reached their full potential. There are, of course, several limitations in transferring a monitoring programme between different seas or even subregions but there are also opportunities for the exchange of single components, experience and know-how which are not fully used until now. An illustrative example is given. OSPAR has an EcoQO on grey seal pup production as an indicator of food webs status. This EcoQO requires related monitoring following common specifications. EU Member States in the Southern Seas could possibly consider developing a production indicator based on a local top predator species, define GES together and consequently also agree on common specifications for data collection.

Table 1. Comparison of monitoring elements required by MSFD and by other marine related EU legislation (further developed from Zampoukas et al., 2013).

MSFD monitoring element	Characteristics (if defined in the MSFD)	WFD	EQS	BD	HD	CFP
phytoplankton/zooplankton	species composition	+/-				
angiosperms, macroalgae, zoobenthos	species composition & biomass*	+				
fish	abundance, distribution, age / size structure				+	+
reptiles, marine mammals and other protected species	range, population dynamics, status				+	
seabirds	range, population dynamics, status			+		
habitats (predominant, special, protected, endangered)					+	
currents, depth, salinity ice cover,		+				
waves	exposure	+				
mixing, residence time						
seabed	topography, bathymetry, structure, substrata composition	+				
temperature, turbidity		+				
upwelling, abrasion, extraction, sealing						
siltation	changes in					
contaminants	concentrations & biological effects	+	+			
oxygen		+				
pH						
marine litter						
underwater noise						
microbial pathogens**						
non-indigenous species	occurrence, distribution, abundance. translocations					
selective extraction of species						+

*Abundance is the required parameter in the WFD ** Microbial pathogens are partially covered by the Bathing Waters Directive (2006/7/CE) and Shellfish Directive (2006/113/CE)

4.2.1 HELCOM

The HELCOM Monitoring and Assessment Strategy[15], first adopted in 2005 and revised in 2013, is a plan laying out a monitoring and assessment system which assists in evaluating whether visions, goals and objectives for the Baltic Sea marine environment are being met. The revised strategy aims at a joint HELCOM monitoring programme to ensure scientifically sound, well-coordinated, optimised and cost-effective monitoring in the Baltic Sea region. It will provide the necessary data for HELCOM's Baltic-wide indicator-based assessment activities, focusing on the state of the marine environment but also on human-induced pressures impacting the status.

Currently there are manuals and guidelines that describe the methods to carry out the HELCOM monitoring programme. The COMBINE manual[16] (Cooperative Monitoring in the Baltic Marine Environment Manual), which was instituted in 1992, defines the contributions made by all Contracting Parties and regulates all methods used for monitoring biological parameters, hazardous substances, hydrography and nutrients. Updating this and other manuals will be carried out at a later step in 2014-15.

The ICES Data Centre hosts the database for the HELCOM COMBINE Programme for the Baltic Sea. COMBINE monitoring data can be downloaded from ICES Oceanographic database. Monitoring data can be also visualized and downloaded in the ICES EcoSystemData map service and from the HELCOM map service.

HELCOM regularly produces a Pollution Load Compilation (PLC) which assesses the data collected by the Contracting Parties on total waterborne loads of nutrients and some hazardous substances to the Baltic Sea. The aim of PLC is to quantify and describe the waterborne discharges and loads. PLC aims also to explain to which extent changes are caused by human activities or natural variations. Atmospheric deposition is also considered by HELCOM.

The monitoring of radioactive substances is being carried out within a specific HELCOM expert group called HELCOM MORS[17].

The HELCOM CORESET project (2010-2013)[18] developed a first set of core indicators for following up the effectiveness of the implementation of the Baltic Sea Action Plan. The core indicators also support the EU Member States in the Baltic Sea region in implementing the MSFD. The Monitoring and Assessment Strategy is taking into account the indicators developed by the CORESET project for its revision.

Components of the HELCOM monitoring programme (some of them are on voluntary basis) are shown in Table 2. Marine litter and underwater noise which are not currently covered in the COMBINE manual are included in the revision of the strategy.

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[15] http://www.helcom.fi/groups/monas/en_GB/monitoring_strategy

[16] http://www.helcom.fi/groups/monas/CombineManual/en_GB/Contents

[17] http://www.helcom.fi/GIS/en_GB/MORS/

[18] http://www.helcom.fi/projects/on_going/en_GB/coreset/

Table 2. HELCOM monitoring activities

Components of the HELCOM monitoring programme	COMBINE manual: Mandatory	COMBINE manual: Voluntary	Pollution Load Compilation (Air and Water)	Included in revised strategy
Biological				
Chlorophyll-a/Phytoplankton	●			●
Zoobenthos	●			●
Zooplankton		●		●
Phytobenthos		●		●
Birds				●
Mammals				●
Fish		●		●
Non-indigenous species				●
Hazardous Substances				
PAH (Polycyclic Aromatic Hydrocarbons)			●	●
Metals	●		●	●
Organotins		●		●
POPs (Persistant Organic Pollutants)	●		●	●
Biological effects		●		●
Hydrography	●		●	●
Marine litter				●
Nutrients	●		●	●
Radioactive	●			●
Underwater noise				●

There are three groups that meet every three years and deal with monitoring and sharing information about specific biota:

- *HELCOM Zooplankton Expert Network (HELCOM ZEN)*[19] *is a* forum to share information about zooplankton research.
- *HELCOM Phytoplankton Expert Group (HELCOM PEG)*[20] organizes training courses and intercalibrations to ensure and maintain quality standards of phytoplankton monitoring.
- *HELCOM Seal Expert Group (HELCOM SEAL)*[21] is developing a coordinated monitoring programme for seals.

[19] http://www.helcom.fi/projects/activities/en_GB/zooplankton
[20] http://www.helcom.fi/projects/on_going/peg/en_GB
[21] http://www.helcom.fi/groups/habitat/en_GB/SEAL

4.2.2 Black Sea

According to the basic principles of the Convention on Protection of the Black Sea Against Pollution and translated into practical steps of the Strategic Action Plan on Rehabilitation and Protection of the Black Sea Against Pollution, the Contracting Parties have developed the Black Sea Integrated Monitoring and Assessment Programme (BSIMAP)[22] for the period 2001 – 2006. The first BSIMAP was updated in 2006 and approved by the Black Sea Commission for the period 2006 – 2011. The aim of the integrated monitoring programme is to provide data for assessing the ecological status of the Black Sea ecosystem. Monitoring programmes of each country are very different as each country has its own legislation but some mandatory and recommended parameters have been set up. The basic principles of WFD were considered and followed to the extent possible. The monitoring parameters are presented in Table 3.

Table 3. Parameters of the Black Sea Integrated Monitoring and Assessment Programme

Mandatory					Optional
Water – Eutrophication	**Biota contamination**	**Biota**	**Water-pollution**	**Sediments pollution**	
BOD_5	Heavy metals (Cd, Cu, Hg, Pb)	Phytoplankton (total density, total biomass)	total petroleum hydrocarbons	Particle size	Radioactivity
N (NH_4, NO_2, NO_3 & N total)	Persistent pesticides (organochlorine pesticides)	Chlorophyll "a"	Heavy metals (Cd, Cu, Hg, Pb)	Description of sediments	Heavy metals (Co, Cr, Fe, Zn, Ni)
O_2 (dissolved and saturation)	PCBs	Mesozooplankton		Heavy metals (Cd, Cu, Hg, Pb)	Persistent pesticides (organochlorine pesticides)
P (PO_4 & P total)		Biomass of Noctilluca		Pesticides (DDT, DDD, DDE, Lindane)	Detergents
SiO_4		Macrophytobenthos		PCBs	Alkalinity
pH		Macrozoobenthos		Total hydrocarbons	Hexachloro-cyclohexane
salinity		Fish landing (annually)			Total Organic Carbon (TOC)
Secchi depth					Phenols volatile
Temperature					Conductivity
Total suspended solids					Polycyclic aromatic hydrocarbons

The monitoring activity is focused in most of the countries in the coastal waters. The funding of monitoring is a very important problem for all countries. Very few countries monitor the open sea and the frequency of samples depends on funds allocated by the government of each country.

Within the frame of the Grant Agreement Baltic2Black, a small scale project funded by the EC DG Environment for the period 2011-2013, it was considered, in a feasibility study, to use remote sensing

[22] http://www.blacksea-commission.org/_bsimap.asp

and automated systems to monitor the eutrophication parameters and to extend the monitoring from coastal areas to the offshore ones.

4.2.3 OSPAR

The current JAMP (2010-2014) is mainly orientated at supporting the activities of Contracting Parties in respect of the EU MSFD and has as its end point the establishment of monitoring programmes under the Directive by 2014. The revised monitoring programmes will build on the existing *acquis* of monitoring arrangements which will be adjusted and expanded to monitoring needs of Contracting Parties for the MSFD. The revision will closely link with the common indicators and priority candidate indicators identified by Contracting Parties in 2013 for future use in support of assessments in relation GES under the MSFD. This means that in addition to current monitoring (e.g. for eutrophication, contaminants, inputs, discharges, human activities etc.), future monitoring programmes are intended to cover additional parameters relating for example to biodiversity, hydromorphology, food webs, litter or noise. The future monitoring programmes will close gaps in current monitoring and will bring the different monitoring activities together into one framework. Many of the existing monitoring activities and data streams[23] (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.

Existing marine monitoring in OSPAR builds on national monitoring and has been further adjusted to link-up with various national monitoring needs. Hence the design of the monitoring programmes takes account of and links up with monitoring for other purposes such as WFD, HD or other national needs. Similar pressure monitoring is orientated towards synergies for OSPAR and other purposes (e.g. European Monitoring and Evaluation Programme, European Environmental Agency). Also cooperation between OSPAR and other entities collecting data (e.g. ICES, industry) exist in order to ensure best use of data collected elsewhere also for OSPAR purposes. The ongoing review of existing monitoring arrangements in OSPAR will take account of any need for further approximation of OSPAR and EU technical guidelines (methods, standards, protocols) and their adjustments in the appropriate forum so as to safeguard comparability of data in Europe.

Formal monitoring programmes in place include:

- the *Coordinated Environmental Monitoring Programme* (CEMP). Its purpose is to assess temporal trend and spatial distribution of concentrations of contaminants in sediment and biota (Cd, Hg, Pb, PCBs, PAHs, TBT, BFRs, dioxins and PFOS), and contaminant-specific as well as general biological effects. It has recently been extended to include, on a voluntary basis ('pre-CEMP') the measurement of pH, total alkalinity, dissolved inorganic carbon and pCO_2 to assess the progression of ocean acidification, and the measurement of beach litter to assess temporal trends of litter on selected beaches. Mandatory CEMP-monitoring requires agreed technical guidelines, established QA and assessment criteria. See CEMP monitoring manual[24] and CEMP assessment manual[25]
- the *Eutrophication Monitoring Programme* as part of the CEMP (see CEMP monitoring manual and OSPAR Common Procedure). It sets out monitoring requirements for nutrient

[23] http://www.ospar.org/content/content.asp?menu=01511400000000_000000_000000
[24] http://www.ospar.org/content/content.asp?menu=00170301000135_000000_000000
[25] http://www.ospar.org/documents/dbase/publications/p00379_cemp_assessment_manual.pdf

concentrations (NH_4-N[2,4],NO_2-N[2,4] NO_3-N[2,4] PO_4-P[3,4] SiO_4-Si[4]) and supporting parameters (salinity, temperature) as well as for eutrophication effects in (potential) eutrophication problem areas (chl-a concentration, TOC, POC, phytoplankton indicator species, oxygen concentration/saturation, benthic communities).

- the *Comprehensive Study on Riverine Inputs and Direct Discharges (RID).* Its purpose is to assess trends in riverborne and direct inputs of selected contaminants (Hg, Cd, Cu, Zn, Pb, lindane) and nutrients (ammonia, nitrates, orthophosphate, total N and P, suspended particulate matter) to marine waters. It includes supporting parameters such as salinity and freshwater flow. See RID Principles and associated guidance and guidelines[26]. This programme is due to be revised by 2014.
- the *Comprehensive Atmospheric Monitoring Programme (CAMP)*. Its purpose is to monitor concentrations of selected contaminants (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, lindane) and nutrients (ammonium, nitrate) in precipitation and air and their depositions in order to assess trends in their atmospheric inputs to the sea. CAMP monitoring and assessment is complemented by periodic emission-based modeled estimates of atmospheric inputs and source-receptor matrices which are commissioned with EMEP. See CAMP principles and associated guidelines[27]. This programme is to be revised in the near future.

4.2.4 UNEP/MAP

In the framework of UNEP/MAP-Barcelona Convention MEDPOL programme, the Contracting Parties have implemented in a coordinated manner since 1982 a regional marine pollution monitoring programme in the Mediterranean coastal waters, according to Article 12 of the Barcelona Convention and Article 8 of the Land–Based Sources Protocol. In 1996, a marine monitoring and reporting strategy was approved and a marine monitoring database was created. As a result, the monitoring programme was better coordinated, including an agreement on common integrated monitoring methodologies, a Quality Assurance/Quality Control system to improve data quality and a common reporting system.

The marine monitoring database is the basis to the preparation of thematic assessment reports on marine pollution. The MED POL marine databases hold data on:

- Seawater: General oceanographic parameters (temperature, salinity, dissolved oxygen),
- Nutrients (NO3-N, NO2-N, NH4-N, PO4-P, SiO4), Chlorophyll-a
- Marine sediments: Total mercury, total cadmium (mandatory), Chromium, Copper, Lead, Zinc, Halogenated hydrocarbons, PAHs
- Marine organisms: Total mercury, total cadmium (mandatory), halogenated hydrocarbons, PAHs, Arsenic, Chromium, Copper, Lead, Zinc, micronuclei frequency (MN), DNA damage (DNAx), EROD activity, lysosomal membrane stability (LMS) and metallothionein content (MT).

Furthermore, a land-based pollution sources database has been created in 2005, which is hosting national data on pollutants industrial and municipal discharges collected by national surveys.

With regard to biodiversity the countries do not implement yet a regionally coordinated biodiversity monitoring programme. However, biodiversity monitoring is included in the SPA/BD Protocol (Articles 3, 7 and 20) as an obligation for the Contracting Parties. The Mediterranean EU Member States have

[26] http://www.ospar.org/content/content.asp?menu=00920301420000_000000_000000
[27] http://www.ospar.org/content/content.asp?menu=00910301410000_000000_000000

monitoring programs for the WFD implementation specifically for macroalgae, angiosperms, macroinvertebrates and phytoplankton. Also for the WFD there is monitoring for nutrients, trace metals and priority substances.

4.3 Geographical scope and methodologies

4.3.1 HELCOM

The current HELCOM COMBINE programme has divided the Baltic Sea in sub-basins and listed monitoring stations within them. The COMBINE programme covers the entire Baltic Sea marine area.

In the new HELCOM Monitoring and Assessment Strategy, there are four levels of assessment units proposed:

1st level: Whole Baltic Sea

2nd level: 17 sub basins

3rd level: 17 sub basins + 41 coastal areas

4th level: 17 sub basins + WFD water types/bodies

The proposed system of assessment units is nested, allowing assessments on different levels of spatial accuracy. The HELCOM core indicators have been developed to fit into these geographical areas.

The HELCOM COMBINE manual ensures that the Baltic Sea coastal countries carry out sampling and analyses of the monitored parameters in a similar way. In addition to the methodologies described in COMBINE, countries may have national parameters with national methods. With the new core indicators the upcoming coordinated monitoring programme will include new parameters and their methodologies will be agreed jointly.

4.3.2 Black Sea

According to the art.4 the MSFD should be implemented at the whole Black Sea region, because the area was not divided in subregions. Technically and scientifically the Black Sea cannot be divided because it is a whole water body. Therefore the geographic assessment scale in relation to initial assessment, GES, environmental targets, and indicators should take into consideration the specific conditions of the Black Sea, as hypoxia zone. In this context the implementation process is focused on the continental shelf, where the ecological areas are.

4.3.3 OSPAR

The OSPAR maritime area is a huge area encompassing different biogeographic regions and hydrographic conditions, remote areas beyond national jurisdiction, areas with heavily populated and industrialised coasts and different environmental problems. It is subdivided, for monitoring and assessment purposes, in five Regions, encompassing broadly the subregions identified in MSFD Art. 4(2)(a):

Region I – Arctic Waters

Region II – Greater North Sea

Region III – Celtic Seas

Region IV – Bay of Biscay and Iberian Coast

Region V – Wider Atlantic.

Monitoring necessarily needs to differ depending on the distribution of ecosystems and their sensitivity and the distribution and extent of human activities. The Quality Status Report (QSR) 2010[28] provides an overview of the differences of the OSPAR Regions and provides a background for justifying different monitoring approaches (see Chapters 2 and 12 of the QSR 2010).

Environmental conditions are also taken into account in monitoring methods. For example, EcoQO monitoring currently exists for the North Sea only and will need adjustment (e.g. in relation to indicator species) to allow their application to other OSPAR Regions. Another example is contaminant monitoring in sediments under the CEMP; depending on the sediments, different methodologies e.g. for normalization, apply. On-going work for monitoring in relation to 'biodiversity descriptors' (D1, D2, D4, D6) equally takes account of the wide geographic range of environmental conditions.

4.3.4 UNEP/MAP

Overall, Mediterranean Sea is subdivided for monitoring and assessment purposes in 10 sub-basins: Alborán, Northwestern, Tyrrhenian, Southwestern, Ionian, central, Aegean, Adriatic, North Levantine and South Levantine (UNEP/MAP, 2012)[29], encompassing broadly the four sub regions identified in MSFD Art. 4(2)(b). The main particularities of the MED eco-region are:

- the generally oligotrophic character
- the high biodiversity
- the high number of non-indigenous species (Lessepsian)
- the large number of commercial fish species and their extremely low stocks
- the natural high level of trace metals (Hg)

As regards the site-specific temporal trends of pollutants (at hot spots; discharge areas, estuaries, bays, etc.) as well as the monitoring of all coastal waters, the national monitoring programmes within the framework of the MED POL programme currently do not cover all the coastal areas with proper sampling station networks, and therefore need to be cautiously considered with regard to the spatial coverage of data even at the local (national) level.

Compliance monitoring of effluents, bathing and shellfish waters has been implemented for inspection of compliance with national and/or international regulations/obligations. MED POL requires compliance reports to be prepared by the national authorities to facilitate the activity as part of the established monitoring systems.

The monitoring of inputs from point sources covers the waste discharge points as well as riverine inputs. Only river mouths are presently monitored to estimate the riverine loads. The content of the database is not fully satisfactory to estimate riverine inputs, particularly in the Adriatic, Northern Aegean and Northeastern Mediterranean where information and data are particularly needed due to important riverine inputs.

The monitoring of atmospheric inputs and depositions is limited to only one country in the Eastern Mediterranean. Cooperative studies with the World Meteorological Organisation have been undertaken

[28] http://qsr2010.ospar.org/en/ch02.html & http://qsr2010.ospar.org/en/ch12.html
[29] http://planbleu.org/sites/default/files/publications/statemedenvt_part1.pdf

and an estimation of diffuse inputs (model studies) from watersheds and agricultural areas has been made under international initiatives including EUROHARB, IOC/NEWS-Med Focus.

Biological effects monitoring utilizing biomarkers (preferably a battery of biomarkers) is designed to establish an early-warning system for the possible impacts of pollutants at the organism/cellular level and the rationale behind this is to provide direct management tools focusing on the early signals of negative effects. This type of monitoring was performed as pilot monitoring at the Mediterranean level during MED POL Phase III [1996-2005], and although research on the subject is still ongoing, the assessment of certain contaminant-specific as well as general biological effects are included within the framework of the MED POL Phase IV [2006-2013] and within the Ecological Objectives in the framework of the Mediterranean Ecosystem Approach..

The eutrophication monitoring programme has been initiated at a limited number of pilot sites. The biological component is planned to be expanded to include other trophic levels than that of primary producers already included in the short-term strategy. Supplementary techniques such as remote sensing have been planned to be incorporated into the routine monitoring activities, however concrete products have not yet been obtained.

4.4 Coordination within and between RSCs

4.4.1 HELCOM

Coordination within HELCOM

The HELCOM Monitoring and Assessment Strategy, adopted in 2005, is the main instrument for coordinating monitoring activities within HELCOM countries. The Strategy was revised in 2013 and it now describes a joint coordinated monitoring system of the Baltic Sea countries. The further revision of the HELCOM monitoring programme is carried out by the HELCOM MORE project and MONAS and its expert groups. The HELCOM COMBINE manual, instituted in 1992, defines methods to identify and quantify the effects of anthropogenic discharges/activities in the Baltic Sea and the changes in the environment.

HELCOM has adopted numerous measures to reduce human pressures on the marine environment. These measures include activities to reduce pressures stemming both from land- as well as from sea-based human activities. They are instituted through HELCOM Recommendations, Ministerial Meeting Declarations, as well as the Baltic Sea Action Plan which was adopted at the ministerial level in 2007. The Action Plan defines eutrophication, changes in biodiversity, pollution by hazardous substances and environmentally friendly maritime activities as focal areas of joint work within HELCOM. Good environmental targets, targets for maximum human pressures (e.g. nutrient loads) and core indicators have been established for these focal themes of the Action Plan. HELCOM joint coordinated monitoring is being redesigned to allow data provision for these core indicators.

Coordination between RSC

There are three countries in the HELCOM area that are also part of the OSPAR convention: Denmark, Germany and Sweden. To ensure compatibility of approaches in both marine areas of these three countries, there is information exchange and coordination between the convention areas. As regards the MSFD, developments of targets and indicators have been done in separate expert groups, but the groups have exchanged information and aimed at comparable products, taking into account differences in the ecosystems. In the context of the IMO Ballast Water Convention, HELCOM and OSPAR have a joint working group to agree on criteria for exemptions in the ballast water treatment.

4.4.2 Black Sea

The BSIMAP was initiated in 2001 as a special programme under Bucharest Convention (art. XV) in support to knowledge-based decision-making, tracing the level of implementation of national and regional policy actions aimed at Black Sea environment protection and their efficiency. Having the socio-economic restrains of the contracting parties (BG, GE, RO, RU, TR, UA) the Black Sea Commission approved a BSIMAP based on national monitoring programmes only, conducted within the territorial waters of each country. The formal approval of BSIMAP for the period 2006-2011 took place in 2006 at the 13th Meeting of the BSC. The adopted Program contained optional and mandatory parameters, agreed frequency of observations and it was well harmonised with the WFD requirements for monitoring of transitional and coastal waters. The new draft BSIMAP that is not yet approved by the BSC contains elements included in the MSFD expressed through the identification of the EcoQOs with respective descriptors for GES (all descriptors identified). Currently, there are ongoing projects supported by the EC MISIS (MSFD guiding Improvements in the Black Sea Integrated monitoring System – implemented by Romania, Bulgaria and Turkey) and EMBLAS (Improving Environmental Monitoring in the Black Sea – implemented by Ukraine, Georgia and Russian Federation).

Future work will be focused in enhancing the cooperation with other Regional Sea Conventions (as HELCOM and UNEP/MAP) and transfer of experience in the Black Sea region (e.g. ecosystem approach for the management of marine environment, etc.)

4.4.3 OSPAR

OSPAR has standing arrangements for the development and maintenance of its monitoring programmes. The main (thematic) Committees and the Coordination Group (CoG) are responsible for the coordination activities required in the context of monitoring and assessment. With reference to the MSFD, on-going monitoring programmes are being serviced by dedicated groups (under the Hazardous Substances and Eutrophication Committee – HASEC), while new monitoring arrangements are being developed for the Biodiversity and Ecosystems part of the portfolio (under the Biodiversity Committee – BDC, and the Environmental Impacts of Human Activities Committee – EIHA).

OSPAR and HELCOM have common commitments and cooperate on their implementation. When opportunities arise to exchange or mutually adjust practices, these are considered and/or implemented. Both organisations rely on cooperation with ICES on technical scientific issues, such as monitoring guidelines, which helps coordination of monitoring approaches in both RSCs. A number of Contracting Parties to OSPAR have also coasts in the Baltic Sea and the Mediterranean Sea Regions. This fact is an additional driver for coordination of monitoring approaches in the three marine regions. HELCOM, ICES and OSPAR currently have active cooperation on data and GIS, aiming to ensure consistency/interoperability and sharing of experience on data management and reporting.

4.4.4 UNEP/MAP

Decision IG 20/4 "Implementing the MAP ecosystem approach (EcAp) roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetable for implementing the ecosystem

approach roadmap adopted by the Contracting parties to the Barcelona Convention" (COP17, 2012)[30] requested the Secretariat to prepare an integrated monitoring programme, based on the agreed 11 Ecosystem Approach (EcAp) Ecological objectives and the respective indicators. This task was decided would be undertaken with the leadership role of MED POL and in cooperation with other regional competent organisations such as the Secretariat of the GFCM, ICCAT and ACCOBAMS.

The implementation of the ecosystem approach roadmap will imply the establishment of a regional monitoring programme that addresses the EcAp ecological objectives and respective criteria, indicators and what constitutes GES. Already at the time of the adoption of the Operational Document of MED POL Phase IV, it was decided that pollution monitoring needed to be better integrated into the scope of the Strategic Action Programme (SAP MED) and of any other pollution control measure adopted by the Contracting Parties in application of the Land Base Sources Protocol.

Additionally, in the framework of the strategic action programme for the conservation of biological diversity a monitoring system of endangered and threatened species has to be established, as well as adequate monitoring and survey of the effectiveness of marine and coastal protected areas.

Therefore, based on the decisions and developments in the ecosystem approach roadmap an integrated holistic monitoring programme will be prepared, including marine pollution and biodiversity, in line with the objectives and steps agreed upon for the application of the ecosystem approach. The philosophy underlying the holistic approach is that all monitoring activities are integrated in a single, well-defined aim – that of achieving a particular level of environmental quality in a specified ecosystem. This means that common practices have to be adopted across all types of monitoring activities and data management.

4.5 Transfer of knowledge between European seas

There is considerable potential for knowledge exchange between RSCs but currently there are limited initiatives. However, some good practices exist but concern mainly assessment and/or research.

4.5.1 HELCOM and Black Sea

Currently, there is a collaboration project "Environmental Monitoring of the Black Sea for nutrients" in short Baltic2Black (2011-2013)[31] between the Secretariats of the BSC and HELCOM. The project is financed by European Commission and involves relevant experts to present and elaborate regionally agreed criteria for assessment of eutrophication. The general objective of the project is to promote environment protection in the Black Sea area by improving the environmental monitoring. The secondary objective of the project is to enhance transfer of knowledge and good practices from Baltic Marine Environment Protection Commission (HELCOM) to the BSC. Within the workshops the participants of the Baltic Sea and the Black Sea discussed on the best way to assess the status of the eutrophication on both seas the indicators, and models to analyze and better assess this process. Currently, Baltic2Black does not explicitly include monitoring but the results as metrics/ methods could be used in monitoring programmes.

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[30] http://195.97.36.231/dbases/Meeting%20Documents%20(Word%20or%20WP)/2012/12IG20_CoP17/ENG/IG20_5%20Draft%20Decisions/Decision%204%20-%20Ecosystem%20approach/Decision%20IV%20-%20Ecosystem%20approach.pdf

[31] http://www.helcom.fi/projects/on_going/en_GB/Baltic2Black/ & http://www.blacksea-commission.org/_projects_Baltic2Black.asp

4.5.2 OSPAR with HELCOM and other RSCs

OSPAR uses platforms such as the EU MSFD CIS process and the advisory services of ICES (joint to OSPAR and HELCOM) to share knowledge between European Seas. On a case-by-case basis, Contracting Parties with an interest to streamline procedures across basins act as facilitators. OSPAR Secretariat staff has regularly provided information on OSPAR activities to other RSCs. Cooperation e.g. on research projects or in the context of the UNEP family of RSCs help the exchange of experiences and knowledge.

4.6 Indicative monitoring approaches developed and tested in recent completed research projects

An important effort to identify, extract, analyse and synthesize the knowledge generated in EU and national research funded activities and make it available for policy makers and MSFD stakeholders is currently being done by the FP7 project STAGES[32] (Science and Technology Advancing Governance of Good Environmental Status). WP1 aims to identify and synthesise the knowledge generated through EU and national research funded activities with relevance to MSFD objectives and make it widely accessible to policy and decision makers and to MSFD stakeholders. It is currently collecting comprehensive knowledge from EU and national public research projects related to MSFD (2005 onwards) and includes aspects of monitoring. 1138 national projects and 1500 EU projects have been initially identified as potentially MSFD relevant. In this chapter, which is based on the preliminary findings of STAGES, we present some indicative completed projects that have outputs related specifically to monitoring. Readers are encouraged to consult the inventory of research projects and results as soon as it will be completed and available on the project's web-site.

The FP7 PEOPLE — Marie Curie Action AIM-HI Acoustic Imaging of Macrophytes and Habitat Investigation[33] (AIM-HI) quantified the extent to which multibeam sounders can provide reliable information at large ranges away from survey platforms, even with acoustically faint macrophyte types. As such, it provides more impetus for R&D in multibeam sonar design and development and offers a more quantified reason for including these sonar tools in any surface or underwater platform. Results from this project have already been presented (Kruss et al., 2012).

The FP7 project CoralFISH[34] (Assessment of the interaction between corals, fish and fisheries in order to develop monitoring and predictive modelling tools for ecosystem based management in the deep waters of Europe and beyond) focused on assessment of the interaction between corals, fish and fisheries, in order to develop monitoring and predictive modelling tools for ecosystem based management in the deep waters of Europe and beyond. Of particular interest are the monitoring indicators developed on fish occurrence / fishing impacts, long-term fishing impacts and ecosystem modelling.

The FP6 PEOPLE — Marie Currie project FSVKW: ACA[35] (function of stereotyped calls of killer whales: a comparative approach) established the vocal repertoires of pulsed calls of both fish-eating and seal-eating killer whales around Shetland. Based on this work it is now possible to identify these species from remotely obtained sound recordings and establish their population identity.

[32] http://www.stagesproject.eu
[33] http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_RCN=11548138
[34] http://www.eu-fp7-coralfish.net
[35] http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_RCN=9633633

The nationally funded Spanish project SARGAL[36] (Invasión del alga Sargassum muticum en Galicia: alcance y factores que afectan a su expansion) used the image sensor AHS (Airborne Hyperespectral Scanner) for mapping forests of the invasive *Sargassum muticum*, trying to find targeting methodologies to efficiently evaluate and monitor the spread of this species. Sampling methods of seaweed communities of rocky shores and algal wrack supply on sandy beaches were applied.

The PROTOOL[37] FP7 project (Productivity tools: Automated tools to measure primary productivity in European seas. A new autonomous monitoring tool to measure the primary production of major European seas) developed automated techniques which can be placed on ships of opportunity, or on fixed stations. Some preliminary work has also been done on minituarized version for moorings and gliders.

MarCoast[38] was funded by the European Space Agency through their GMES (Global Monitoring for Environment and Security) Service Element programme to develop operational services that make use of satellite data streams. MarCoast provides water quality monitoring services, water quality indicator services and ocean colour data services to support the implementation of directives, policies and legislations (e.g. monitoring Chl-a as a parameter for the quality index required by the WFD). MarCoast also intended to establish links with other monitoring and products providing projects such as MyOcean.

4.7 Indicative on-going related research projects

In this chapter, that is also based on the STAGES project preliminary work, we present some indicative on-going research projects that have already delivered or are expected to deliver outputs useful for MSFD monitoring.

The DEVOTES[39] project (DEVelopment Of innovative Tools for understanding marine biodiversity and assessing good Environmental Status) addresses specifically marine biodiversity (D1, 4 & 6) and is closely related with the implementation of the MSFD. It started in 2012 and aims at improving understanding of human activities impacts (cumulative, synergistic, antagonistic) and variations due to climate change on marine biodiversity, using long-term series (pelagic and benthic). It starts from cataloguing indicators (including the ones proposed by the EC) and critically reviewing them in relation to their response to pressures and their geographical scope. The gaps that will be revealed will be covered by the development of amended, new and innovative indicators for assessment at species, habitats and ecosystems level. It will integrate the indicators into a tool that will allow unified assessment of the biodiversity and status classification of marine waters. Monitoring is also addressed and existing monitoring networks will be reviewed and innovative monitoring techniques (e.g. remote sensing, high definition multibeams, genomics) will be developed. It will also determine the socio-economic implications of maintaining or changing monitoring and management practices in order to support development of cost-effective monitoring systems and cost-effective adaptive management strategies and measures. Furthermore, it will further develop the work of MEECE on models by developing/testing/validating innovative integrative modelling tools to further strengthen understanding of ecosystem and biodiversity changes (space & time); such tools can be used by statutory bodies, small medium enterprises and marine research institutes to monitor biodiversity,

[36] http://recursosmarinos.udc.es/wp-content/uploads/2008/03/sargal.pdf
[37] http://www.protool-project.eu
[38] http://www.marcoast.eu/
[39] http://www.devotes-project.eu

applying both empirical and automatic data acquisition. It will be completed in 2016 but outcomes will be communicated to the MSFD CIS (and to others stakeholders and end users) as soon as they emerge.

The PERSEUS[40] project (Policy-orientated marine Environmental Research for the Southern European Seas (SES)) is also directly related to the MSFD implementation and focuses on the Mediterranean and the Black Seas (SES). The project aims to assess the current environmental status of the Mediterranean and the Black Seas, in a coherent and integrated manner, fill the existing scientific knowledge gaps and then design and support an ecosystem-based approach to management so that the EU goal of Clean Seas by 2020 can become a reality, while conserving the surrounding marine environment. Particularly useful for monitoring is objective 2 on developing tools for the evaluation of the environmental status using existing and upgraded monitoring and modelling capabilities. This objective is intended to propose options which ensure that monitoring and modelling capabilities remain well-coordinated in the long-term. In other words, the project will develop the overall strategy for monitoring the SES using existing structures while developing new ones in line with the latest technological developments. To this end, a small research and survey vessel concept will be also designed for use in areas where currently available research vessels cannot operate effectively and can serve as a scientific survey tool beyond the project's duration. Moreover, modelling systems will address both basin and coastal scales, while tools will explicitly tackle specific quantitative/qualitative descriptors of the MFSD and will support a results-based approach that will allow identification of the most efficient strategies to achieve or maintain GES.

CoCoNET[41] (Towards COast to COast NETworks of marine protected areas (from the shore to the high and deep sea, coupled with sea-based wind energy potential) focuses on marine protected areas (MPA), including coastal, off-shore and deep sea habitats, and will individuate areas where offshore wind farms might become established, avoiding too sensitive habitats but acting as stepping stones through MPAs. The project will produce the guidelines to design, manage and monitor a network of MPAs and also an enriched wind atlas for the Mediterranean and the Black Seas.

MESMA[42] (Monitoring and Evaluation of Spatially Manages Areas) is an EU-FP7 project on monitoring and evaluation of spatially managed marine areas (2009-2013). Monitoring related outputs include the 2012 Katsanevakis et al. (2013) and the Stelzenmüller et al. (2013) publications. The first reviews monitoring methods for marine populations such as plot sampling, distance sampling, repetitive surveys for occupancy estimation and modelling, mark-recapture techniques and removal methods for specific biodiversity components. The second provides guidance on the selection, mapping, and assessment of ecosystem components and human pressures, the evaluation of management effectiveness and potential adaptations to management.

The ODDEM[43] project (Options for Delivering Ecosystem-based Marine Management), covers Europe's four regional seas and focuses on supporting implementation of MSFD by developing tools and understanding required to weigh up options by Member States, Regional bodies and the EC. A tool on pressure assessment[44] has been developed which identifies the sector/pressure combinations that currently present the greatest threat to marine habitats and their associated assemblages and its application to Europe's regional seas. This tool will help identifying the key pressures, specifically from human activities, on marine ecosystem characteristics and will allow management action to be focused on the most damaging activities and identify the most vulnerable ecosystem characteristics and

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[40] http://www.perseus-net.eu
[41] http://www.coconet-fp7.eu
[42] http://www.mesma.org
[43] http://www.liv.ac.uk/odemm
[44] http://www.liv.ac.uk/media/livacuk/odemm/docs/Pressure_Assessment_Guidance.pdf

consequently, prioritise resources. Although more directly related to measures, this prioritization could also be useful for the establishment of monitoring programmes under the light of the risk-based approach. Furthermore, the ODEMM Linkage Framework[45] provides a conceptual tool to describe the relationships between the ecological, socio-cultural and economic characteristics of the European marine environment and addresses the integrated approach required by the MSFD. This linkage framework guidance document presents part of this integrated concept by specifically describing the linkages between the MSFD high level objectives, the ecological characteristics of the natural environment, and the ecosystem goods and services provided by these ecological characteristics. It can thus be useful for planning the monitoring of the social and economic component.

The GES-REG[46] INTEREG project (Good Environmental Status through Regional Coordination and Capacity Building) Central Baltic INTERREG IV A Programme 2007-2013 is a European territorial co-operation programme that focuses on environment, economic growth as well as attractive and dynamic societies in the central Baltic Sea area. The main aim of the GES-REG project is to support coherent and coordinated implementation of the MSFD in the central and north-eastern sub-regions of the Baltic Sea. The project improves the marine environmental management in the region via dissemination efforts towards the main target groups of environmental authorities, institutions responsible for marine monitoring and assessment, HELCOM, stakeholders and wider public. The project promotes a sound and cost effective joint monitoring and assessment scheme. Existing monitoring and assessment programs are analyzed and a joint cost-effective monitoring network will be elaborated. A study will be carried out on cost-effectiveness of monitoring methods using autonomous platforms (e.g. Ferryboxes, automatic buoys etc.). A Ferrybox system will be installed on a ferry travelling between Riga and Stockholm. Data of all Ferrybox systems currently operating in the sea area (Helsinki-Travemünde, Gothenburg- Kemi, Helsinki-Tallinn, Tallinn-Stockholm, and Riga-Stockholm) will be pooled together and analyzed. The expected results include a report on the gaps in the monitoring programs. Recommendations on updating of monitoring network and assessment methods will also be formulated. A joint scientifically sound and cost-effective monitoring and assessment scheme for the sub-region will be proposed. The project is thus working on transboundary regional cooperation using also less applied monitoring techniques. In this sense is very much compatible with recommendations of Zampoukas et al. (2013) for integrated monitoring and could provide a good practice of the application of the overarching principle of coordination and coherence.

CleanSea[47] (Towards a Clean Litter-Free European Marine Environment through Scientific Evidence Innovative Tools and Good Governance) is a multidisciplinary and collaborative FP7 project, addressing marine litter from different perspectives. It aims at providing Member States and other stakeholders with knowledge and tools to be able to better define, monitor and achieve GES. CleanSea looks at marine litter impacts on ecosystems, its monitoring and characterization, remediation techniques, the economic dimension of the issue and the policy options to address it. The result will be a roadmap to GES for marine Litter in 2020 derived from a transparent, coherent synthesis in an integrated assessment framework of natural and social science research outcomes and stakeholder's needs and perceptions.

The MISIS[48] project (MSFD Guiding Improvements in the Black Sea Integrated Monitoring System) is expected to improve marine monitoring in the Black Sea by:

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[45] http://www.liv.ac.uk/media/livacuk/odemm/docs/ODEMM_Linkage_Framework.pdf
[46] http://gesreg.msi.ttu.ee/en
[47] http://www.cleansea-project.eu
[48] http://www.misisproject.eu

- Contributing to development of national integrated monitoring programmes compliant with the MSFD and the WFD allowing also compliance of beneficiary countries with other international obligations, in particular implementation of the Bucharest Convention and its Protocols.
- Initial testing of the revised monitoring programmes (field and laboratory work), management of data, assessments organising a Joint Black Sea Survey.
- Contributing to existing database systems (Black Sea Commission, WISE-MARINE) as far as marine/coastal environment monitoring is concerned

The MedSeA[49] FP7 project (Mediterranean Sea Acidification in a changing climate) addresses marine acidification in the Mediterranean and, among other things, will generate new observational and experimental data on Mediterranean organism and ecosystem responses to acidification and fed into existing fine-scale models of the Mediterranean Sea that are modified to better represent key processes, and then used to project future changes. The outputs of the project could be potentially useful for Member Sates considerations on addressing this emerging pressure.

The MyOcean2[50] project aims to deliver and operate a rigorous, robust and sustainable Ocean Monitoring and Forecasting system of the Global Monitoring for Environment and Security Marine Service to users for all marine applications, including marine resources, marine and coastal environment and climate. MyOcean2 produces and delivers services based on the common-denominator ocean state variables that are required to help meet the needs for information of those responsible for environmental and civil security policy making, assessment and implementation. Frequently requested parameters include temperature, salinity, currents, sea level, chlorophyll-a, dissolved oxygen, nutrients and PAR (light).

The MG4U[51] project (Marine Genomics for Users) will spread results from recent and on-going projects in marine genomics and enhance rapid, efficient knowledge transfer to generate interdisciplinary research capacity in Europe. Scientists, government officials and representatives from small, medium and large enterprises will participate in diverse transfer activities.

The CREAM[52] FP7 project (Coordinating Research in support to application of Ecosystem Approach to fisheries Management advice in the Mediterranean and Black Seas) will be based on existing data and will propose a series of key prioritized indicators, models and methodologies for the implementation of the ecosystem approach for fisheries in the Mediterranean and Black Seas. More related to monitoring, it will develop protocols for data collection and quality evaluation.

MED-JELLYRISK[53] (Integrated monitoring of jellyfish outbreaks under anthropogenic and climatic impacts in the Mediterranean Sea (coastal zones): trophic and socio-economic risks") is a 2012-2015 ENPI-CBC MED[54] Strategic Project. MED-JELLYRISK addresses an integrated coastal management approach into 10 marine coastal zones in the Western and Central Mediterranean sea basin to face with increased jellyfish proliferations. The strategic objective is to assess, prevent, mitigate and foresee the negative natural, health and economic impacts of jellyfish proliferations. MED-JELLYRISK has developed an online data collection application for citizens to report monitoring sightings of jellyfish. An innovative monitoring related application for smartphones will be developed by MED-JELLYRISK in the frame of citizens' monitoring that would generate a shareable database for jellyfish proliferation areas.

[49] http://medsea-project.eu
[50] http://www.myocean.eu/web/76-coastal-marine-environment-description.php
[51] http://www.mg4u.eu
[52] http://www.cream-fp7.eu
[53] http://jellyrisk.eu/
[54] http://www.enpicbcmed.eu

The collection of data to populate some biodiversity indicators that need intensive sampling for which the enforcement of monitoring programme might be economically not feasible (e.g. detection of invasive species, description of rare/sensitive species in terms of distribution/ occurrence, benthic habitats mapping) may benefit from the use of cheap sampling platforms like fishing vessels and the involvement of fishermen and the collection/use of traditional ecological knowledge in the framework of participatory science activities (see for instance the on-going FP7 project GAP2[55]). This approach proved to be efficient, for instance, in the assessment of discard in the Netherlands, the identification of non-indigenous species in the Wadden Sea as well as for habitat mapping in Galicia (Spain, Golf of Biscay and Iberian Coast) and the Northern Adriatic Sea. It is worth noting that to exploit the full potential of such approach it would be necessary that consolidated and standard protocols are developed and applied.

4.8 Pilot projects on "new knowledge for an integrated management of human activities in the sea"

Three pilot projects funded by DG ENV[56] started recently and focus on the development of integrated, multi-disciplinary monitoring programmes that aim to maximise the use of existing resources by improving the efficiency of existing programmes as well as joint monitoring programmes in marine regions/sub regions that help forge synergies between Member States and can potentially reduce overall costs. A short description of these projects follows below.

The aim of IRIS-SES project (Integrated Regional monitoring Implementation Strategy in the South European) is to develop a new concept and decision-making tools for integrated environmental monitoring for MSFD and other environmental legislation, in the Mediterranean and Black Seas. It is structured in five Activities: Activity 1 (*Analysis of the monitoring programs carried on the framework of European/Regional /National legislation in relation to MSFD requirements*) will prepare a comprehensive analysis of existing monitoring programs, including assessment of the programs described to meet the MSFD needs. Activity 2 (*Integrating scales of monitoring with those of processes to be monitored*) will assess opportunities in developing multi-disciplinary programs (including platforms, surveyors on ship of opportunity, spare capacity, etc), the development of these monitoring programs across states (EU/non EU), within the regions/subregions of Mediterranean and Black Sea, joint planning/implementation and the recognition of relevant gaps and needs. Activity 3 (*Adaptation and development of intelligent tools*) will develop tools, (software/GIS) for planning and optimization of resources and monitoring requirements, as well as decision-making tools. Activity 4 (*Optimization and adaptation to MSFD requirements of ongoing joint marine monitoring in the Mediterranean and Black Sea*) will integrate all previous to develop strategies for the joint monitoring programs within a marine region/sub-region, to forge synergies within and between Member States for monitoring and assessing pressures and impacts from human activities. It will be based on the design and implementation of common protocols and the creation of coordination mechanisms. Finally, Activity 5 (*Coordination and Management, Dissemination and Sustainability)* will focus on project management and implementation, actions for monitoring/supervision of the operation and risks involved in its implementation, dissemination of results and sustainability of the project's achievements.

The BALSAM project (Testing new concepts for integrated environmental monitoring of the Baltic Sea) aims at enhancing the capacity of the Baltic Sea Member States to develop their monitoring

[55] http://gap2.eu
[56] http://ec.europa.eu/environment/funding/sea_12.htm

programmes. Although coordinated monitoring of the Baltic Sea has for long been carried out under the HELCOM umbrella, the project will increase and improve the cross-border coordination and joint activities especially related to monitoring of biodiversity. For biodiversity, this project will augment the capacity of the Baltic Sea coastal countries in monitoring of marine mammals, water birds, non-indigenous species in ports and biotopes. A decision support tool will be developed for non-indigenous species monitoring in ports for use under the MSFD as well as the IMO Ballast Water Management Convention. Improvements in shared and coordinated use of research vessels for monitoring between the countries, as worked upon by the project, will enhance resource- and cost-efficiency of monitoring in the Baltic Sea region. Integration of monitoring carried out under different policy frameworks (EU and HELCOM) and sectors (e.g. environmental and fisheries) and compatibility of data from different monitoring schemes is one of the themes of the project and it will contribute to the integration of monitoring activities in the Baltic Sea region. Overall, the project has great potential to enhance coordinated and integrated monitoring capacity in the Baltic Sea region and in such a way upgrade the preparedness of the Baltic Sea region EU member states for implementing the monitoring requirements of the MSFD. It will also provide input to the ongoing revision of HELCOM's coordinated monitoring system that has been initiated with the revised HELCOM Monitoring and Assessment Strategy and will continue in 2013-2014 with development of a monitoring manual describing the revised joint coordinated monitoring system for the Baltic Sea and in 2015 is expected to finalise the revision of monitoring guidelines. The BALSAM project will contribute to the specific themes in the monitoring revision.

The JMP NS/CS project (Towards a joint monitoring programme for the North Sea and the Celtic Sea) is focusing on successful and cost-effective implementation of the MSFD that depends on regional cooperation between EU Member States and third countries. This project will develop a proposal for a joint monitoring programme for the North Sea and for the Celtic Sea. It will be based on an analysis of all ongoing monitoring in these subregions and the requirements of the MSFD, taking account of other legal frameworks and agreements. Using existing and new planning tools, integration will be sought between types of monitoring in order to efficiently use monitoring platforms, i.e. ships, permanent stations and aerial surveys. Innovative and proven technology and current practices in integrated monitoring will serve as building blocks and examples. Since the project covers two subregions with different characteristics, transferability of approaches to other subregions and identification of opportunities to trial integrated ecosystem surveys will be major aspects of the work. Perhaps the main aim of this project is to build a constructive network between all institutions that are responsible for monitoring in these subregions, concerning both fisheries and environmental monitoring. The consortium consists of all relevant institutes (18) in 9 countries bordering the North Sea and Celtic Sea. MSFD policy leads support the work and will actively contribute to it. The consortium will work towards lasting cross-border cooperation for current and future implementation of the MSFD.

5. MONITORING FOR SPECIFIC DESCRIPTORS

5.1 Biodiversity monitoring (Descriptors 1, 2, 4 & 6)

The most widely agreed definition of biodiversity is the one found in the Convention on Biological Diversity (CBD)[57]: “the variability among living organisms from all sources including, inter alia, [terrestrial,] marine [and other aquatic ecosystems] and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems”. Marine biodiversity is undergoing rapid alteration under the combined pressure of climate change and human impact, but protection measures, either for species or ecosystems, are still scarce. Biological diversity has to be documented and understood before it can be totally preserved. The structure and organisation of aquatic communities, molded in each environment by combinations of abiotic factors, recruitment and productivity rates, rely upon a network of both pairwise and transitive interactions among organisms (Piraino et al., 2002). To understand the role and patterns of marine biodiversity, marine ecological research should revalue those scientific areas, such as taxonomy, suffering from an important lack of funding (Guerra-Garcia et al, 2008) and experts and start monitoring biodiversity with a long-term approach at a large scale (Bianchi & Morri, 2000).

According to the MSFD, biological diversity is maintained when the quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. It covers the whole range of species, habitats and pressures in all European marine regions (from coastal waters to open seas). The Commission Decision 2010/477/EU sets certain criteria and indicators to define GES on the species, population, habitat and ecosystem level. It is widely recognized that there are links between D1 (biodiversity per se), D2 (non-indigenous species), D4 (food-webs) and D6 (sea-floor integrity) which are frequently addressed together as the “biodiversity theme” since the data requirements for these descriptors overlap when addressing state and/or alteration of biodiversity, although there are separate descriptions of what GES is for each one of them. It is also recognized that although aspects of these descriptors are, to some extent, already addressed by other EU pieces of legislation the MSFD implementation requires further scientific and technical developments to better conceptually frame biodiversity in a “risk approach” (i.e by which processes biodiversity is impacted by pressures induced by human activity) and achieve an operational capacity for a meaningful monitoring and assessment.

A recent review of sampling methods for the main components of marine biota is provided by Katsanevakis et al. (2012) together with considerations on imperfect detectability. These methods are summarized in Table 4. Furthermore, the use of environmental DNA and high definition cameras for biodiversity monitoring are promising approaches and highlighted in Boxes 1 and 2.

[57] http://www.cbd.int/

Table 4. Methods applied for monitoring marine populations, for each of the main components of marine biota. Underlined: the most common methods for each component, ROV: remotely operated vehicle, CPUE: catch-per-unit-effort, PIT: passive integrated transponder, na: not applicable or not relevant, potential: potentially applicable methods (from Katsanevakis et al., 2012)

Plot sampling	Distance sampling	Mark-recapture	Repetitive surveys for occupancy estimation	Removal methods	Other
Fish					
Trawls, dredges; strip transects (divers, ROVs, drop cameras)	Line transects by divers or submersibles	Tagging	By divers; based on fisheries data (potential)	A variety of methods based on fisheries data	Acoustic methods; fixed-time swims, rapid visual techniques
Invertebrates					
Endobenthos Grabs, corers; dredges; burrow counting	na	Tagging of megafauna (mollusks, crustaceans)	Based on repetitive endobenthic samples (potential)	Simple removal or CPUE (for megafauna)	
Epibenthos Trawls, dredges, sledges; strip transects (divers, ROVs, drop cameras); quadrats, photo quadrats	Line transects by divers or submersibles	Tagging (mollusks, crustaceans, echinoderms)	By divers	Simple removal or CPUE	Line intercept transect or point intercept transect surveys
Hyperbenthos Sledge-mounted gear	na	na	Based on repetitive sledge samples (potential)	CPUE	
Zooplankton Towed nets; strip transects for mega-plankton (shipboard, aerial, ROVs, video profilers, divers)	Shipboard line transects (for megaplankton)	na	For megaplankton (potential)	na	Continuous plankton recorder acoustics
Marine mammals					
Cetaceans Shipboard or aerial strip transects	Shipboard or aerial line transects	Photo identification from natural markings on flukes or dorsal fins	Shipboard or aerial (potential)	CPUE (bycatches), simple removal	Migration counts
Pinnipeds Quadrat sampling of colonies	na	Photo identification from natural markings in pelage	In marine caves, beaches, etc. (potential)	CPUE (bycatches), simple removal	Colony counts
Seabirds					
Shipboard or aerial strip transects	Shipboard line transects	Ringing	Shipboard or aerial (potential)	CPUE (bycatches), simple removal	Seawatching
Marine turtles					
Shipboard or aerial strip transects	Aerial or boat surveys (line transects)	PIT tagging, satellite tagging	Shipboard, aerial, or diver-based (potential)	CPUE (bycatches), simple removal	Nest counts

Box 1: Environmental DNA

Marine organisms are often hard to count. However, they consistently shed DNA in various ways (plant parts, decay, fish slime and scales, etc.) which can be sampled, purified and easily amplified by a PCR. Downstream analysis can either be species specific, through cheap PCR or hybridisation techniques, or open ended, with high throughput sequencing. Machine time and analyses are rapidly becoming cheaper. Taking samples is relatively straightforward and protocols can be developed for opportunistic sampling. Sampling, processing and relating to actual occurrence of the organism are investigated in many projects, in most cases in fresh water. There is an ever increasing information resource available on the internet[58].

There is no restriction on the type of organism studied and it is relatively easy and cheap to develop a species specific DNA marker, as long as their DNA occurs in the water column and a pure sample can be obtained for validation of probes. However, due to the vast number of marine species, particularly for components such as phytoplankton, the development of markers for all species of the community is of questionable feasibility. The method is particularly useful to determine the absence or presence, since the DNA concentration depends on currents, rate of decay, size of the water body, characteristics of the species (e.g. much higher DNA concentrations during spawning periods), etc. The collected DNA may therefore not adequately reflect the abundance of the species. The method is therefore good to determine species composition and occurrence of rare and invasive species. Well-designed sampling schemes taking into account characteristics of the water body already generate semi-quantitative data and experts predict that it can generate sufficiently reliable quantitative data within a few years. The potential of genomics in marine monitoring has been recently reviewed by Bourlat et al. (2013).

Box 2: High definition cameras

Birds and mammals are usually counted from an airplane or a ship. Disturbance, proper identification of species and high costs are problems in monitoring these species. Getting reliable counts of species that form dense groups such as eider ducks may require another counting method than the standard line transect sampling usually used for species with a more scattered distribution. Separate counts are costly. High definition cameras hanging under a plane may offer a solution. Commercial companies already offer it as a reliable method to survey seabirds and sea mammals (see examples on the internet). The method was used to study the impact of wind farms on sea birds in the UK[59] and in a windfarm project in the Netherlands. Some companies claim that these cameras detect more than the naked eye and may thus be used at much higher altitudes than with human observers. That results in less disturbance and more accurate counts. The method is further developed in several research projects[60] and it is expected that it can be implemented in national monitoring programs from 2015 onwards. Possibilities also exist for synergies between patrol flights and environmental monitoring e.g. Finland has initiated collaboration between environmental agencies (SYKE) and the Border Guard.

[58] http://edna.nd.edu/Environmental_DNA_at_ND/Home.html
http://www.environmental-dna.nl
http://pubs.usgs.gov/fs/2012/3146
http://www.asiancarp.us/edna.htm
http://www.ncbi.nlm.nih.gov/pubmed/22151771

[59] http://www.ebanmagazine.com/mag_story.html?ident=10351
http://wwtconsulting.co.uk/site_media/user/downloads/HiDef_Poster_4.pdf

[60] http://mhk.pnnl.gov/wiki/images/d/d6/High_Definition_Imagery_for_Surveying_Seabirds_and_Marine_Mammals.pdf

5.1.1 Links to HD, BD, WFD and CFP and needs for further monitoring

A useful document on the link between MSFD and the Nature Directives (MSFD Common Implementation Strategy, 2012) addresses interactions and synergies between these legal instruments and has been considered for the drafting of the present guidance.

In the HD there is no definition of biodiversity but reference to the need to maintain it. It requires that EU Member States take measures to ensure that the listed species and habitats "of community interest" are protected so as to be in "favourable conservation status" and report every six years the measures taken and their impact on the conservation status of concerned habitats and species. Although there are no explicit monitoring requirements status assessment requires data on the natural and current range and population dynamics of species and size of the habitats.

Specifically, the HD requires status assessment of habitats that are listed in HD Annex I, with particular regard to priority natural habitat types. Priority natural habitat types mean natural habitat types in danger of disappearance, which are present on the territory referred to in HD Article 2 and for the conservation of which the Community has particular responsibility in view of the proportion of their natural range which falls within the territory referred to in Article 2; these priority natural habitat types are indicated by an asterisk (*) in HD Annex I. There are eight marine or potentially marine habitat types in Annex I, of which one is priority habitat (Table 5).

Table 5: Marine habitat types in Annex I of the Habitats Directive[61] (based on MSFD Common Implementation Strategy, 2012 and modified by excluding estuaries and coastal lagoons as they tend to be excluded from MSFD area).

Annex I habitat types which are reported according to the HD marine regions	
1110	Sandbanks which are slightly covered by sea water all the time
1120*	*Posidonia* beds (*Posidonion oceanicae*)
1140	Mudflats and sandflats not covered by seawater at low tide
1160	Large shallow inlets and bays
1170	Reefs
1180	Submarine structures made by leaking gasses
1650	Boreal Baltic narrow inlets
8330	Submerged or partially submerged sea caves

HD Annex II lists the species of community interest whose conservation requires the designation of special areas of conservation. According to MSFD Common Implementation Strategy (2012), HD Annex II includes 30 marine or potentially marine species of whom nine are marked with an asterisk and considered priority species. Specifically, there are two cetaceans, four seals (two*), two reptiles (two*), nineteen fish (five*) and one invertebrate. HD Annex IV lists species of community interest in need of

[61] Detailed descriptions of these habitat types are given in the EU-27 habitats Interpretation manual http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/2007_07_im.pdf.
** = Priority habitats.*

strict protection and adds 39 more marine, or potentially marine, species, including 31 cetaceans, 3 reptiles, 1 fish and 4 invertebrates. HD Annex V lists species of community interest whose taking in the wild and exploitation may be subject to management measures. It further adds 13 species, including 3 seals, 6 fish, 2 invertebrates and 2 plants. In total, 82 marine or potentially marine species are included in HD Annexes. The list of marine, or potentially marine, species in different HD Annexes are presented in detail in Annex III of this document.

Habitat extent is the most and common, and sometimes only, parameter monitored for habitats. Abundance is the most common parameter measured for species. Size and age measurements as well as reproduction and mortality rates are monitored for some species in some areas. Although the six years reporting cycle implies updated info at least every six years, monitoring needs to take into account natural variability, changes in physical environment and life cycle of the species as well as human pressures.

The BD does not define biodiversity either but refers to the need for a sufficient diversity and area of habitats for listed bird species. It requires the establishment of measures to maintain the population of the listed species. These measures should be reported every three years. There are no explicit monitoring requirements but the establishment of conservation measures should take into account trends and variations in populations. Specifically, the BD lists 68 marine, or potentially marine, bird species that require special protection areas. The detailed list of species, based on the MSFD Common Implementation Strategy (2012) and further developed, is presented in Annex IV of this document. Abundance of species and abundance of nests are the main parameters monitored and can also give an estimate of reproduction rates. For certain species the number of eggs laid is also monitored. A good effort that takes into account the requirements of both the BD and the MSFD and makes progress towards a region wide coordination are the birds monitoring activities of HELCOM. A summary is presented in Annex V.

The approach of the MSFD is different from the HD and BD, not focusing on specific species or habitats but proposing qualitative descriptors of marine environment. Table 1 of Annex III to the Directive provides the environmental components to be addressed in the Initial Assessment (Art. 8) and subsequent six-yearly assessments (Art. 17). These are to be assessed in relation to the objectives set in the Descriptors in Annex I and the overall definition of GES in Art. 3.5. In terms of species, this includes those which are dependent for all or part of their life cycle on the marine environment, including for breeding, feeding, resting and migratory purposes. The overall aim should be to undertake assessment and monitoring across a sufficient range of species (and their discrete populations where appropriate), habitats/communities, geographical areas and pressures, to enable a robust and systematic assessment against the objectives of the Descriptor 1. The Task Group 1 report (Cochrane et al., 2010) groups marine species to ‘ecotypes’, which could be taken into account when selecting species to the monitoring programme. There is not however need to monitor and assess vagrant species i.e. species that occur, through natural means (i.e. not introduced through human activities), well outside its normal distributional range. However, national monitoring systems like the stranding network for vagrant protected species could feed to regionally coordinated programmes and provide useful info.

As for habitats, MSFD Annex III, Table 1 gives three categories of habitats that should be taken into account in marine monitoring and assessments: (1) predominant habitat types, (2) special habitat types and (3) habitats in areas which by virtue of their characteristics, location or strategic importance merit a particular reference (predominant habitats, special habitats and of particular reference).

The report of the Task Group 1 for Biological Diversity (Cochrane et al., 2010) clarifies that predominant seabed and pelagic habitats are broadly-defined types on the EUNIS classification system and these

should be included in the monitoring of the marine region (Cochrane et al., 2010). A list of predominant habitat types of the seabed and water column is provided in the MSFD Commission Staff Working Paper of October 2011[62]. For the Baltic Sea, HELCOM has addressed the classification of underwater biotopes and habitats in a recent report (HELCOM, 2013a).

The Task Group 1 report also defines the special habitat types to be 'listed habitats' which may mean habitat types that are listed in threat assessments (e.g. IUCN red lists) or national or international legislation. The special habitats are not meant to be included in the 'wider marine monitoring', like the predominant habitats, but should be subject to a risk-based monitoring, in areas where anthropogenic pressures are higher or identified to threaten the special habitat types. According to the MSFD Commission Staff Working Paper of October 2011 many of these listed types are at a finer level of definition than the predominant types and their assessment may contribute in whole or in part to the assessments required for the predominant habitat types. The MSFD Common Implementation Strategy (2012) document explored the potential overlap between MSFD and HD marine habitat types and table 6 shows these overlaps.

The third types of habitats were considered by the Task Group 1 as (1) Areas subject to specific or multiple pressures and therefore addressed as part of the risk assessment approach for predominant and listed/special habitats, communities and species and (2) Areas designated as marine protected areas (MPAs) or subject to other forms of protection, such as fishery closed areas. The report specifies that monitoring of these habitats is not meant to be done in the entire region but according to the risk-based approach. Moreover, the habitats in MPAs may provide good information of the threshold levels for GES.

In the marine environment, the WFD monitoring only covers coastal waters at the water body scale. The WFD does not explicitly mention biodiversity but it requires data on taxa and their abundance and/or biomass for only three Biological Quality Elements (BQE), i.e. phytoplankton, macrophytes (macroalgae and angiosperms) and benthic invertebrate fauna, as an indicator of overall ecological integrity that could lead to effective measures in the whole river basin. There is also monitoring in transitional waters, lakes and rivers that do not fall in the scope of the MSFD but the methods developed (e.g. for fish in transitional waters) could potentially be adapted to the marine environment.

[62] Relationship between the initial assessment of marine waters and the criteria for good environmental status. Commission Staff Working Paper. SEC(2011) 1255 final.
http://ec.europa.eu/environment/marine/pdf/SEC_2011_1255_F_DTS.pdf

Table 6: Potential overlap between MSFD and Habitats Directive marine habitat types (Based on MSFD Common Implementation strategy, 2012 and adjusted by excluding estuaries and costal lagoons)

<table>
<tr><th rowspan="2">Predominant seabed habitat types for MSFD[a]</th><th colspan="8">HABITAT TYPES LISTED IN ANNEX 1 OF THE HABITATS DIRECTIVE AND CONSIDERED 'MARINE' FOR ARTICLE 17 REPORTING</th></tr>
<tr><th>1110 Sandbanks slightly covered all the time</th><th>1120 Posidonia beds</th><th>1140 Mudflats & sandflats not covered at low tide</th><th>1160 Large shallow inlets and bays</th><th>1170 Reefs</th><th>1180 Submarine structures made by leaking gas</th><th>1650 Boreal Baltic narrow inlets</th><th>8330 Submerged or partially submerged sea caves</th></tr>
<tr><td>Littoral rock & biogenic reef</td><td></td><td></td><td></td><td style="background-color:#d99694"></td><td style="background-color:#d99694"></td><td rowspan="18">These structures may occur in a range of predominant habitat types</td><td rowspan="18">To be confirmed by MSs</td><td style="background-color:#d99694"></td></tr>
<tr><td>Littoral sediment</td><td></td><td></td><td style="background-color:#d99694"></td><td style="background-color:#d99694"></td><td></td><td></td></tr>
<tr><td>Shallow sublittoral rock & biogenic reef</td><td></td><td style="background-color:#d99694"></td><td></td><td style="background-color:#d99694"></td><td style="background-color:#d99694"></td><td style="background-color:#d99694"></td></tr>
<tr><td>Shallow sublittoral coarse sediment</td><td style="background-color:#d99694"></td><td style="background-color:#d99694"></td><td></td><td style="background-color:#d99694"></td><td></td><td></td></tr>
<tr><td>Shallow sublittoral sand</td><td style="background-color:#d99694"></td><td style="background-color:#d99694"></td><td></td><td style="background-color:#d99694"></td><td></td><td></td></tr>
<tr><td>Shallow sublittoral mud</td><td></td><td style="background-color:#d99694"></td><td></td><td style="background-color:#d99694"></td><td></td><td></td></tr>
<tr><td>Shallow sublittoral mixed sediment</td><td style="background-color:#d99694"></td><td style="background-color:#d99694"></td><td></td><td style="background-color:#d99694"></td><td></td><td></td></tr>
<tr><td>Shelf sublittoral rock & biogenic reef</td><td></td><td></td><td></td><td></td><td style="background-color:#d99694"></td><td style="background-color:#d99694"></td></tr>
<tr><td>Shelf sublittoral coarse sediment</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shelf sublittoral sand</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shelf sublittoral mud</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shelf sublittoral mixed sediment</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Upper bathyal rock & biogenic reef</td><td></td><td></td><td></td><td></td><td style="background-color:#d99694"></td><td></td></tr>
<tr><td>Upper bathyal sediment</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Lower bathyal rock & biogenic reef</td><td></td><td></td><td></td><td></td><td style="background-color:#d99694"></td><td></td></tr>
<tr><td>Lower bathyal sediment</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Abyssal rock & biogenic reef</td><td></td><td></td><td></td><td></td><td style="background-color:#d99694"></td><td></td></tr>
<tr><td>Abyssal sediment</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

a From Commission Staff Working Paper (October 2011)

Commission Regulation 665/2008[63] establishes the Data Collection Framework (DCF), for the collection, management and use of data in the fisheries sector and to support management decision by establishing coordinated actions with standard protocols to collect data at European scale in the frame of the CFP. The Regulation was followed by the Commission Decision 2010/93/EU[64] which describes in detail the Multiannual Community Programme to support the DCF. The collected datasets could provide significant input into the MSFD implementation in both D3 as well as the biodiversity descriptors (D1, D2, D4 and D6), particularly since they provide long time-series with valuable information on trends and indications on potential alterations. The DCF programme includes specifications for collection of biological, economic variables and transversal variables and for research surveys at sea. The DCF is mainly aimed at collecting data on the fisheries sector (biological data on exploited species, socio-economic data and structural data on fleets and fishing activity) and not specifically tailored to collect data on biodiversity (e.g. due to selectivity of the gear, seasonality of sampling, spatial coverage and habitat types). However, sampling at sea (in particular trawl-surveys) and on board of fishing vessels can provide data to assess marine biodiversity and fishing pressure in the frame of MSFD. In particular, variables as well as the data collected during research surveys, have a direct input to specific MSFD biodiversity criteria, namely, the population abundance and/or biomass (1.2.1), population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/ mortality rates) (1.3.1), Large fish (by weight) (4.2.1) and others. Moreover, the DCF foresees the estimation of indicators of environmental effects of fishing that could be particularly relevant for the MSFD. Amongst the environmental indicators that have been included in the Commission Decision 2010/93/EU, the conservation status of fish species, the proportion of large fish, the mean maximum length of fishes, the size at maturation of exploited fish species and areas not impacted by mobile bottom gears have a direct linkage with the MSFD biodiversity indicators.

The MSFD requires monitoring of the whole range of species and habitats in all marine waters in order to take measures to protect the ecosystem as a whole. These data concern traditionally collected ones (i.e. cover, taxa richness and abundance) as well as less commonly collected data on distributional pattern, size, age structure, mortality and fecundity. Data on genetic structure are collected much less commonly and may be helpful scientific research tools, but do not constitute mandatory components of routine MSFD monitoring.

Genetic diversity is the basis of all biological diversity, as cited by the CBD, which puts it explicitly in its objectives and at the centre of the Nagoya Protocol[65]. The definition of a GES on the genetic structure of populations (indicator 1.3.2) may offer some advantages such as to provide information directly to the adaptive potential of a species and to infer such information from a relatively small number of samples. The species should be selected on the basis of their ecological importance in the sub-regions and the information that may be deducted from their genetic structure. For the evaluation of GES in the different sub-regions should be implemented indices resulting from the combination of some genetic parameters, chosen according to the nature of the genetic marker used, the size and consistency of the datasets analysed and taking into account the biological characteristics of the selected species.

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[63] 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

[64] 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)

[65] http://www.cbd.int/abs/

Moreover, the MSFD requires data on occurrence, abundance and impacts of non-indigenous species. These species are not explicitly neither included nor excluded from the scope of the WFD and only some countries consider them in assessing good ecological status. According to Vandekerkhove & Cardoso (2010) there are some regional and national databases on non-indigenous species but most existing monitoring programs fail to detect some indicative non-indigenous species. This may be due, to some extent, to the fact that up to now there has been no requirement to report or assess non-indigenous species.

The Task Group 2 Report (Olenin et al., 2010) recommends to use standard monitoring methods traditionally used for marine biological surveys and that specific approaches may be required in order to ensure that non-indigenous species are likely to be found (e.g. ports, marinas, aquaculture areas etc.) and to target delicate organisms (e.g. jellyfish). Existing monitoring programmes (e.g. for the WFD) should be complemented to explicitly record non-indigenous species, to include high priority samplings sites (hot spots, stepping stones), to possibly include more frequent sampling to catch life stages that may only occur in certain seasons and to include all taxonomic groups (e.g. non-indigenous disease agents, bacteria and viruses). Monitoring data could be complemented by citizen science (see chapter 7.3).

Of particular interest is the recent HELCOM work on non-native species port surveys protocols. Specifically, HELCOM has adopted the HELCOM ALIENS 2 Report (HELCOM, 2013b), which presents a regionally harmonized method for granting exemptions from ballast water treatment (regulation A-4) for marine traffic in the Baltic Sea. The publication establishes a protocol to be used in collecting information from ports in order to conduct reliable risk assessments, defines the criteria for selection of target species to be used in the risk assessment and creates a harmonized decision support tool to run the risk assessments using the available data (collected by using the protocol) and target species (selected using the criteria). The proposal for the HELCOM port survey protocol includes, in addition to the description of the existing sampling in Baltic ports, a survey design with monitoring guidance for environmental data, human pathogens, plankton, epifauna, fouling organisms and benthic infauna. It also includes guidance on specimen handling and sample processing.

An important tool that could assist Member States in assessing non-indigenous species is the European Alien Species Information Network (EASIN)[66] developed by the Joint Research Centre of the European Commission. EASIN facilitates the exploration of non-indigenous species information in Europe from distributed resources through a network of interoperable web services, following internationally recognized standards and protocols. EASIN does not collect new information but integrates information provided by other providers (including Member States) and its quality depends on monitoring effort by Member States. Consequently, it cannot, by any means, replace monitoring but can provide maps and other overview info on the occurrence of non-indigenous species based on the input of data providers. There are many other European, regional or national online databases that offer support to Member States for assessing non-indigenous species in European waters, such as AquaNIS[67] (that has been proposed to be the HELCOM MARITIME platform for the non-indigenous species), DAISIE[68], NOBANIS[69] and ELNAIS[70]. These information systems provide useful information on alien species distribution and impact on a national, regional, or European scale.

[66] http://easin.jrc.ec.europa.eu/
[67] http://www.corpi.ku.lt/databases/index.php/aquanis
[68] http://www.europe-aliens.org
[69] http://www.nobanis.org
[70] https://services.ath.hcmr.gr

The assessment of food webs is also an innovation of the MSFD. Many indicators for this descriptor need further development in order to be operational and to dictate more explicit monitoring needs. There are three criteria and respective indicators in the COM Decision 2010/477/EU based on productivity of key predator species, on proportion of large fish and abundance of functionally important groups/species. Several marine key predator species (particularly mammals, reptiles and birds) are included in the provisions of the HD and BD and thus monitoring of the healthiness of their populations (e.g. in terms of reproduction/ population dynamics) is assumed to be already on-going. The existing good practices of HELCOM and OSPAR EcoQO (e.g. on reproductive success of ringed seal and grey seal pup production) refer to species already monitored for the HD and the BD. Moreover, the DCF requires data collection for the vast majority of top predator fish species and thus the use of length based indicators may not require additional monitoring. However, in some areas length based data are collected only for a relatively limited number of species, therefore a rationale assessment on the potential need to increase the number of assessed species should be carried out. Data for many of the species and functional groups needed (e.g. fish, phytoplankton, bivalves, habitat defining species, top predators) are already collected for other policies but they may not cover all required/important ones (e.g. zooplankton, jellyfish[71]). Additionally, phytoplankton and benthic invertebrate fauna (including bivalves) are at present only monitored for EU law in coastal waters and thus existing information from WFD monitoring need to be supplemented by open sea data of the RSC moitoring programmes to classify wider marine areas. Additional off shore monitoring and/or exploration of modelling possibilities may be needed.

It is worth noting that the definition of functional groups should rely on trophic features (e.g. trophic level) and ecological traits (e.g. life-history traits). In particular, trends in trophic-based functional groups can be assessed by considering time series of catches from trawl-surveys. However, detailed analysis on the trophic level of species according to size (ontogenetic shift) are missing in some areas. Moreover a re-arrangement of trophic web interactions might happen on overexploited/disturbed ecosystems. Therefore data on species diet (by stomach content analysis or the use of stable isotopes) could be in some areas very useful to in order to estimate species' trophic level and thus select appropriate indicators for MSFD based on functional groups. Experience/data obtained in fisheries science on both the use of stomach content and stable isotopes could be used to guide monitoring activities in such issue. Moreover, accurate trophic level data could support the use of multispecific and/or ecosystem models (e.g. mass balance models, see later section on such issue).

Sea-floor integrity (D6) is also an MSFD innovation *per se* but according to the Task Group 6 report (Rice et al., 2010) the challenge is not the complete absence of related monitoring but the impracticability of monitoring the European seas comprehensively on scales where the quality of sea-floor integrity and pressures on the sea-floor are highly patchy. Risk-based monitoring is proposed as the only practical approach. Monitoring of benthic flora and fauna (in terms of abundance, taxonomic composition and sensitivity groups) is also a WFD requirement. Both WFD and MSFD require to explicit the links and processes between human activities, pressures and impact on biology. The MSFD adds the possibility for size spectra monitoring. Size spectra monitoring together with typical WFD monitoring on taxonomic composition and sensitiveness/tolerance could fulfil the criterion on condition of benthic community if they will be extended out of the coastal zone. HD monitoring of biogenic reefs could provide some data for indicator 6.1.1 (type, abundance, biomass and areal extent of relevant biogenic substrate). For 6.1.2

[71] For jellyfish there is a data collection system in the Mediterranean Sea on voluntary basis coordinated by CIESM (jellywatch programme) but is not done on a regular basis http://www.ciesm.org/marine/programs/jellywatch.htm Experience gained in such programme could be used to define sampling protocol to trace the trends in such species' group.

(extent of the seabed significantly affected by human activities for the different substrate types), the HD and WFD monitoring provides data on human activities inducing pressures that impact the benthic communities but not necessarily to all areas required by the MSFD. The CFP can also provide related data on fishing activity derived from the blue box of trawlers as well as data on pressure intensity and on the distribution of some special biogenic habitats as the maerl beds. Moreover, logbook and VMS data would be very useful as input data to assess indicators of pressure induced by trawling fishing, related to D6 (but also D1 & 4). Accessibility and aggregation of data required should be done in such a way that provides its use for MSFD implementation. Experience gained by Member States in the estimation of environmental indicators to assess the impact of fishing on ecosystems indicators assessed for the DCF (appendix XIII, 2010/93/EU) could be used as a basis to establish indicators and analytical methods to obtain pressure indicators that can support MSFD needs. In particular VMS data can allow to trace the potential interaction between fishing gear, sea-floor abrasion and sensitive/protected benthic habitats (by conflict matrix, see for instance methods proposed in the document from N2K, 2012) as well as identifying those portion of the seabed that are subjected to significant adverse impact.

Sea floor integrity may also be altered by human exploitation of sea resources (e.g. mineral extraction, dredging and dredged-sediment immersion, shell farming) or seafloor permanent occupation (by groynes, walls, breakwater, wind/current farms and other constructions). The involved surfaces or volumes are much smaller than surfaces affected by trawl fishing but are concentrated in the near shore zone (mediolittoral to circalittoral) harbouring important ecosystems in term of biodiversity and functionalities. The pressures resulting from such activities can be cumulative and may also affect the water column (turbidity, changes in hydrodynamics). Intensity (in terms of volume and frequency) of those activities can give a "proxy" indicator of the pressure. Otherwise, the physical pressures induced by those activities such as sealing, modification of sedimentation and of local hydrodynamics could be monitored or modelled by surveying changes in bathymetry/topography and nature of the seafloor. Existing information can be acquired, at different quality level, from the EIA asked prior to exploitation or construction and from the compulsory surveys that may be prescribed.

5.1.2 How to select parameters for biodiversity monitoring and the appropriate spatial and temporal focus

Due to the multitude of parameters needed to be addressed for the MSFD reporting, monitoring programmes could be structured upon pre-described indicators which are used to follow up the achievement/maintenance of GES. Good indicators for MSFD:

- should ideally inform on more parameters, species, habitats, or pressures than the ones measured. Such indicators include ones on the abundance, productivity/condition of key-stone and habitat forming species and community based indicators,

- in case of state indicators they should respond to anthropogenic pressures in a predictable way, notably with simultaneous monitoring of pressures (i.e. ensure a linkage to Programme of measures),

- should be statistically robust and have a quantitative threshold level or a range of values indicating GES/sub-GES,

- should be cost-efficient (e.g. monitoring costs vs. acquired information, integration of monitoring with other monitoring, good repeatability and confidence, etc.), and

- should be coordinated with neighbouring Member States in order to obtain comparable assessment products taking into account regional differences.

Monitoring of the whole range of selected characteristics of the marine environment cannot be done by a single monitoring strategy but requires an approach which considers spatial and temporal variability of the monitored parameter. For instance, planktonic species have short life cycles and respond quickly to changing environmental conditions and thus require spatially and temporally denser monitoring than species of longer life histories and slower reproduction. This continuum of scales requires good planning of the monitoring and assessment and, basically, implies setting of assessment units which are relevant for each indicator. The monitoring of the underlying parameters should be established to provide data to each assessment unit. For example, in the Baltic Sea the draft HELCOM Monitoring and Assessment Strategy defines a nested system of assessment units, which recognizes the smallest assessment scale to be a combination of WFD water bodies and offshore sub-basins (further divided by national EEZ boundaries, if necessary), whereas these units can be combined to larger units, such as coastal and offshore waters of sub-basins, 17 sub-basins and the entire Baltic Sea. The benefit of such a pre-defined system of assessment units is in its flexibility to link indicators and their associated monitoring to relevant spatial scales while still be able to decide the appropriate level of reporting at later stages.

Monitoring resources being finite (and often limiting), there is always a trade-off between frequent monitoring and spatially dense monitoring. The choice between the two may be difficult to make, but a guiding principle may be again the selected indicator and its threshold level. If a static threshold has been set for an indicator, the need for a statistically significant time series can be relaxed and the focus can be shifted to spatial coverage. Quite often, however, GES is estimated on the basis of progress towards a better direction – this being true especially for many pressure indicators – and therefore the focus should be on reliable time series.

Another aspect to guide in selecting between spatial and temporal focus is the variability of monitored parameters. A parameter following a condition of a marine mammal population does not vary greatly across a marine region, as the animals move over large distances and the condition 'mixes'. In such a case, monitoring can be done almost anywhere and it applies over the larger area. In contrast, population sizes of marine mammals (or birds) require for the same reason (mobility) censuses that cover almost the entire region (being spatially very demanding) but temporal variability in the estimates of the population size may be smaller (suggesting less frequent monitoring). An extreme case is the monitoring of phytoplankton (or microbes) where spatial and temporal variability is very high.

Data collected/used in the Initial Assessment as well as those historical data that have not been used in such framework for limited spatial/temporal range or other methodological reasons could be useful in determining the historical range of variability (and in some cases, historical baselines) of parameters. But more prominently the could contribute to set up monitoring programme features for each parameter in order to obtain data whose statistical properties are consistent with the need of being able to trace change in GES over time/space. To this purpose it is envisaged monitoring activities to be conceived against their statistical power since this approach in environmental monitoring allows indicating sample size necessary to detect an environmental change as well as provide a better rational to results interpretation (Fairweather, 1991).

The approach of HELCOM on developing a core set of biodiversity indicators could be highlighted as a good practice aiming to form the basis of an indicator-based follow up system for measuring progress towards achieving good environmental status with a full set of operational core indicators. On this basis, joint monitoring of such indicators will be developed and consequently lead to a more coherent monitoring approach in the Baltic Sea. Box 3 gives an overview of these indicators.

Box 3: HELCOM Core set of biodiversity indicators

HELCOM has published an overview of the proposed core indicators which are developed to regularly assess the status of the Baltic Sea marine environment against targets that reflect GES. The indicator development has been carried out within HELCOM CORESET project (2010-2013, cf. HELCOM, 2012a and 2012b). The work was divided between two expert groups; one for biodiversity and another for hazardous substances which met in regular workshops and worked also intersessionally. Altogether about 140 experts from the Contracting Parties and Observer organisations participated in the CORESET work as a whole.

The CORESET project developed the set of core indicators for biodiversity with the aims that the core indicators reflect or directly measure anthropogenic pressures, be scientifically sound, be quantitative, have targets for GES, enable assessments under the HELCOM Baltic Sea Action Plan (BSAP) and the MSFD, be regularly updated with new data and be publicly available. The development of biodiversity core indicators also required consideration of the Baltic Sea ecosystem and its trophic structure, functional groups, keystone species and predominant habitats.

The following biodiversity core indicators have been approved as core indicators:

- Population growth rates, abundance and distribution of marine mammals,
- Pregnancy rates of marine mammals,
- Nutritional status of seals,
- Number of drowned mammals and waterbirds in fishing gears,
- White-tailed eagle productivity,
- Abundance of waterbirds in the wintering season,
- Abundance of waterbirds in the breeding season,
- Abundance of key fish species,
- Abundance of fish key functional groups,
- Proportion of large fish in the community,
- Abundance of sea trout spawners and parr,
- Abundance of salmon spawners and smolt,
- Zooplankton mean size and total abundance,
- State of the soft-bottom macrofauna communities,
- Population structure of long-lived macrozoobenthic species,
- Trends in arrival of new non-indigenous species,
- Red-listed benthic biotopes.

The following have been approved as pre-core indicators, which will be further developed during 2013-2015 within CORESET II by HELCOM experts:

- Lower depth distribution limit of macrophyte species,
- Number of waterbirds being oiled annually,
- Cumulative impact on benthic habitats,
- Extent and distribution of benthic biotopes.

For each indicator, a “fact sheet” has been developed, including also information on current monitoring activities and gaps to be filled in at a later stage. The fact sheets will be published on HELCOM’s web site*.

* HELCOM HOD 41/2013 (LD48) agreed to publish the first HELCOM core set of biodiversity and hazardous substances core indicators on the HELCOM web page.

5.1.3 Links between biodiversity monitoring and monitoring for other descriptors

Biodiversity monitoring for the descriptors 1, 2, 4, and 6 can be seen to naturally support each other and be implemented within a same monitoring programme. Obvious synergies also exist with some eutrophication indicators e.g. data on the composition and abundance of macrophytes are needed for both eutrophication and sea-floor integrity and it would be logical that a monitoring programme will collect data on composition and abundance of the widest possible range of species so as to cover as many descriptors as possible.

Additionally, monitoring of descriptors falling under other regimes, like fisheries sector (D3), oceanographical sector (D5), contaminant sector (D8) and food safety authorities (D9), could be integrated and the cost-efficiency of the marine monitoring programme improved. According to ICES (2013) report of the working group of biodiversity science, integration of fish stock surveys and environmental monitoring of other sectors have great unused potential. Detailed considerations on this potential are presented in chapter 5.3.4.

Another possibility of improved integration is streamlining between national monitoring for habitats, vegetation and zoobenthos under the different EU directives (HD, WFD, MSFD) and the monitoring by municipalities as well as industry and other permit holders. The environmental permits are often given for rather long terms and the permitting authorities may be different than the monitoring authorities. Streamlining the monitoring and reporting guidance between these monitoring regimes may improve cost-efficiency of marine monitoring considerably.

There are possibilities for synergies also between species and habitats monitoring and monitoring of pressures and impacts. As an example, monitoring of beach washed fulmars provides data on their demographic characteristics (mortality rates) while the analysis of their stomach content provides info on the impact of plastic debris. There are also considerations that pressures levels could potentially, in some cases, indicate the status of a species or habitat more sufficiently than cost intensive surveys that require, to some extent, destruction of benthic habitats. Monitoring for activities/pressure/impacts should take into account the appropriate proper monitoring scales that are usually wider than the ones for species/habitats monitoring. It is important to measure pressure more close to the scale of the state e.g. to know the exact track of trawlers. One possible method to do it is to use the ongoing research outputs on effects of fishing activities in MPAs where some fishing activities are allowed. Moreover, integration of VMS data could support such analysis as well as allow the extension of such approach in other non-protected areas where state indicators on benthic habitats are (or will be) available according to ongoing and future monitoring efforts.

5.1.4 Monitoring in Marine Protected Areas

According to IUCN guidelines (Dudley, 2008) «a protected area is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values». A study jointly undertaken by MedPAN and RAC/SPA and validated by MedPAN's scientific committee has led to adapt this definition; therefore a marine protected area is considered to be «any clearly defined geographical marine area - including sub-tidal, inter-tidal and supratidal or lagoon / coastal lake area which is continuously or temporarily connected to the sea, together with its overlying water - recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values» (Claudet et al., 2011) .

The HD requires the designation of Special Areas of Conservation while the BD requires the designation of Special Protection Areas in order to protect the habitats and species listed in these two Directives. A Marine Expert Group has been established in the frame of the implementation of these Directives and its work can be followed on CIRCABC[72]. Member States can also designate MPAs under other international (e.g. Ramsar Convention) and national legislation. The MSFD foresees the reporting of existing MPAs. In the Mediterranean, for example, there are a large number of different national and international designations. It is possible to count up to four different overlapping designations for a single area. This is partly explained by the fact that international statuses are often attributed to sites which already have a national designation. In addition, a large number of Natura 2000 sites have partially overlapping areas with MPAs which have a national designation (Gabrié et al, 2012). Different designations may imply specific institutive objectives and different management purposes. This may imply different management measures and different systems of data collection and monitoring, specifically conceived to support the adaptive management of the MPAs. A useful reference is the Marine Monitoring Handbook (Davies et al, 2011) published by the UK Joint Nature Conservation Committee that addresses the principles behind, and the procedures for, monitoring the habitats and species within marine Special Areas of Conservation in UK waters to assess their condition. These assessments are intended to fulfil the requirements of the HD and the UK's common standards for monitoring.

Particularly in the Mediterranean Sea and according to Gabrié (2012), 20% of the MPAs do not have regular monitoring but in the vast majority there is monitoring of species or particular functions of the ecosystem (e.g. shelter, wintering, feeding, reproduction etc.) and there is a clear increase in monitoring effort compared to 2008 when according to Chassanite et al., (2012) the monitoring of habitats and species did not seem to be common practice. Monitoring in MPAs could serve several purposes:

- Based on the risk approach some MPAs may be designated as such because of the risk to be under high pressures requiring thus more intense monitoring;
- Other MPAs may be in remote areas only very slightly affected by pressures. Monitoring in these MPAs could be useful for determining reference conditions and/or defining GES for several indicators;
- Monitoring of MPAs in different protection status could also inform on the effectiveness of protection measures.

Consequently Member States should consider monitoring in their MPAs as an integral and important part of their monitoring strategies aiming not only to evaluate the conservation status of the area itself but also contributing to the effective implementation of MSFD articles 8, 9, 10 and 13.

MedPAN[73] is currently developing a directory of existing, quality assured, monitoring protocols, especially those which are implemented and adaptable to Mediterranean MPAs. The directory is to be linked to the MAPAMED Database[74] and to the MedPAN database on large-scale monitoring programmes. One of the criteria the user will be able to search a protocol with is ‘’Legal Framework’’. This is where information on whether the protocol is used for the MSFD will be recorded. Readers are encouraged to consult this directory; open access is planned for January 2014.

[72] https://circabc.europa.eu/w/browse/d93ae1d6-59b2-4107-8f51-b872e08f4615
[73] http://www.medpan.org/
[74] www.mapamed.org

5.1.5 Available models useful for biodiversity evaluation

Marine biodiversity models that look at lower and/or higher trophic level components either in a static or spatial dynamic manner (e.g. habitat and activity-pressures maps) can be useful for several MSFD related purposes such as to determine baseline conditions in the past and to determine the impact of pressures and suitability of measures in the future. It is worth noting that due to the high quantity of data (biomass/production, diet, etc.) needed for the development of ecosystem models, as well as the opportunity of including spatially explicit information on habitats and species distribution, it would be useful to allow a flow of information from different data sources to populate such models as well as to help in developing well-structured models. Wide data coverage will allow setting realistic parameters based on local and experimental data also including opinion from experts of different research fields for considering peculiarities and main features of the modelled ecosystem.

For monitoring purposes models can complement scarce datasets, limiting but not completely substituting data collection in the field and inform on prioritization of sampling activities. For instance, food-web modelling (e.g. mass-balance models; Christensen and Walters, 2004) can be used to explore the relative role of species/ecotrophic groups in ecosystems (i.e. keystone species; Heymans et al., 2012) thus allowing to select those species/groups who might deserve more accurate monitoring and that could be used, for instance, to trace ecosystem changes/shifts for D4 purposes.

Currently, the only existing repository of models at European scale is the MEECE FP7 project model library[75] where interested users can search for available models by region, descriptor and attribute (~indicator). The DEVOTES FP7[76] project aims at updating the MEECE library focusing on biodiversity theme and it will report on needs for further development. A preliminary table resulting from the on-going DEVOTES work showing operational biodiversity related models and their area of applications is shown below (Table 7).

[75] http://www.meece.eu/library.aspx
[76] http://www.devotes-project.eu/

Table 7. Operational models, area of application and biodiversity descriptors that are (at least partially) covered (preliminary output of the DEVOTES project).

Model name	North Adriatic Sea	Eastern Ionian Sea	Aegean Sea	Black Sea	Northern Spain	Gulf of Lions	Baltic Sea	Norwegian Sea	Northern North Sea	Portuguese Waters	Bay of Biscay	North Sea	N.E. Atlantic	Barents Sea
BALTSEM[a]							1, 4							
BFM-POM[b]	1, 4													
Oguz_Dorofeev dynamics biogeochemical model[c]				1, 4										
Ecopath with Ecosim[d]	1, 4, 6	1, 4, 6	1, 4, 6		1, 4, 6	1, 4, 6								
ECOSMO[e]							1, 4		1, 4				1, 4	1, 4
ERGOM[f]							1, 4							
ERSEM-POM[g]			1, 4											
MOHID – LIFE[h]										1, 4	1, 4			
NORWECOM.E2E[i]								1, 4						
OSMOSE[j]											1, 4			
PDMM[k]												1, 4		
POLCOMS-ERSEM[l]													1, 4	
POM-BIMS-ECO[m]				1, 4										
RCO-SCOBI[n]							1, 4							
ROMS-BioEBUS[o]														4
ROMS-N2P2Z22[p]											1, 4			
SPBEM[q]							1, 4							

[a]http://www.balticnest.org/balticnest/research/publications/publications/baltsemamarinemodelfordecisionsupportwithinthebalticsearegion.5.d4ae509138dcbba8a2158.html
[b] http://www.meece.eu/documents/deliverables/WP3/D3%204_Part7_Adriatic.pdf
[c] http://www.myocean.eu/web/24-catalogue.php
[d] http://www.ecopath.org/
[e] http://www.meece.eu/documents/deliverables/WP3/D3%204_Part4_Baltic.pdf
[f] http://ocean.dmi.dk/models/ergom.uk.php
[g] http://www.meece.eu/regions/Aegean.pdf
[h] http://www.mohid.com/
[i] http://www.imr.no/temasider/modeller/norwecom.e2e/en
[j] http://www.meece.eu/library/osmose.html
[k] http://axel.rossberg.net/paper/Rossberg2008_Ecology.pdf
[l] http://www.meece.eu/documents/deliverables/WP3/D3%204_Part3_NE%20Atlantic.pdf
[m] http://www.meece.eu/documents/deliverables/WP3/D3%204_Part5_BlackSea.pdf
[n] http://www.smhi.se/en/Research/Research-departments/Oceanography/scobi-1.8680
[o] http://www.meece.eu/documents/deliverables/WP3/D3%204_Part4_Baltic.pdf
[p] http://www.romsagrif.org/
[q] http://www.baltex-research.eu/projects/BALTEX_Survey_SPBEM.pdf

5.2. Hydrographical monitoring (Descriptor 7)

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

7.1 Spatial characteristics of permanent alterations

- Extent of area affected by permanent alterations (7.1.1)

7.2 Impact of permanent hydrographical changes

- Spatial extent of habitats affected by the permanent alteration (7.2.1)
- Changes in habitats, in particular the functions provided (e.g. spawning, breeding and feeding areas and migration routes of fish, birds and mammals) due to altered hydrographical conditions (7.2.2).

5.2.1 Identification of issues to address

Permanent alteration of hydrographical condition can have two main causes: climate change factors combined with natural variability and large scale human activities implemented by infrastructures. The former have a natural global scale description with possible different local effects. The latter can be generally identified with coastal defence works, damming of large rivers and soil usage related to water abstraction, discharges of salts or warm/cool water by industrial plants, dredging and dumping of dredged materials, land reclamation projects and structures in coastal or open sea, such as wind farms, offshore airports, ocean energy device arrays, large scale aquaculture facilities, fishing and maritime transport (with effects on turbidity) and may permanently influence residual and tidal currents, waves, tides, sediment dynamics, turbidity, salinity,temperature and the seafloor integrity (sediment distribution, bathymetry/topography). In particular, changes taking place in "choke points" between basins can affect much bigger areas (e.g. the Baltic Sea is very sensitive to changes in the Danish Sounds). Changes due to large scale human activities take place against a background of much broader scale basin wide hydrographical changes, both human induced and natural variability. The cumulative effects of both impact types on GES should be covered by the Descriptor.

According to OSPAR[77], the term "permanent" could be understood as alteration lasting for more than ten years. Following such approach, human activities whose effect in terms of alterations of hydrographical alteration is reversible and lasting less than 10 years, should not be considered for GES of D7. Otherwise, OSPAR also proposed that "permanent" could be understood as a change of more than 5% of a particular parameter on top of natural variability[78]. At present there is no agreed definition of "permanency" at EU level and the search for a common interpretation should be tackled with a possible coordination by the European Commission.

Indicators for D7 as specified in COM Decision 2010/477/EU, consider the level of pressure (7.1.1) and the level of impact (7.2.1 & 7.2.1).

Concerning the level of pressure, the main difficulty is the separation between changes directly linked to large-scale human activities and natural multi-decadal variability and slow long-term changes like climate changes and/or ocean acidification.

The alteration of hydrographical conditions has a combined effect on both ecosystem processes and functions which in turn complicates the assessment of the impact level. For example, changes in currents and waves can in turn induce further changes to sediment transportation, bed forms, salinity and temperature which might lead to further positive or negative impacts on fauna as a result of changes to

[77] Advice Document on GES 7 – Hydrographical conditions presented by the Netherlands. Meeting of the Environmental Impact of Human Activities Committee (EIHA). The Hague (The Netherlands) 16-20 April 2012
[78] EIHA common indicator workshop report , Gent (Belgium), 15-19 April 2013

their immediate dynamic environment or through food chain effects. Changes in currents and salinity can also influence the spreading pattern of larvae and breeding and spawning areas. Furthermore there are areas of very high natural variability where the assessment of impact would be particularly difficult.

The broader scale of hydrographical changes (in part basin wide) also implies that a distinction should be made between indicator-related monitoring for D7 requirements, as specified in COM Decision 2010/477/EU, and the need for basic hydrographical data (e.g. temperature, salinity, Secchi depth, ocean acidification etc.) which are not necessarily indicators but are required to pick up long-term changes in the ecosystems and are relevant for implementing indicators and interpreting indicator results.

As a consequence, the scale issue is especially important in monitoring for D7. Small spatial and temporal scale has partially been already addressed by WFD but consensus should be achieved on how to monitor at the medium (e.g. changes in hydrological process due to river regulations) and large scale (e.g. changes in hydrological dynamics due to climatic change). For coastal waters (i.e. within 1 nautical mile from the baseline), WFD monitoring on hydromorphological changes is also important for meeting the requirements of the MSFD, especially given that an important part of permanent alterations of the hydrographical conditions arise from human activities in coastal marine waters. Necessary measures and monitoring for permanent alteration *sensu* D7 that are limited to coastal waters should already be considered by WFD so to cover also MSFD purposes in a satisfactory manner. In these cases MSFD will not go further or take additional action.

WFD sets hydro-morphological objectives that need to be addressed through measures in the context of river basin management plans. In this context the D7 impacts are related to the ecological potentials for WFD heavily modified water bodies but ecological potential has to be further developed in order to take into consideration assessment of impacts *sensu* D7. Moreover, the hydrographical conditions outlined under the MSFD are, to some extent, comparable (Table 8 in this document) to the hydro-morphological conditions referred to under the WFD (See WFD Annex II "Characterisation of surface water types" section 1.2.4 coastal waters system B). However, the MSFD Annex III, Table 1, lists some additional characteristics. It is recommended, therefore, that these additional characteristics are appropriately considered.

In order to monitor human activities causing alterations, a list of possible areas where permanent alterations could be expected (using WFD marine morphology datasets and/or existing EIA, SEA and MSP) is needed. The Decision 2010/477/EU has indicated that this indicator is related to future activities that will have to fulfil Environmental Impact Assessment (EIA) requirements. Any possible additional monitoring should be seen in the light of such activities. D7 foresees that monitoring will be focused on new large-scale developments. Indeed, even when the current status is not considered to be ideal in some areas that have already been impacted, reverting to a former state is unlikely to be feasible. In the future new knowledge could provide feasible approaches to restore former state and then such position could be revised.

This descriptor is meant to address mainly new developments such as wind farms, large artificial islands, etc. not discarding existing activities suspected to produce a significant impact on hydrographical conditions at a large scale. For this reason it is pertinent to choose a baseline in the (very) near future for the initial assessment from which good status can be based upon. As initial assessment was reported on 2012, this year can be considered a reasonable baseline. This does not mean that the current status can or should be maintained in all circumstances; it is important to recognise there can be good reasons for an activity that changes the hydrographical conditions and some of these changes may only be temporary. Efforts should, however, be made to prevent further deterioration and to minimise any negative effects on the ecosystem. In some cases it may even be possible to promote positive effects. This may be achieved through existing EIA and associated measures. Also measures taken for the WFD may already improve several aspects of Descriptor 7 - e.g. many Member States plan to improve the possibilities for migrating fish in and between marine and freshwaters. If needed, deterioration by new permanent structures or activities can be prevented by mitigation, for example by facilitating development of habitats that were lost or by improving the quality of the remaining habitat.

Table 8. Hydrographical conditions outlined under the MSFD and hydro-morphological conditions referred to under the WFD.

MSFD (from Annex III, Table 1)	WFD (from Annex II, section 1.2.4 B)
<u>Physical and chemical features</u> - Topography and bathymetry of the seabed - Annual and seasonal temperature regime and *ice cover* - Current velocity - *Upwelling* - Wave exposure - Mixing characteristics - Turbidity - *Residence time* - Spatial and temporal distribution of salinity - *Spatial and temporal distribution of nutrients and oxygen* - *pH, pCO2 profiles or equivalent information used to measure marine acidification*. <u>Habitat types</u> - The predominant seabed and water column habitat type(s) with a description of the characteristic physical and chemical features, such as depth, water temperature regime, currents and other water movements, salinity, structure and substrata composition of the seabed,	<u>Obligatory</u> - Latitude, longitude, depth, reference level, e.g. WGS 84 - *Tidal range* - Salinity <u>Optional</u> - Current velocity and direction - Wave exposure - Mean water temperature - Mixing characteristics - Turbidity - *Retention time (of enclosed bays)* - Mean substratum composition - Water temperature range

Also, this descriptor is meant to address large-scale developments. Smaller scale activities, such as aggregate extraction, capital dredging etc. can also result in hydrographical changes – albeit at a more local, site specific scale if sediment transport phenomena are negligible. These changes are associated to other physical pressures on the seafloor (D6) at comparable scale. Before implementing new plans or projects, the making of an EIA is compulsory for a range of human activities, including the activities mentioned above. Such impact studies do not always produce readable and effective datasets for the benefit of MSFD but EIA procedures at national level should be upgraded if necessary in order to take fully into account D7 (and D6, see chapter 5.1.3) needs. If such works are part of a higher level strategic plan, a Strategic Environmental Impact Assessment is often required. Hydrographical changes caused by those smaller scale activities should generally not be considered under this Descriptor as they are sufficiently covered by existing legislation. However, in some cases, many small-scale activities can produce effect at a larger scale. For example, in local modification of the coastline, many little dikes perpendicular to the coastline are established that may create disruptions of hydrodynamic conditions and then in turn modify the sediment transport characteristics at scales much larger than the scale of the single dike.

Thus, monitoring of hydrographical conditions should be treated in two ways:

- Monitoring in order to give background information at different spatial (from sub-region to local) and temporal scale (still mostly the same characteristics as set in Table 1 of Annex III to MSFD) on variations of hydrographical conditions, which might not be connected (at least not directly) to the human activities.
- Specific monitoring for D7 (and D6) purposes to assess the extent of area affected by alterations and impacts with a focus on the list of possible areas where alterations could be expected due to activities (dredging/immersion) or new developments infrastructures and eventually existing ones suspected to

produce significant impact; this monitoring is to be associated also to sea-floor physical pressure monitoring for D6.

5.2.2 Monitoring of physical characteristics

The physical characteristics to be monitored are: topography and bathymetry of the seabed, current velocity, upwelling, wave exposure, mixing characteristics, turbidity, residence time; spatial and temporal distribution of salinity, temperature and ice cover. Also other parameters such as sedimentology and sediment transport, ocean acidification (pH, pCO2 and alkalinity), maritime meteorology, river flow can be relevant reliable reference data. The knowledge of parameter related local dominant time-scales of natural variability are a pre-condition for an authoritative assessment of change in the hydrographical background conditions.

Even though climate change is considered to be part of the prevailing environmental conditions and therefore not explicitly addressed through the MSFD, for the interpretation of monitoring data, the effects of climate change need to be taken into account. For this reason the existence of an adequate monitoring programme able to describe these background large-scale changes together with long time series dataset is an implicit requirement for this descriptor and for the MSFD as a whole.

If the hydrographical conditions are unknown they are initially monitored over the entire marine area to characterize the hydrographical regime and to provide background information for physical characteristics and establishment of hydrographical models to be used in the assessment of human activities. Parameters, monitoring positions and frequencies are defined based on the local natural variability (both in time and space) but also with regard to the requirements specified by the needs of other descriptors/indicators for background information. Special monitoring programmes are devoted to local human activities (construction of bridges, wind parks, pipe-lines etc.) with the aim also to differentiate between activities whose impact is only local (i.e. not relevant for D7) and those whose impacts can, e.g. by cumulative effects, lead to large-scale changes of the hydrographical regime and therefore relevant for D7.

As an example, the selection of monitoring methods for some hydrographical parameters could consider the following:

- Remote sensing can be used for spatial distribution of temperature, ice parameters and marine optics such as water transparency and turbidity in the surface layer, chlorophyll and yellow substances. .
- Use of autonomous devices or scientific vessels allowing high-resolution data collection (temperature, salinity, currents, waves etc.), including data about the development of vertical stratification, circulation, water masses distribution etc.
- Use of numerical circulation and ecosystem models to characterize the conditions over the large sea areas and to forecast local changes due to direct human impacts.

Such approach (with proper modifications) could also be generalized to other parameters describing hydrographical conditions.

Existing operational observations, and in particular the products of GMES/Copernicus, should be used for D7 monitoring. Satellite products provided by GMES/Copernicus downstream services can provide area-wide near-real time data. Upwelling, currents, wave-field, mixing characteristics, residence time and salinity are parameters well adapted for numerical models with data assimilation and are delivered by Copernicus. Other global or regional operational oceanographic observing systems (such as BOOS[79], NOOS[80] etc.) that provide marine forecasts, can also be part of the D7 monitoring. Further on, basin wide assessment of hydrographical changes and local status reports can provide valuable information on long-term change, e.g. the annual ICES Report on Ocean Climate (IROC) providing harmonised basin wide assessments.

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[79] http://www.boos.org/index.php?id=12
[80] http://www.noos.cc/

5.2.3 Evaluation of impacts

In order to evaluate the impacts, any monitoring programme tailored to meet the requirements of D7 should be designed to determine the extent and size of any changes in current and wave regimes resulting from human activities. This could be undertaken within EIA. Changes in bottom shear stress, due to its consequences on changes on sediment resuspension and nutrient enrichment, is an example of a good indicator of modifications of dynamic environment of the seabed with effect on biota development. Direct measurements are not easy and it is usually deduced by wave motion measurements. Another good parameter could be the pressure variation range induced by waves at the seabed, where relevant. This repetitive process facilitates the erosion of crumbly sediments so that an increase in wave height may significantly increase the erosion of specific habitat.

Although modeling activities about the potential changes that may cause hydrodynamic activity need to be started, a minimum monitoring program should be done in order to confirm the model results (even when the model results indicate that no changes would happen).

Also important is that the monitoring of the effects of hydrographical changes should not aim primarily at field based measurements in the affected area, but concentrate on modelling of the changes in currents, waves and bottom shear stress due to a human activities in the area (this may be undertaken within EIA), using appropriately calibrated models, validated with *in situ* datasets. This will make it possible to determine the extent of any parameter changes including how large the change will be in a certain area. From this starting point the effect on marine ecosystems can be determined. Field measurements will be necessary in areas where the changes are large enough to have significant effects on the marine ecosystem at which point ground truthing will be considered appropriate. In such a situation on-going monitoring of changes in benthic or pelagic fauna and/or flora could be used to indicate any effects of permanent hydrographical alterations. Even when there is no clear indication that an activity will cause an important hydrographical alteration, some minimum field measurements will be needed to confirm the prediction of the models.

A scale must be applied that detects hydrographical changes in line with the intentions of the MSFD in preventing significant negative effects on ecosystems. For benthic habitats, the most appropriate scale for assessing this Descriptor could be one equivalent to EUNIS level 3 (e.g. high-energy littoral rock, sublittoral mixed sediments). Reasoning for advising to use a scale equivalent to EUNIS level 3, at least for benthic habitats, for assessing Descriptor 7 are as follows. Descriptor 7 states that the permanent changes to hydrographical conditions should not adversely affect marine ecosystems. Because human interventions on hydrographical conditions are hardly visible on a very large scale, e.g. on the scale of the subregion North Sea, Baltic Sea or Western Mediterranean Sea, it will be necessary to consider smaller scales in the first instance in order to build a full picture of GES at the relevant scale. It should be noted that using very small scales (e.g. EUNIS level 5 habitats) to determine GES is not appropriate given they cannot be connected directly to status of marine ecosystems, as required under the MSFD.

Emphasis has to be placed also on the proportion of habitat that is affected. The effects of permanent changes in conditions on the marine ecosystem can be detected in a comparable manner. It will also be important to consider the use of scale for other Descriptors, in particular Descriptor 6 and 1.

It is worth to point out again that a lot of the above mentioned human activities occur on a small scale in the coastal waters and have mainly been considered under and covered by the WFD. These small-scale changes are also considered in other Directives like the BD and the HD and especially the EIA Directive but for the HD and the BD the requirement is to evaluate the impact of alterations of hydrological conditions to listed habitats and species. The MSFD adds the evaluation of the impacts on the whole ecosystem. If appropriate an effect on that scale should be judged and monitored under those Directives and the national EIA legislation. However, small-scale changes can be aggregated up to assessments at larger scales and this would give the opportunity to identify where many small-scale changes add up to a significant cumulative impact across a larger spatial extent that reaches the scale of the MSFD. At present it is difficult

to efficiently assess these cumulative impacts, even though it is recognised that this is needed. Therefore, more work on assessing cumulative impacts is needed.

5.2.4 Parameters, monitoring approaches, targets and additional considerations

Table 9 below outlines the GES indicators and the associated advice based on information collated from a questionnaire circulated to OSPAR Contracting Parties.

Table 9. MSFD D7 indicators (COM Decision 2010/477/EU) and related parameters, monitoring approaches, targets and advice/considerations based on a questionnaire circulated to OSPAR Contracting Parties

Indicator	Parameter	Monitoring approaches	Target	Advice/ consideration
7.1.1	Area (e.g. km^2) where significant, regional scale changes in currents, waves, salinity, temperature and other hydrographical conditions occur or are expected (modelling or semi quantitative- estimation)	Map human activities that cause permanent alterations of hydrographical conditions (using Directive 2000/60/EC marine morphology datasets and/or existing EIS, SEA and MSP) and subsequent use of models. Main aim of the models is to assess changes in the condition and extent of areas affected by permanent alterations. This would include changes in currents, upwelling patterns, waves, bathymetry, and salinity. Models should be calibrated and continuously supported and validated with "in situ" monitoring datasets.	Minimise impacts resulting from alterations of hydrographical conditions. This target can be further specified as: a. Prevent further deterioration; b. Area of different habitat functions (feeding zones, spawning areas etc.) stay in comparable quantity[81] or quality;	Implementation of the indicators 7.1.1, 7.2.1 and 7.2.2 by modelling the changes in hydrographical conditions like currents, waves, bottom shear stress and salinity to assess the extent of the possible affected area and the intensity of the changes to determine the effect on habitats. Models should be supported by "in situ" monitoring datasets.
7.2.1	Area of habitats and the proportion of the total habitat if that type is significantly affected by the permanent change for example in bottom shear stress, waves, temperature or salinity (modelling or semi quantitative- estimation)	Model changes in the spatial extent of habitats affected by permanent alterations, using field data and validated model data.		
7.2.2	As far not already covered by HD in coastal waters: Key species and habitat types (including benthic communities) [82]significantly affected by the changes in hydrographical conditions (needs to be determined on a case-by-case basis)	Model changes in habitats due to altered hydrographical conditions, using field data and validated model data. Note: only if 7.2.1 gives reason for concern it will be necessary to define the change in function for diverse habitats by interpreting the changes determined in 7.2.1 in terms of food web and life cycle of concerned fauna		

[81] Contracting Parties can fill this in more quantitatively depending on their local situation
[82] For OSPAR Contracting Parties and for their waters in the N.E. Atlantic, habitats/species should be chosen on the basis of the lists determined by ICG Cobam.

5.3 Monitoring of commercially exploited fish and shellfish populations (Descriptor 3)

5.3.1 Summary of the developments in the CFP and other related policies.

The MSFD is intended to '*...contribute to coherence between different policies and foster the integration of environmental concerns into other policies, such as the Common Fisheries Policy (CFP),...*'. The MSFD explicitly requires fishing activity to be managed so that conservation objectives for the broader marine ecosystem might also be achieved.

EU member states are committed to an ecosystem-based fisheries management which is implemented through the Common Fisheries Policy (CFP)[83] and the MSFD. While the MSFD requires the application of the ecosystem approach, the precautionary principle as well as the polluter pays principle to provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive, the CFP aims at maximum sustainable yield (MSY)[84] and also considers the economic viability of fisheries and fair sharing of the fishing possibilities among the EU Member States. The DCF is established under the CFP and sets out the data collection and management in the framework of multi-annual programmes, of biological, technical, environmental and socio-economic data concerning the fishery sector. For the time both the CFP and the DCF are under reform and revision. These processes will also take into account the objectives and requirements of the MSFD as the environmental pillar of the maritime policy for the European Union and in return the outcomes will also influence the implementation of the MSFD Descriptor 3.

The MSFD concerns GES for the marine ecosystem and requires the consideration of fisheries impact on other ecosystem components than the commercial fish stocks. Thus, there is a need to link CFP and MSFD targets; i.e. to evaluate if fishing at the MSY level for a fishery is economically feasible and at the same time assures that the corresponding exploitation pressure limits the fisheries impact on the ecosystem so that MSFD GES criteria are met.

The EU Biodiversity strategy[85] is providing a way to fulfil the obligations of the CBD (in particular the Aichi targets) and is aimed at reversing biodiversity loss and speeding up the EU's transition towards a resource efficient and green economy. In the section on the sustainability of agriculture, forestry and fisheries, the EU Biodiversity strategy mentions that the forthcoming reform of the CAP (Common Agricultural Policy) and CFP and the new Multiannual Financial Framework present opportunities to enhance synergies and maximise coherence between biodiversity protection objectives and other policies. Regarding fisheries the strategic target 4 reads: *Fisheries: Achieve Maximum Sustainable Yield (MSY) by 2015. Achieve a population age and size distribution indicative of a healthy stock, through fisheries management with no significant adverse impacts on other stocks, species and ecosystems, in support of achieving Good Environmental Status by 2020, as required under the Marine Strategy Framework Directive.*

In the Commission Decision 2010/477/EU three criteria including methodological standards were described for MSFD Descriptor 3 (D3). The three criteria and associated indicators are:

Criterion 3.1 Level of pressure of the fishing activity

- Primary indicator: Indicator 3.1.1 - Fishing mortality (F)

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[83] http://ec.europa.eu/fisheries/reform/index_en.htm

[84] COM(2006) 360 final. Communication from the commission to the Council and the European Parliament. Implementing sustainability in EU fisheries through maximum sustainable yield. (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0360:FIN:EN:PDF)

[85] COM(2011) 244 final. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions. Our life insurance, our natural capital: an EU biodiversity strategy to 2020. (http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/1_EN_ACT_part1_v7%5b1%5d.pdf)

- Secondary indicator (if analytical assessments yielding values for F are not available): Indicator 3.1.2 - Ratio between catch and biomass index (hereinafter 'catch/biomass ratio')

Criterion 3.2 Reproductive capacity of the stock

- Primary indicator: Indicator 3.2.1 - Spawning Stock Biomass (SSB)
- Secondary indicator (if analytical assessments yielding values for SSB are not available): Indicator 3.2.2 Biomass indices

Criterion 3.3 Population age and size distribution

- Primary indicator: Indicator 3.3.1 - Proportion of fish larger than the mean size of first sexual maturation
- Primary indicator: Indicator 3.3.2 - Mean maximum length across all species found in research vessel surveys[86]
- Primary indicator: Indicator 3.3.3 - 95% percentile of the fish length distribution observed in research vessel surveys
- Secondary indicator: Indicator 3.3.4 - Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation

5.3.2 Fisheries monitoring and assessment in the N.E. Atlantic and the Baltic Sea

The ICES' approach to fisheries advice integrates a precautionary approach, MSY and an ecosystem approach into one advisory framework. The aim is, in accordance with the aggregate of international guidelines, to inform policies for high long-term yields while maintaining productive fish stocks within healthy marine ecosystems.

Science development underpinning the identification and adoption of indicators within this broad categorisation has continued in earnest. Prior to 2012, ICES only provided quantitative management advice for stocks that were fully assessed and, of the approximately 200 stocks that ICES provides annual advice for, 122 were without quantitative forecasts and advice. However, in 2012 ICES started providing quantitative catch advice for data-limited stocks on the basis of its new Data-Limited Stocks (DLS) approach. The introduction of quantitative advice based on the DLS approach has marked a significant change in the advice provided by ICES for DLS, and the approaches used have necessitated ICES categorising its assessment and advisory techniques within a common framework.

ICES recognises six main categories of stocks taking into account biological information and data availability:

Category 1 – Stocks with quantitative assessments
This type of stock can be considered in two sub categories a) stocks with several year-classes contributing to the fishery that includes stocks with full analytical assessments and forecasts as well as stocks with quantitative assessments based on production models; and b) short-lived species stocks with quantitative assessments. These are the stocks that have short life cycles with catches dominated by single year-classes. They are not considered data-limited and this category includes stocks with full analytical assessments and forecasts as well as stocks with quantitative assessments based on production models.

Category 2 – stocks with analytical assessments and forecasts that are only treated qualitatively
This category includes stocks with quantitative assessments and forecasts which for a variety of reasons are considered indicative of trends in fishing mortality, recruitment, and biomass.

Category 3 – stocks for which survey-based assessments indicate trends

[86] According to ICES (2012d) this indicator is considered not appropriate to describe criteria 3.3 of D3

This category includes stocks for which survey indices (or other indicators of stock size such as reliable fishery-dependant indices; e.g. LPUE, CPUE, and mean length in the catch) are available that provide reliable indications of trends in stock metrics such as total mortality, recruitment, and biomass.

Category 4 – stocks for which only reliable catch data are available
This category includes stocks for which a time-series of catch can be used to approximate MSY.

Category 5 – Landings only stocks
This category includes stocks for which only landings data are available.

Category 6 – negligible landings stocks and stocks caught in minor amounts as by-catch
This category includes stocks where landings are negligible in comparison to discards. It also includes stocks that are part of stock complexes and are primarily caught as by-catch species in other targeted fisheries. The development of indicators may be most appropriate for such stocks.

The principles underlying the ICES' common framework with respect to data-limited stocks (Categories 2-6) is that the available information should be used, that the advice to the extent possible should be based on the same principles as applied for stocks with analytical assessments and catch forecasts and that a precautionary approach should be followed. The latter implies that as information becomes increasingly limited more conservative reference points should be used and a further margin of precaution should be adopted when the stock status is poorly known. The margin of risk tolerance is a management prerogative.

Unlike the classic fishery management problem of estimating maximum sustainable yield (MSY), fishery analysis on stocks without quantitative assessments must estimate a yield that is likely to be sustainable. The overall approach adopted by ICES has been developed under WKLIFE (ICES 2012a) and WKLIFE2 (ICES 2012c) and is explained in ICES report on the implementation of RGLIFE advice on Data-Limited Stocks (ICES 2012b). The majority of the DLS have more information available than merely either catch or landings. The starting point for this analysis is therefore a categorization of the stocks according to the data and analyses that are available. The categorization of stocks is intended to reflect the decreasing availability of data, and thus the conclusions on the fishing pressure and state of the stock are likely to be less certain as one goes down the categories. As a consequence, a precautionary approach implies that exploitation rates advised for stocks below the data-rich stocks (Category 1) will be more conservative than F_{MSY}.

For so-called data-rich stocks (ICES' category 1), *common indicators* are available for Criterion 3.1 (a quantitative estimate of exploitation relative to F_{MSY}) and Criterion 3.2 (a quantitative estimate of stock biomass relative to MSY $B_{trigger}$) whereas for data-limited stocks (ICES' categories 2-6) *candidate indicators* are available for Criterion 3.1 (exploitation relative to a proxy for F_{MSY}) and 3.2 (sustainable stock biomass relative to precautionary considerations). For both types of stock, the Criterion 3.3 is not essential but does provide the ability to track biological improvements in stock development as MSY-based management is achieved. The process requires further work to select and define indicators and associated reference levels for Criterion 3.3 that respond to changes in the populations subject to fishing. Simulation studies suggest that not all proposed indicators of the COM decision 477/2010 provide suitable sensitivity in the time-scales required for management and that indicators for Criterion 3.3 need to be robust to variation in natural processes such as recruitment variability, regional and seasonal variation in the spatial distribution of juveniles, adults, small and large species (Probst et al., 2013b). A question which needs to be addressed is whether meeting Criteria 3.1 and 3.2 would lead to fulfilment of Criterion 3.3 after a time lag, thereby making Criterion 3.3 redundant. First simulations suggest that the achievement of good environmental status within Criterion 3.3 depends on fishing mortality and the selection pattern of fisheries (Brunel & Piet, 2013). Furthermore, according to Brunel & Piet (2013) Criterion 3.3 requires a specific definition of what is considered as a "healthy" population age or size structure.

What is monitored for the CFP/DCF?

The Data Collection Framework (Council Regulation (EC) 199/2008) specifies 238 stocks in Northeast Atlantic European waters (including the Baltic) that are covered by data collection requirements in 2011-2012. ICES conducts annual stock assessments of more than 200 of these stocks. Recently, for example, ICES conducted analytical assessments and provided catch advice in relation to MSY objectives of 31 stocks in the Northeast Atlantic.

In addition, ICES' observations include 100 years of oceanographic data, 33 years of biological community data, international bottom trawl survey (IBTS) for 48 years, and historical plankton records for the last 11 years which all constitute important time-series for the assessments.

No Member State is currently entirely compliant with the European fisheries Data Collection Framework. For nearly all data-limited stocks improved data reporting would enhance the basis upon which management advice is provided and would allow many data-limited stocks to be assessed under a higher data category.

Further principles for the selection of stocks in MSFD monitoring

For the selection of relevant commercially exploited (shell)fish stocks in a particular (sub)region, the following key issues were identified: (1) Identification of the appropriate area a member state should report on; (2) Match of existing spatial units to that area; (3) Choice of data source; (4) Choice of time period; (5) Selection criteria. While each of these issues was seen to have some consequences for the selection of relevant populations, the overall assessment appeared fairly robust against a range of sensible choices.

For commercially exploited (shell)fish populations with assessments, primary indicators and MSY-based and/or precautionary reference levels are defined. As the assessed stocks do not always match the MS's marine waters, issues pertaining to the selection of stocks considered representative for the MS's waters arise. Another issue in the selection of assessed stocks to be examined under D3 concerned the quality of the assessments and, thus, the information they provide, i.e. (1) all indicators with reference levels, (2) not all reference levels, or (3) no reference levels. As the assessed stocks can be considered the best source of information, any decision on these aspects may have significant consequences for the GES assessment.

For commercial populations that do not have full assessments scientific monitoring surveys were identified as a potential data source for calculating some secondary indicators. Three options for determining the current status from trend-based time series were considered: (1) comparing the recent period mean with the long-term average (Probst et al., 2013a), (2) comparing the current value of the indicator in relation to the historic mean setting a threshold based on appropriate percentile of the Normal distribution (Greenstreet et al., 2012) and (3) detection of trends. However it is noted that trends based methods do not provide specific definition of reference levels in relation to 'good' status, and can only provide an indication of change (Trenkel and Rochet, 2010; Blanchard et al., 2010). None of the considered methods were evaluated, and therefore no recommendations are provided with regards to secondary indicators for Criteria 3.1 and 3.2 or Criterion 3.3. It was noted that the 'mean maximum length across all species' indicator proposed under criterion 3.3 is not appropriate as a stock condition metric and it is not advised for application under Descriptor 3.

Which improvements in scientific monitoring, evaluations and management are needed for the MSFD?

1) Conduct a strategic ranking of target data categories for managed stocks:

It may not be feasible, or desirable, for all stocks to be elevated to a data-rich status. Similarly it may not be necessary for all stocks to be data-rich in order to meet political objectives for fisheries management. A strategic stock ranking could be conducted to specify target data categories for different stocks to ensure

proportionate and cost effective data collection and assessment. The definition of stock target data-categories could be based on a combined utility and risk assessment (risk-based approach, the precautionary principle taken into account); together with an evaluation of the required frequency of assessments.

2) Evaluate management procedures to ensure there are no perverse incentives to degrade data provision:

The range of assessment and management procedures applied to different data-categories of stocks should be evaluated to ensure that degrading data provision does not lead to increased fishing opportunities. If fishing opportunities were greater for stocks assessed through data-limited procedures than if they were subject to data-rich assessments there could be an incentive for data provision to be compromised to increase fishing opportunities. The full range of assessment and management procedures applied to different data categories of stocks should be evaluated to ensure a consistent approach to uncertainty and precaution.

3) Define acceptable risk thresholds for management decisions:

Addressing data-limited fisheries requires both scientific evaluations and management decisions. Defining acceptable risk thresholds for management is a decision for managers rather than a scientific task although scientific analyses can inform the choice of acceptable risk thresholds. Managers need to define acceptable risk thresholds in order to allow stock assessments and analyses of catch options and control rules to be developed and evaluated against the defined risk threshold. The definition of appropriate risk thresholds is necessary to ensure that the management procedures are consistent with the precautionary approach.

4) Ensure political objectives are consistent with the resources available for implementation:

Data collection, collation and stock assessment demand time and resource. Access to resources already hampers i) full use of collected data, ii) application of the appropriate data-limited assessment methods to all stocks, and iii) the further development and evaluation of data-limited assessment methods and management procedures. The resource requirements associated with data collection and assessment should be considered in establishing the target data categories and assessment frequency of managed stocks to ensure that political objectives are consistent with the resource available for implementation.

5.3.3 Data poor regions– the case of the Mediterranean Sea

Some particularities makes the Mediterranean (and the Black Sea) different from the other EU regions. There are many third countries sharing their waters in these areas and part of the catches is possibly unrecorded. Further, the Mediterranean fisheries are characterized by a high multi-specifity of the catches, the presence of a large number of métiers, the presence of small sized (artisanal) vessels that represents, in number, the large majority of the fishing fleet in the area (Colloca *et al.*, 2013). Colloca et al., 2013 also highlighted that most assessed stocks are overexploited and that catches mainly rely on juveniles (thus on the strength of recruitment). The majority of current fisheries are characterized by the exploitation of individuals well below the optimum length.

It should be also emphasized that different actors interact in the context of fisheries management in the Mediterranean. For EU Member States the prescriptions of DG MARE and the CFP/DCF apply, in some cases with the enforcement of special regulations related to Mediterranean specificities (e.g. Reg CE 1967/2006). The overall aspects of Mediterranean fisheries are also dealt with by the General Fisheries Commission of the Mediterranean (GFCM, FAO) whose aim is to harmonize the management and data collection of fisheries in the Mediterranean and Black Sea, thus including both EU and third countries. Moreover, ICCAT plays a relevant role on the assessment and management of large pelagics (e.g. bluefin tuna, swordfish). Finally the Barcelona Convention is now going to play a major role on the application of an Ecosystem Approach, including fisheries aspects. It is also worth noting that the Commission established a group under the STEFC, the so called “SGMED” in order to foster the application of stock assessment in EU countries for Mediterranean stocks.

The current framework for GES assessment of Descriptor 3 can be consistently applied in all (sub)regions, in particular for the portion of the sea where EU countries collecting data under DCF are present. However there are considerable differences between (sub)regions in terms of data availability that may compromise the quality of the assessment. For example, a first assessment of the proportion of landings of all commercial species for which stock assessments are conducted shows that in the Baltic Sea this is more than 90% on an annual basis while in the central Mediterranean this is approximately 26% on an irregular basis.

Current monitoring under CFP/DCF and available stock assessments

In the EU Mediterranean waters, fisheries and trawl survey data are collected by Member States under the DCF according to the GFCM Geographical Sub-Areas (GSAs), which represent the GFCM management units (Annex VI) which were established in 2001 and amended in 2009 (GFCM Resolution GFCM/33/2009/2). The Data Collection Framework specifies 97 stocks in the Mediterranean and Black Seas that are covered by data collection requirements in 2011-2012. At present STECF provides management advice for stocks in the Mediterranean and Black Sea. For the period 2008-2010, the GFCM conducted assessments in relation to either MSY exploitation objectives or precautionary objectives for 39 stocks and STECF conducted assessments for 30 stocks and plan to conduct stock assessment for 63 stocks in 2013-2014.

Data collected under the DCF includes, among others, information on the catches and landings of the most important métiers in the EU Mediterranean Member States, the biological sampling of the most important species, the collection of socio-economic data, the estimate of ecosystem indicators as well as the collection of trawl-survey data (MEDITs) and acoustic data (MEDIAS) for the assessment of demersal fish species and stock biomass of small pelagics, respectively (ICES, 2012d). In addition, large pelagic stocks are assessed by ICCAT at large geographical scale: eastern Atlantic and Mediterranean for bluefin tuna (*Thunnus thynnus*) and Mediterranean for swordfish (*Xiphias gladius*). It is worth noting that the quality of available data, as highlighted by the STECF (2013a), in some cases is not sufficient to allow analytical approaches to be applied.

Data limitations in relation to MSFD Descriptor 3

In the Mediterranean Sea where biodiversity is high (Coll et al., 2010) and there is a large number of species caught and landed, the amount of assessed stock can be still considered not adequate for a general assessment of EU Mediterranean stocks, at least in terms of spatial coverage and representation of the total landings. According to Le Quesne et al. (2013), in the Mediterranean and Black Seas approximately 80% of landings by weight, and 90% by value, came from unassessed stocks prior to 2011. In general, the proportion of unassessed shellfish stocks is higher than the proportion of unassessed fish stocks, possibly due to uncertainty over some aspects of shellfish biology and life-history.

To fill this gap of knowledge, an important effort has been made during the last years in order to increase the number of assessed stocks. Today, 93 Mediterranean stocks (demersal and small-pelagics stocks) belonging to 29 species (23 fish and 6 shellfish) have been assessed since 2008 (Annex VII). In many cases, in particular in third countries belonging to the southern and eastern Mediterranean, the lack of quantitative data does not allow to carry out stock assessment. However, in particular in areas where shared-stocks are present (Annex VIII), both the GFCM and regional projects enforced by FAO (i.e. MEDSUDMED[87], COPEMED[88], ADRIAMED[89], EASTMED[90]) allowed increase of the collaboration between countries and the establishment of common stock assessments.

[87] http://www.faomedsudmed.org/
[88] http://www.faocopemed.org/
[89] http://www.faoadriamed.org/
[90] http://www.faoeastmed.org/

In general, Mediterranean stock assessments are affected by a lack of data (in particular age-readings that could allow an age-based assessment as well as the shortness of available time-series) and economic resources, together with difficulties in calculation of stock-recruit relationships. Accordingly, data collected in the EU Mediterranean waters within the DCF do not allow to fully meeting requirements of MSFD as regards the calculation of indicators proposed within Descriptor 3. In fact, while the bulk of available Mediterranean stock assessments usually provides proxies for pressure indicators (F0.1 as proxy of Fmsy and, most often, Fmax), Fpa levels are not yet established. Moreover, and more prominently, reference points related to SSB are usually not available, due to the lack of established Stock/Recruit relationships as well as the lack of long time series on landings/catches data.

It is also worth noting that the estimation of secondary indicators of criteria 3.1 and 3.2 and some indicators of criterion 3.3 probably require an improvement in existing monitoring programmes by a focused revision of data collection and monitoring methods. For example, indicators depending on maturity estimation of individuals are usually computable only for few species and often only for the females, when the size at first maturity (L50) is available. However, methods of data collection applied in the MEDITS trawl survey do not allow a reliable estimation of this parameter for all assessed species, because of the limited sampling period within the year that may not overlap with the species' spawning season. Relevant data are partially collected from biological sampling on board of fishing vessels or biological sampling of landings according to the DCF.

Current approaches for prioritizing monitoring effort on data-deficient stocks in the Mediterranean Sea

Given the multi-specificity of fishing activities, the limited and spatially uneven availability of stock assessments, the lack of data and the lack of adequate resources in the Mediterranean Sea there is a need of defining a prioritization scheme and a rationale and transparent framework in order to provide, in the short-medium term, the data and information required for the DCF and CFP implementation, also taking into account the requirement of the MSFD. This process should be aimed at defining a priority list of stocks to be assessed, timeline and frequency of assessments, data requirement, methods for the assessments and related uncertainty, as well as how to deal with stock assessment output from a management perspective. It is worth noting that different institutional bodies have set up similar, but not completely equivalent and comprehensive, approaches to this purposes, that we briefly recall below:

STECF approach. STECF recently provided a proposal for setting a priority list of species to be routinely assessed on a three year basis (STECF, 2013a). The list should take into account the catch composition of the different fisheries/métier, the biological characteristics and the current level of overfishing, allowing the selection of the major stocks whose scientific assessment has to be carried annually, biennially or over a longer timeframe starting from 2013. The selection should also consider the importance of the fisheries while the frequency of the assessment might be different according to the quality of data, current stock status, stock evolution, and the assumptions made about stock resilience and productivity. The exercise resulted in a species priority list that comprises 31 and 32 different stocks to be assessed in 2013 and 2014 (Annex IX).

GFCM approach. The Scientific Advisory Committee (SAC, 2013) recommended using an agreed common set of biological parameters for the same stock at sub-regional level and continuing to increase the number of stocks with defined reference points as well as the number of conceptual reference points available (i.e., in addition to a reference point on exploitation rate, it would be desirable to have also reference points for F and biomass). Future monitoring and assessment should take into account also the GFCM list of the "priority species" (Annex X) for the Mediterranean and Black Sea. This list was drafted for assessment and management purposes and consists of pelagic and demersal vertebrates and invertebrates, including also threatened species. The GFCM is currently preparing a Data Collection Reference Framework that is expected to provide guidance on monitoring requirements for fishery and biological parameters, providing priority monitoring objectives based on the value and quantity of the catches.

The Barcelona Convention approach. According to the MSFD the Regional Sea Conventions are playing an increasing role on coordinating effort between EU Member States and third countries for the MSFD implementation. In the context of the Mediterranean Sea, the Barcelona Convention is currently developing the Ecosystem Approach (EcAp) for the management of the marine environment; this framework is functionally equivalent to the one of MSFD, and the process could be considered a sort or extension/integration of MSFD at pan-Mediterranean scale, with the added value of the participation of third countries. The list of priority species provided by FAO GFCM (Annex X) is taken under consideration along with other relevant species already included as target/priority species within the Barcelona Convention itself, and the development of indicators related to exploited populations is expected to be carried out in collaboration with the GFCM. So far no final agreement on a priority list of species has been reached.

Future steps for monitoring prioritization in DLS of the Mediterranean Sea

For the future it seems appropriate first to establish a framework that allows to direct activities in an efficient, harmonized and transparent approach with the aim of prioritizing monitoring activities in the short-medium term. Three main steps should be considered as necessary:

1) Categorizing stocks according to a hierarchy of data availability

Given the already shown data limitation, the majority of available stock assessments mainly rely on the use of life-history based yield-per-recruit reference points as incorporated into the ICES' DLS approach. According to the categorization of data it would be necessary to define the analytical approach to be applied, with increasing range of uncertainty according to decreasing data availability. Such a categorization has been proposed, for instance, by Abella (2011) in reference to stock assessment methods to be applied for Mediterranean elasmobranches (see also SCSA, 2011, appendix C). Beyond the specific objects of the study, the categorization proposed by Abella (2011) might be used to define possible approaches for the analysis of data-poor stocks in the Mediterranean since elasmobranches represent a typical case of data poor stocks and the review of Abella (2011) encompasses all possible methods to be applied for stock assessments considering Mediterranean fisheries and data features. When trend based indicators are concerned it would be also necessary to establish a framework to define a minimum level of data quality for the use of trawl-survey based indicators. In this sense STECF -SGMED (2010) proposed an assessment methodology that could be used, as a first approach, for such categorization.

2) Setting a priority list of species and medium term target in terms of stocks assessment coverage

According to the stock categorization above it would be necessary to define a threshold value of "coverage" in stock assessments to be considered as a target for implementing fisheries management in the Mediterranean EU waters. A possible time-frame to be considered for such target definition could be related to the 2018 future MSFD assessment and 2020 limit for the implementation of new CFP.

For the purposes of this report we show some possible criteria that, among others, could be taken into account:

- coverage of total landings;
- stocks which are shared between MS or between MS and third countries would also have high priority;
- a balance between demersal and small pelagic stocks should be obtained, in order to include stocks that are exploited by different metier;
- life-history traits should be also considered, taking into account the potential resilience of species;
- a time frame for species assessment (e.g. annual vs. multiannual assessment) could be developed considering both species' ecology and stock status (see STECF, 2013a).

3) Defining the framework to reach the medium term target

According to stock categorization and the setting of priority list, it would be necessary to define a plan for achieving the medium term target. This approach should take into account relevant changes in the CFP as well as the complexity of management and research/technical bodies that interacts in the Mediterranean Sea, where EU members are sharing resources with third countries.

In this context we highlight that the report of STECF (2013b) proposes that Regional Coordination Meetings should play a relevant role in defining the priority list of stocks to be included into the stock assessment by establishing Regional Coordination Groups which could have a more definite role in leading DCF at regional level. The definition of the institutional framework to be applied in such process, including the availability of resources and the possible official requirement of stock assessment from EU according to the DCF and the new CFP, is beyond the aim of this report, while it is considered more relevant to suggest some criteria that could be taken into account, among others, for the implementation of such a framework. In particular:

- the framework should be transparent and a medium term plan should be established at least at EU Mediterranean countries in a coordinated approach;
- priority should be given to those activities (e.g. improvement in monitoring) that allows biological reference points to be defined, in particular for SSB related reference points;
- priority should be given to the full use of available data in order to provide proxies for reference points or at least qualitative assessments that could be used for the setting of management activities,
- where limited resources would be available, priority should be given to assess at least some demersal and small-pelagic stocks with contrasting life-history traits within a given GSA;
- improvement in data collection should be enforced in order to allow the most quantitative approach to be applied as soon as possible;
- cost-benefit analysis should be carried out in order to direct the effort into cost-effective activities.

5.3.4 Possibilities for integration of DCF monitoring with monitoring for other descriptors

General considerations

In general there is a clear separation between the fisheries surveys conducted under the Common Fisheries Policy DCF regulation and the national environmental monitoring programmes. The Commission co-finances the fisheries surveys while the Member States finance the environmental surveys.

Resources can be, potentially, saved by combining the two types of surveys. This requires a closer cooperation and coordination between national authorities. Also there is a need to coordinate between countries the timing and location of monitoring surveys as is the case of fisheries surveys coordinated by ICES. In general a major part of cruise time is taken up by moving between stations and to and from survey areas. So, improved efficiency lies in collecting more data at a station and in between stations.

The potential for synergies is often high but are often missed opportunities due to a lack of coordination - often in combination with different governance systems in the countries. Depending on the amount of parameters to be measured an integrated survey may take longer than the single discipline survey but the alternative of using two vessels will lead to significantly increased vessel time and associated costs (fuel and staff working hours).

A precondition for integrating disciplines within a single survey design is that the vessel can accommodate the necessary activities on-board (equipment, qualified staff, and space for working up or preserving and storing samples and data). This means vessels of sufficient size must be used and the issue of sharing costs between disciplines and clients' needs to be resolved. Staff skills should also be considered. Carrying staff in

order to carry out one specialism is no longer an efficient use of resources. Staff with multiple skills may well be needed in future integrated surveys, and hence there may be a need for new training programmes.

Contributions by scientific surveys

Several ICES coordinated annual surveys could, with relatively minor additional effort, be used to better inform the assessment of the state of the marine environment relevant to several MSFD descriptors. For the International Bottom Trawl Survey (IBTS) and the Baltic International Trawl Survey (BITS), data are already available for fish (and shellfish) indicators (Descriptor 3). Additional data products would be available contingent on a number of procedural developments including the development of swept area estimation procedures and appropriate maturity estimation keys. Data support could be provided for food web indicators e.g. supported in terms of stomach sampling (or stable isotopes) and marine litter.

For the Beam Trawl Surveys (BTS), the conclusions are broadly similar, although swept area estimates are much more straightforward with this gear, and could be improved with use of covariates. Biomass and abundance estimates of taxa that can be caught by the survey could support food web indicators. Also data on marine litter could be collected.

The combined possible contributions from these surveys are presented in Table 10. IBTS covers the North Sea and NE-Atlantic, the BTS covers the North Sea, Western Shelf, France/Biscay, Adriatic Sea and Inshore

Table 10. Possible contributions by the ICES international coordinated fisheries surveys to the MSFD.

International coordinated Survey	**Possible contribution to MSFD indicator**	**Possible contribution with some extra effort to MSFD indicator**
International Bottom Trawl Surveys (IBTS) and the Baltic International Trawl Survey (BITS)	1.1.1, 1.1.2, 1.2.1, 1.3.1, 1.7.1, 3.3.1, 3.3.2, 4.2.1, 4.3.1, 10.1.2, 10.2.1	1.1.2, 1.2.1, 1.3.1, 1.7.1, 2.1.1, 3.3.1, 4.2.1, 4.3.1 6.2.1
Beam Trawl Surveys (BTS)	1.1.1, 1.1.2, 1.2.1, 1.7.1, 3.3.2,4.2.1,4.3.1, 10.1.2, 10.2.1	1.1.2, 1.2.1, 1.3.1, 1.7.1, 2.1.1, 3.3.1, 4.2.1, 4.3.1 6.2.1

A similar potential for the contribution of trawl survey to MSFD can be seen in the Mediterranean pertaining the MEDITs survey (Mediterranean International Bottom Trawl survey) that collects data on several target and non-target species as well as, more recently, on benthic fauna. MEDITs is carried out on a yearly basis since 1994 in all MSFD Mediterranean subregions: Western Mediterranean Sea (GSAs 1-3, 5-11), Ionian Sea and Central Mediterranean (GSAs 15, 16, 19, 20), Adraitic Sea (GSAs 17, 18) and Levantine Sea (GSAs 22,23, 25) (Table 11). It is worth noting that in the Adriatic Sea the SoleMON trawl survey collects benthic epifauna samples since 2005.

Table 11. Possible contributions by the Mediterranean Sea international coordinated fisheries surveys to the MSFD.

International coordinated Survey	Possible contribution to MSFD indicator	Possible contribution with some extra effort to MSFD indicator
Mediterranean International Bottom Trawl Survey (Medits)	1.1.1, 1.1.2, 1.2.1, 1.7.1, 3.3.2,, 4.2.1, 4.3.1, 10.1.2, 10.2.1	1.1.2, 1.2.1, 1.3.1, 1.7.1, 2.1.1, 3.3.1, 4.2.1, 4.3.1 6.2.1
SoleMON trawl-survey (Adriatic Sea)	1.1.1, 1.1.2, 1.2.1, 1.5.1, 1.7.1, 3.3.2, 4.2.1, 4.3.1, 6.2.1, 10.1.2, 10.2.1	1.1.2, 1.2.1, 1.3.1, 1.5.1, 1.7.1, 2.1.1, 3.3.1, 4.2.1, 4.3.1 6.2.1

The following surveys can (potentially) also provide information suitable for use in evaluating ecosystem indicators:

- Icthyoplankton - egg survey (Descriptors 1, 2, 3 and 4)
- Pelagic ecosystem survey (Descriptor 1, 2, 3 and 4)
- Acoustic surveys including multi-beam technology (Descriptor 1, 3, 6 and 10)
- SONAR and echo sounder on research vessels (Descriptor 11)
- Nephrops TV surveys (Descriptor 4 and 6)
- VMS data from commercial vessels (Descriptor 6)
- Oceanographic surveys (Descriptor 5, 7 and 8)
- Observers-at-sea (Descriptor 1 and 10)

The surveys can also be useful platforms for the collection of data on seabirds and mammals at sea compared with slower trawl surveys. All vessels can collect water samples (Descriptor 5 and 8). Finally, ships of opportunity with ferry boxes can support Descriptor 1, 2, 4, 5 and 8.

None of the single surveys can provide all the information that would be required to service the full suite of MSFD indicators. Possibly the most effective cruise, if it were possible to organise it, would be a bottom trawl survey where in addition to the standard fish sampling:

- Stomach (and/or stable isotopes) and biological samples of a wide range of taxa (including benthic megafauna) were collected;
- Benthic habitat acoustic survey data were collected between fishing stations;
- Seabirds and marine mammals at sea were surveyed between fishing stations;
- A continuous plankton recorder was deployed while the vessel was underway between stations;
- Hydrographical data were collected continuously by on board autonomous samplers;
- CTD data and water and plankton samples were collected at each sampling station;
- The night-time period was utilised to sample benthic invertebrates

Monitoring suggestions related to Descriptors

- *Biological biodiversity (D1)*

Data from already existing surveys can be used to monitor changes in the overall fish community which are attributable to long-term shifts in species distribution as well as changes in the spatial distribution and occurrence on non-commercial species or of fishing (bycatch of non-target species). Furthermore survey data may help to improve monitoring, evaluation and management of pressures and impacts resulting out of commercial fisheries e.g. on benthic communities by certain types of fishing gear (compare D6).

- *Non-indigenous species (D2)*

Data from research scientific fisheries surveys may be used to analyse the abundance of non-indigenous species which are caught representatively with the applied fishing gear. New monitoring programmes with new sampling techniques (e.g. pots, traps or gill-nets) may be required to close these gaps. Excess vessel time e.g. during night may be used to sample invasive species with additional gears.

- *Marine food webs (D4)*

In addition to the trawl surveys also pelagic and egg surveys as well as stomach sampling (or stable isotope analysis) may support this descriptor. Data collected on species' trophic level could allow better setting of tropho-dynamic indicators under D4 (i.e. functional groups definition) also taking into account ontho-genetic shift on species' diet.

- *Eutrophication (D5)*

Research vessels may collect water samples for nutrients. 'Ferry-boxes', self-maintaining sample platforms which are installed on ships i.e. ferries, freight ships or research vessels can also be used (Petersen et al., 2003). They contain an array of scientific instruments to autonomously sample physical, chemical and biological parameters of the surface water. Ferry-boxes can be used to measure chlorophyll-a density along the cruise track as indicators of nutrient levels. The advantage of ferry-boxes are the high sampling frequencies with sampling rates of 1Hz, the disadvantages are the horizontal and vertical resolution. Remote sensing may be a preferable option to measure large scale distribution of phytoplankton.

- *Sea-floor integrity (D6)*

Groundfish surveys catch epibenthic invertebrates such as mussels, sea stars and crustaceans. Data of these catches are nowadays recorded and available in data bases such as ICES DATRAS. Time series of these data could be used to assess the abundance and distribution of macro-invertebrates as well as the impacts resulting out of commercial fisheries e.g. on benthic communities by certain types of fishing gear. A similar approach is carried out in the Mediterranean in the framework of MEDITs and SoleMON trawl surveys. Assessment of seafloor integrity could also benefit from the use of VMS and logbook data in order to derive high resolution information on spatial distribution of fishing pressure (i.e. trawling). This allows assessing fishing impacts on sensitive habitats and species. An R- routine for VMS data analysis is already available and tested in ICES' areas (VMStools; Hintzen et al., 2012) while a similar platform tailored to Mediterranean fishing fleets will be released soon (Russo et al., in preparation).

- *Hydrographical conditions (D7)*

Oceanographic surveys may provide information on currents etc.

- *Contaminants (D8)*

All vessels can in principle collect water samples and sediment and biota samples. The latter at least in case of fisheries research surveys. Ferry-boxes might also be useful.

- *Contaminants in fish and other seafood (D9)*

The food quality control authorities monitor and produce data on e.g. contaminants in fish and aquaculture products. These data would be useful for the implementation of the MSFD if made available with a clear identification of the area of origin. The present EC Regulations do not make it possible to link (trace) the data to area of origin in sufficient detail to make the data useful. The food quality data would provide a very valuable and cost efficient contribution to the environmental monitoring related to descriptor 9.

- *Marine litter (10)*

Scientific fisheries research surveys using active gears such as pelagic, bottom or beam trawls may provide opportunity to monitor macroscopic litter in the water column or at the sea floor. The recording of marine

litter is currently attempted on a provisional basis in several scientific fisheries surveys such as the IBTS (ICES, 2012d) using a standardized protocol. However, this data is yet not available in a public data base and further efforts in standardizing and collating recorded litter data from fisheries surveys into a central data base in ICES is being developed. Also experience in the collection of data on marine litter has been gained in the Mediterranean Sea although not on a regular and spatially even basis.

Litter may be recorded on board of commercial vessels either by fishermen or observers-at-sea. Observers-at-sea (OAS) could sample marine litter on board of commercial fishing vessels using a similar litter protocol as scientific fisheries surveys.

Many marine organisms are known to ingest marine litter (Cole et al., 2011). Marine litter has been found in stomachs of sea birds, marine mammals (Baird & Hooker, 2000) and fish. Fisheries surveys can provide stomach or tissue samples of susceptible species for the analysis of ingestion rates of microplastics (Lusher et al., 2013). The monitoring of microplastics may be closely related to monitoring of contaminants under D8, as microplastics are known to be adhesive to pollutants.

- *Energy including underwater noise (D11)*

Fixed moorings with the appropriate equipment to continuously measure noise within an adequate frequency range (5 - 500 Hz; Simmonds & MacLennan, 2005) may be the preferred option to measure noise. Depending on available financial resources, noise monitoring could focus on areas of increased concern, e.g. estuaries and entrances to major ports or areas of planned wind farm construction.

Fishing research vessels are commonly equipped with SONARs and echo sounders which are able to passively measure noise levels within a given frequency range. Therefore fisheries acoustic devices on board of research vessels could theoretically be used to measure ambient noise during periods of vessel inactivity e.g. during night. However, the equipment used is operating in a range between 38 to 200 kHz, whereas many anthropogenic sound sources (e.g. shipping) emit noise at frequency ranges between 5-500 kHz. Furthermore, anchoring survey vessels cannot provide continuous or integrated noise measurements, because the vessels are stationed only for a short period of time.

Currently there are no established methodologies to measure other forms of energy input from light or electromagnetic fields using research vessels. Thermal energy inputs may be measured by using CTD or ferry-boxes, but the use of remote sensing technologies may be better suited for this purpose.

5.4 Eutrophication monitoring (Descriptor 5)

The purpose of the Marine Strategy, with regard to Descriptor 5, is to minimise human-induced eutrophication, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters. The MSFD requires information gathering on order to be able to assess the eutrophication status of marine regions or sub-regions.

5.4.1 The information and monitoring cycle

The structure of this chapter is based on the 'information and monitoring cycle' (see definition in chapter 2.2). Distinguishing the separate steps in thiscycle has proved to be effective in designing monitoring, comparisons between programs of Member States and for communicating about monitoring programmes. Basically, it discriminates between '**what'** information and data are needed and '**how'** the data are collected. Similar approaches are used elsewhere, for instance by CEFAS and its partners in the UK in their Monitoring Delivery Program.

The steps of the information and monitoring cycle are:

- Specification of the need for information
- Information collection strategy
- Requirements with respect to the data
- Monitoring strategy
- Monitoring plan

5.4.2 The need for information

The choice of eutrophication indicators should be made taking into account the Commission Decision 2010/477/EU, as well as relevant advice of the Regional Sea Conventions (i.e. UNEP[91], HELCOM[92] and OSPAR[93]) in implementing D5. Member States should focus their monitoring on nutrients levels and on those direct effects (e.g. Chl-a concentration, phytoplankton abundance and composition, water transparency) and indirect effects (e.g. oxygen concentration, macrophytes) that are closely linked to nutrient enrichment and relevant to their marine region or sub-region.

Pressures need to be included in any relevant analysis that supports a programme of measures. Nutrient input is a dominant pressure for eutrophication. Nutrient inputs are not included in the list of indicators for D5 in the COM Decision 210/477/EU as such but annex III specifies the importance of locating the sources of the nutrient input determining the level of eutrophication and according to article 11 of the MSFD monitoring should be based on annex III.

River discharge is generally the most important input. It is already covered in the WFD and by the RSCs, at least for OSPAR and HELCOM. However, rivers are not the only source of nutrients. An important source is atmospheric deposition (also included in table 2 in annex III) that HELCOM and OSPAR addresses it in cooperation with the European Monitoring and Evaluation Programme (EMEP). Nutrient input from diffuse sources as well as Internal load are also possible important source of nutrients. Member States should specify how important such additional sources of nutrients are, and how they obtain sufficient data; for example some countries use models to calculate atmospheric deposition.

5.4.3 Information collection strategy

Member States should aim at developing coherent data sets at the regional sea level and, as far as feasible, also at the pan-European level and cooperate and coordinate their actions at regional sea level as required under MSFD Article 6. A good example is the roadmap of OSPAR ICG EUT for jointly testing common

[91] http://195.97.36.231/acrobatfiles/03WG231_14_eng.pdf

[92] HELCOM COMBINE Manual which is to be reviewed in 2013-2015

[93] The Common Procedure for the identification of Eutrophication Status (OSPAR 2013, actualized in June 2013, refs OSPAR 13/6/4 and OSPAR 13/6/4-Add.1) will appear on the OSPAR web-site during the course of 2013.

indicators for eutrophication. Additionally, the websites of the RSCs and also the JRC report of Piha & Zampoukas (2011) list useful documents on ISO standards and analytical methods that are or can be employed. Interoperability and coherence of data at regional or sub-regional level is crucial. The aim should be to harmonise the methods used at the regional level and as far as possible also in the pan-European level with the aim to arrive at data sets that can be "produced once and used many times". For biological variables, such as phyto- and zooplankton as well as benthic invertebrates, constant taxonomic training (e.g. regional training workshops, such as those of HELCOM Phytoplankton Expert Group PEG and Zooplankton Expert Group ZEN QAI[94]) is important to maintain a relevant level of expertise. Such regional activity may also incorporate intercalibration e.g. via ringtests. Dedicated expert groups and cooperation at the regional level are fundamental for regular activity on these issues. In addition, quality assurance activities like e. g. ringtests should be performed on national level to assure equal quality of the laboratories involved in national monitoring.

In the interests of coherence and efficiency, Member States should, where possible, build on existing data collection programmes in designing monitoring for the MSFD. In particular, account should be taken of monitoring carried out for the RSCs at the regional scale and for the WFD at the coastal water body scale. Tables 12, 13 and 14 specify the minimum requirements that have been agreed in OSPAR and HELCOM[95] and the current monitoring programs in the Baltic, the Mediterranean and the Black Sea. While there are differences between the MSFD, WFD and the RSCs requirements similar data are generally being collected. In future, Member States should ensure common design for the basic data gathering operations.

The WFD seeks to assess ecological status resulting from a wide variety of human pressures in coastal waters including the important pressure due to nutrient input. The MSFD seeks identification of where eutrophication problems exist and what are the trends in eutrophication. A similar approach is used in some RSCs (e.g. HELCOM). Each approach seeks to identify measures necessary to achieve good ecological status (WFD) or GES (MSFD). According to the MSFD, Member States should focus monitoring on nutrients and direct and indirect effects, with parameter selection similar to that of the WFD. The way the parameters are used is different allowing an assessment of the quality and functioning of the aquatic ecosystem (WFD) or eutrophication status (MSFD). Parameters to assess change in the different BQEs (e.g., benthic invertebrates and macroalgae) have been further elaborated in the WFD to assess the ecological quality of these elements. These similarities between the WFD and the MSFD allow the application of the two assessment procedures to the same data.

In principle, information can be gathered by (a combination of) data collection, data from the past, modelling and expert knowledge. The data requirements (accuracy, reliability, spatial resolution etc.) and availability of data and models determine which of these can be of use. Given the purpose of MSFD, to provide data on the current state in relation to GES, data collection will be the most important source of information in most regions. However, models and data from the past or expert knowledge may often play an important role. Model generated data can be used as an additional data source. Guidance on where and when to use models in addition or instead of *in situ* measurements is given below. Expert knowledge and data from the past are important because they may show the distance to GES and the variability in eutrophication parameter values and thus help to determine the monitoring strategy in terms of location of sampling sites to ensure representivity, sampling frequency sufficient to tackle natural variability and so on.

The choice of parameters, frequencies and spatial resolution determine to what extent the monitoring data can be used in the application and development of models. Therefore, the overall effectiveness of the data collection may be improved by asking model developers to help in setting up the monitoring programmes. Obviously, the model developers need to be asked to find an optimal balance between the need for data for model validation and calibration and a desire to use models as a cost effective way to make best use of relatively sparse data sets. HELCOM has extensively used modelling to determine past trends of

[94] http://www.helcom.fi/projects/on_going/peg/en_GB/PEG_QA/ and http://www.helcom.fi/projects/on_going/en_GB/zenqai/

[95] HELCOM COMBINE programme http://www.helcom.fi/groups/monas/CombineManual/AnnexesC/en_GB/annex2/

eutrophication in the Baltic Sea, set eutrophication targets for GES[96] and determined maximum allowable inputs of nutrient loads that allow reaching the GES targets[97].

The extent of eutrophication shows spatial variation, for instance coastal regions versus open sea. The monitoring programme (frequency, spatial resolution, etc.) should reflect this spatial variation in eutrophication status and pressures. The risk based approach and the precautionary principle are important components of the MSFD. (Sub)regions that are in sub-GES status in terms of eutrophication, or that could be considered at risk of not achieving GES (for those Member States who have not defined GES yet) generally require more intense monitoring than regions shown to be achieving GES. Flexibility should be incorporated into the design of the monitoring programme to take account of differences in each marine region or sub-region (cf. Article 4 of the MSFD).

The spatial distribution of the monitoring stations should, prior to the establishment of the eutrophication status of the marine (sub)region, be risk-based and commensurate with the anticipated extent of eutrophication in the (sub)region under consideration as well as its hydrographic characteristics. Consequently, each Member State should determine the optimum frequency per year and optimum locations for their monitoring stations in coordination and cooperation with Member States and third countries sharing the marine region, sub-region or sub-division

Salinity gradients can be a proxy for river discharge and salinity and nutrient concentrations are often strongly correlated (see for instance the use of mixing diagrams in Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area, Agreement 2005-3). Salinity can thus be used to determine an optimal spatial distribution of sampling sites, in particular if a model is available to couple salinity and hydrodynamics to nutrient levels. Salinity (and temperature) are also important parameters supporting the interpretation of eutrophication indicators (cf. Annex III, Table 1 of the MSFD). Therefore, annual and seasonal temperature regime and, where relevant, spatial and temporal distribution of salinity should be measured in both GES and non-GES regions.

[96] Examination of trends in eutrophication variables may also assist in determining GES targets http://www.helcom.fi/stc/files/Publications/Proceedings/BSEP133.pdf

[97] Modeling for the HELCOM system for Maximum Allowable Inputs and Country Allocated Nutrient Reduction Targets (expected to be adopted by HELCOM Ministerial Meeting and with background documents explaining modelling approaches to be available after 3 October 2013)

Table 12. Harmonisation with respect to choice of parameters and monitoring intensity within and between the four European RSCs: nutrient enrichment[1] and supporting parameters. Non-GES: subregions not achieving GES, see paragraph 5.4.6.

Nutrients concentration in the water column. (5.1.1)	**Baltic Sea Ø***		**Black Sea ***		**Mediterranean ***		**North East Atlantic @**	
	GES	non-GES	GES	non-GES	GES	non-GES	GES[5]	non-GES[5]
Total N (μmol l^{-1})	+	+	+	+	-	-	-	-
NH_4-$N^{2,4}$(μmol l^{-1})	+	+	+	+	+	+	+	+
NO_2-$N^{2,4}$ (μmol l^{-1})	+	+	+	+	+	+	+	+
NO_3-$N^{2,4}$ (μmol l^{-1})	+	+	+	+	+	+	+	+
Total P (μmol l^{-1})	+	+	+	+	(+)	(+)	-	-
PO_4-$P^{3,4}$ (μmol l^{-1})	+	+	+	+	+	+	+	+
SiO_4-Si^4 (μmol l^{-1})	+	+	+	+	+	+	-	+
Nutrient ratios (silicium, nitrogen and phosphorus), where appropriate (5.1.2)								
N:P	+	+	-	-	-	-	-	-
N:Si	+	+	-	-	-	-	-	-
Supporting parameters								
Temperature	+	+	+	+	+	+	+	+
Salinity	+	+	+	+	+	+	+	+

* at present separate monitoring requirements for GES and non-GES not specified

Ø Parameters as included in the HELCOM COMBINE Programme for monitoring of eutrophication and its effects (under a review in 2013-2015, currently no differentiation between GES/non-GES)

@ The monitoring programme is included in OSPAR 13/6/1, Annex 1 Reference number of existing = Agreement 2005-04. Number might stay the same as the changes are not very big.

\+ Monitoring required (in the Mediterranean and Black Seas the mandatory parameters may not be currently measured by all Member States).

(+) Monitoring flexible, taking into account the risk-based and precautionary approaches

\- Monitoring discretionary

1 All parameters should be monitored in conjunction with supporting parameters and subregion-specific ecosystem features.

2 Winter dissolved inorganic nitrogen (DIN) is the sum of NH_4-N, NO_2-N and NO_3-N.

3 Winter dissolved inorganic phosphate (DIP)

4 Monitoring of winter DIN, DIP and Si should be in conjunction with salinity measurements.

5 Yearly in non-GES subregions, every three years in GES

Table 13. RSC harmonisation with respect to measuring direct effects[1] of eutrophication.

Parameter	Baltic Sea Ø*		Black Sea *		Mediterranean *		North East Atlantic	
	GES	non-GES	GES	Non-GES	GES	Non-GES	GES	Non-GES
Chlorophyll *a* (µg l^{-1}) (5.2.1)	+	+	+	+	+	+	-	+
Secchi depth or remote sensing of water transparency (m) (5.2.2)	+	+	+	+	+	+	-	-
Blooms of toxic/nuisance algae (5.2.3) including Phytoplankton indicator species (cells l^{-1}; species composition) #	+ (phytoplankton species composition abundance and biomass)	+ (phytoplankton species composition abundance and biomass)	+	+	+	+	-	+ (+ TOC and POC[2])
Macrophytes, including abundance of opport. and perennial macroalgae, seaweeds and seagrasses (5.3.1) %	- (4)	- (4)	-	-	?	?	-	+ @

* at present separate monitoring requirements for GES and non-GES not specified

Ø Parameters as included in the HELCOM COMBINE Programme for monitoring of eutrophication and its effects (under a review in 2013-2015, currently no differentiation between GES/non-GES)

\+ Monitoring required

(+) Monitoring flexible, taking into account the risk-based and precautionary approaches

\- Monitoring discretionary

1 All parameters should be monitored in conjunction with supporting parameters and subregion-specific ecosystem features.

2 TOC: Total Organic Carbon; POC: Particulate Organic Carbon.

3 In shallow subregions, primarily in estuaries and coastal waters

4 Macrophytes are not mandatory in HELCOM COMBINE but used in thematic assessment of eutrophication

\# such as diatom to flagellate ratio, benthic to pelagic shifts, as well as bloom events of nuisance/toxic algal blooms (e.g. cyanobacteria) caused by human activities; annual to multi-year changes in frequency and/or duration of blooms. RSC differ in specific parameters. For instance, in Black Sea only monitoring of biomass Noctilucca mandatory

% e.g. fucoids, eelgrass and Neptune grass, adversely impacted by decrease in water transparency, annual to multi-year changes from fucoid/kelp to opportunistic green/brown algae. RSCs differ in specific parameters

@ biomass, species composition, coverage, reduced depth distribution

Table 14. RSC harmonisation with respect to measuring indirect effects[1] of eutrophication.

	Baltic Sea Ø		Black Sea *		Mediterranean *		North East Atlantic	
	GES	non-GES	GES	Non-GES	GES	non-GES	GES	non-GES
Dissolved O_2 (5.2.3) #	+	+	+	+	+	+	-	+
Hydrogen sulphide (as a parameter related to oxygen depletion)	+	+	–	–	–	–	–	+
Benthic communities of invertebrates %	+	+	-	-	-	-	-	+

* at present separate monitoring requirements for GES and non-GES not specified

Ø Parameters as included in the HELCOM COMBINE Programme for monitoring of eutrophication and its effects (under a review in 2013-2015, currently no differentiation between GES/non-GES)

\+ Monitoring required

\- Monitoring discretionary

(+) Monitoring flexible, taking into account the risk-based and precautionary approaches

\# i.e. changes due to increased organic decomposition; O_2 concentration (mg l^{-1}; including % O_2 saturation or oxygen debt)

% biomass, species composition and eutrophication indicator species

1 All parameters should be monitored in conjunction with supporting parameters and subregion-specific ecosystem features

5.4.4 Requirements of the data

The amount and type of data that need to be collected depends on how the data will be used. For instance, the ambition or requirement to be able to determine with statistical significance ($p<0.05$) a 10% change in a parameter requires a larger sampling effort than a requirement of being able to detect changes of 50% or more. The required reliability may be set higher close to the level defined for GES than at levels well below that point.

Data requirements should be defined with respect to:

- frequency
- spatial resolution
- reliability
- accuracy
- accessibility of data: period between data collection and data availability

Concerning frequency and spatial resolution, the OSPAR - JAMP Eutrophication Monitoring Guideline for Nutrients (1997-02)[98] may act as guidance (HELCOM and Barcelona Convention have similar specifications):

"It is intended that the region-specific temporal trend monitoring programme should have the power (e.g. 90%) to detect a change in concentration (e.g. 50%) over a selected period (e.g. 10 years). To clarify the situation and to help define objectives Contracting Parties should undertake statistical analyses of their existing data sets. This would help to determine the representativeness of the monitoring stations and would also help to determine the selection of suitable sampling stations and sampling frequencies".

[98] http://www.ospar.org/documents/dbase/decrecs/agreements/97-02e.doc

"The spatial distribution monitoring programme should enable member states to determine the representativeness of their monitoring stations with regard to spatial variability in nutrient concentrations. This would include a definition of the extent of the monitoring area and some understanding of the randomness of the monitoring stations" and *"Monitoring for nutrients should take place along salinity gradients in order to account for freshwater run-off from land to sea and as a measure to improve consistency. Monitoring for nutrients should take account of inputs and the oceanographic characteristics of each region."*

Available references on reliability and accuracy:

- JAMP Eutrophication Monitoring Guidelines: Nutrients (Agreement 2013-04)[99]
- JAMP Eutrophication Monitoring Guidelines: Chlorophyll a in Water (Agreement 2012-11)[100]
- Guidelines for estimation of a measure for uncertainty in OSPAR monitoring (Agreement 2011-3)[101]
- Sampling and Analysis Techniques for the Eutrophication Monitoring Strategy of MED POL. UNEP[102]
- HELCOM COMBINE Programme for monitoring of eutrophication and its effects[103]

Accessibility of data is specified under article 19.3 of the MSFD and WG DIKE is developing appropriate data management mechanisms. The aim is to make use as much as possible of existing data reporting mechanisms of ICES, the RSCs and EMODNET or Copernicus. ICES is currently the data centre for marine environmental monitoring data of HELCOM and OSPAR and, according to the agreements of those conventions, Contracting Parties are obliged to report their monitoring data to ICES by 1 September in the year following the year of monitoring using the agreed formats and should resolve any data processing issues with the ICES data centre. As for MED POL monitoring data, an official reporting format has been developed for pollution monitoring data, which can be uploaded in the MED POL Info System. The Info System is a networked information system intended to provide the Contracting Parties and MED POL Unit with the tools to manage, share, preserve and analyse MED POL data to MED POL users. The Info System is not yet operational. Other Member States under MSFD should consider equivalent arrangements to arrive at a regional/sub-regional data pool. At least they should specify how fast validated data can be made available after data collection.

5.4.5 Monitoring strategy

Once it has been decided that monitoring is required to cover the need of information (instead or besides modelling, use of existing data) and once the requirements are clear, the monitoring strategy can be determined. The monitoring strategy describes how the optimal monitoring programme may be derived, by taking into account:

- the data requirements, as explained in the previous paragraph
- characteristics of (sub)region and parameters:
  - general (differences in) characteristics listed under information strategy and
  - characteristics specific for regional sea or subregion
- available methods and their pro's and con's

[99] http://www.ospar.org/documents/dbase/decrecs/agreements/13-04e_guidelines_monitoring_nutrients.doc
[100] http://www.ospar.org/documents/dbase/decrecs/agreements/12-11e_JAMP_GL_Chrolophyll.doc
[101] ww.ospar.org%2Fv_measures%2Fget_page.asp%3Fv0%3D11-03e_Guidelines_reporting_uncertainty.doc%26v1%3D5&ei=oZZBUsIUiqzgBLWcgMAO&usg=AFQjCNHnBYdpWHTF1JFSpMWKzLql0_NRAg&bvm=bv.52434380,d.bGE
[102] http://195.97.36.231/acrobatfiles/MTSAcrobatfiles/mts163.pdf
[103] http://www.helcom.fi/groups/monas/CombineManual/PartC/en_GB/main/#c2

Characteristics of subregions and parameters

The monitoring strategy should take into account the general principles mentioned under information collection strategy but is mainly subregion/ Member State specific. As an example, in cooler regions (HELCOM and most OSPAR regions) winter is an optimal period for measuring nutrients since the data are not disturbed by (variable) uptake by algae/macrophytes. In those regions, spring/summer is an optimal period of the algal growing season and therefore for measuring effects of high nutrient availability. In warmer regions productivity continues during (a large part of) the winter period. In these regions, year round measurements of nutrients may be more appropriate. Additionally, subregions with high variability (often coastal zones) require higher sampling density than stable subregions (often open sea) to obtain the same statistical power. Salinity gradients need to be taken into account where relevant.

The extent of the eutrophication problem should be taken into account, in line also with the specifications of the WFD. For state monitoring (surveillance monitoring *sensu* WFD), with regard to eutrophication, the monitoring programme has the function of detecting changes in natural conditions and in the eutrophication status or confirming the status of particular subregions at GES. This should be done with respect to criteria and indicators as well as GES boundary levels. In subregions that have achieved GES in the previous assessment, a limited frequency of measurements will be needed although spatial coverage should not be neglected. For target and measure monitoring (operational monitoring *sensu* WFD), in subregions not meeting GES with regard to eutrophication, the monitoring programme should focus on most sensitive relevant parameters. A higher sampling frequency should be considered than is the case for subregions at GES, so as to satisfy statistical requirements that a Member States may have specified. The spatial coverage should also be more focused than for subregions at GES. Monitoring should continue until GES status is achieved for eutrophication. This approach reflects the risk in any given subregion not achieving GES. It is based on evidence provided through the initial assessment of the status of different sub-regions and relevant sub-assessment subregions and can draw on information from WFD and from the assessment programmes of the RSCs. Additional information on, for example, trends in nutrient input, can also be used to inform decisions about the extent of monitoring required. Where Member States have not been able to conclude on status through an initial assessment then a high level of risk is assumed, and extensive monitoring required, until such time as GES status is determined. Within HELCOM, nutrient loads into the Baltic are determined on a regular basis and quantitative status targets for eutrophication have been established and distance to the target is assessed using core-indicator based assessments for the whole Baltic Sea basin[104]. OSPAR has developed a pragmatic screening procedure to identify obvious non problem subregions. In the screening procedure contracting parties are invited to obtain readily available information about, *inter alia,* demography, industry and agriculture, hydrodynamics, (occurrence or absence of) algal blooms, nutrient levels, atmospheric and riverine inputs, nutrient budgets and (other) relevant available monitoring data (OSPAR Agreement 2005-3)[105].

Methods

Traditional methods for eutrophication monitoring in coastal waters involve *in situ* sampling/measurements of commonly measured parameters such as nutrients concentration, chlorophyll 'a' concentration, phytoplankton abundance and composition, transparency and dissolved oxygen concentration. Concerning available methods for *in situ* measurements, ships provide flexible platforms for eutrophication monitoring, while remote sensing provides opportunities for a synoptic view over regions or sub-regions. Besides traditional ship measurements, ferry-boxes and other autonomous measuring devices have been developed that allow high frequency and continuous measurements. Other platforms such as

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[104] Consise thematic assessment of eutrophication of the Baltic Sea in 2007-2011 (web link to be provided after new website established in the end of September 2013).

[105] www.ospar.org%2Fdocuments%2Fdbase%2Fdecrecs%2Fagreements%2F05-03e_common%2520procedure.doc&ei=zphBUsDeCMSO4ATY9ICIDQ&usg=AFQjCNHQjHs0OfB0usi6QWqqML0Zg73CNg&bvm=bv.52434380,d.bGE

poles, smartbuoys, gliders and towed devices also provide various temporal and spatial sampling and data storage capabilities. Countries such as Germany, Sweden and Finland have ample experience with these devices. These are all suitable, depending on the requirements with respect to the data collecting and provided adequate quality assurance and quality control is in place. Data should be collected with a spatial resolution and frequency sufficient for validating or calibrating models. When changing the method, there should be a transition period for calibration and intercomparison exercises by Member States, jointly, at their borders. 'Human sensors' should also be considered (e.g. measuring algal blooms by citizens with smart phones) and are more extensively addressed in chapter 7.3.

In situ measurements are more suitable:

- in (sub)regions with an increasing eutrophication problem,
- when an subregion is close to or under GES for eutrophication
- when the status with respect to eutrophication is still unclear
- in subregions where for other reasons accurate and reliable data are needed (generally these are coastal subregions, in particular close to rivers)

In addition to these methods that provide essential -'ground truth'- direct measurements other methods may be employed that provide better spatial and temporal cover but with either lower accuracy (on average) or with indirect measurements. As an example, outbreaks of nuisance algae at the sea surface can be detected during inspection flights carried out for other purposes, such as oil pollution. This allows qualitative detection of local and temporary outbreaks in high risk subregions (coastal zones) which is difficult to accomplish 'ground-based' sampling programs. Note that these surveys are not able to detect outbreaks that occur in stratification layers below the surface layer.

Modelling and remote sensing should also be considered as alternatives or in addition to *in situ* measurements, depending on the requirements with respect to data. In general, *in situ* measurements always remain necessary to validate and calibrate the models and data calculated from satellite measurements. *In situ* measurements give information about the actual state but show daily, seasonal and 'random' variation. In comparison, model generated data are derived from relationships based on understanding fluxes between different ecosystem components as they are affected by physical processes. They incorporate a geographical averaging (at least at a grid-cell level) that may be less variable than a measured profile, facilitating the determination of nutrient trends. A further advantage of some models is that data can be generated with high temporal and high spatial resolution. However, modelling data may not adequately reproduce the current and local situation since if they are too much based on data from the past and other places than the site under consideration and regular validation and calibration have not been carried out. Model generated data are more suitable:

- in (sub)subregions with a stable, predictable eutrophication status
- in subregions in GES or where the eutrophication problem is decreasing
- in offshore areas where taking *in situ* measurements is costly and where nutrient levels are correlated with levels in the coastal zone (extrapolation)
- in case satellite data are inaccurate or not available
- where there is a need for an average picture of the local eutrophication status; models are very good at calculating this average picture combining hydraulic models and *in situ* measurements of standard sampling sites (interpolation)
  for spatial planning purposes, for instance the planning of locations for sea farms for predicting eutrophic and hypoxic events

As with models, remote sensing generally allows the production of data with a higher spatial and temporal resolution than *in situ* measurements. Thanks to the use of satellites it is possible to have synoptic measurements over large areas. This makes the satellite data particularly useful for large-scale studies and observations and/or for studies of temporal trends. Large-scale studies should take into account the fact that phytoplankton may peak in different times in different areas/latitudes, even within the same regional sea. In the most northern parts of Europe (i.e. Scandinavia) synoptic observations may be on the whole

impossible, even in summer. Furthermore, in the case of observation of off-shore areas, that may be difficult to operate in due to bad weather conditions in winter, the use of remote sensing data can be a good option. Cloud cover is a limiting factor so high frequency satellite data can be more relied upon in southern Europe than in the north. On average good satellite images can be obtained once a week in northern Europe and 1-2 times per day in southern Europe. Clearly, this high data frequency could not be implemented with the classical methods of sampling and *in situ* measurements. The ability to consistently acquire data over an area on daily basis is essential if the goal is to analyse the day to day changes in the parameters and the factors causing these changes. Ocean colour data and the processing software can be downloaded free of charge through the portal MyOcean. Further development of regional processing schemes to account for regional ecological processes is still necessary. Also the spatial resolution should be improved especially in coastal zones. It is recommended for the best use of satellite data to calibrate remote sensing data with *in situ* data. These calibration exercises and development of algorithms are quite frequent. As for the Mediterranean Sea, relevant references are Volpe et al. (2007) and Santoleri et al. (2008). For coastal waters there are various algorithms since bio-optical characteristics of coastal waters are highly variable (i.e. D'Alimonte & Zibordi, 2003 in the Northern Adriatic and the OC5 by Gohin et al., 2002). Satellite data are more suitable:

- in (sub)subregions with a stable, predictable eutrophication status
- in subregions in GES or where the eutrophication problem is decreasing
- in offshore subregions where taking *in situ* measurements is costly and where nutrient levels are correlated with levels in the coastal zone
- in case models are inaccurate or not available
- for comparisons of the eutrophication status over large subregions
- for validation and calibration of the information on spatial distribution
- in subregions where funds are limiting
- in subregions where for other reasons the accuracy can be lower than provided by *in situ* measurements (generally these are offshore areas)
- in addition to *in situ* measurements

However, satellite data need to be supported by ground truth data.

5.4.6 Monitoring plan - joint monitoring

In practice, it appears challenging to combine national efforts in a joint international monitoring program. Even with a relatively simple set of parameters such as for eutrophication and with a long tradition of harmonization within RSCs, there are still few examples of common surveys.

- HELCOM has a tradition in sharing sampling efforts at off-shore monitoring stations[106], and despite a clear coordination of scheduling of cruises/sampling is still missing, coordination of approaches and methods allows having common core indicators and indicator-based assessments of eutrophication for the Baltic Sea.
- In the Dutch part of the North Sea the Netherlands and UK jointly operate a smart mooring system in the Oysterground area to detect and assess various important parameters related to eutrophication.

The development of joint monitoring programmes needs sufficient time because separate Member States first have to determine their own ambitions (what) and then how they could use or adjust current national monitoring programs for MSFD monitoring (how). Another step is to work towards common indicators and assessment procedures. And once that is accomplished, at least in general terms, it is possible to effectively discuss possibilities for joint monitoring. If these discussions start earlier it is difficult to give them sufficient focus. In other words, the definition of the national MSFD monitoring programmes is a suitable starting point for developing joint monitoring programs. As a consequence, monitoring programmes may need to

[106] With the basis defined in 2013 HELCOM Monitoring and Assessment Strategy http://www.helcom.fi/groups/monas/en_GB/MonitoringStrategy_2013/

be adapted in years to come. That is in line with the general recommendation to make the monitoring programmes adaptive, to be able to incorporate new insights and international agreements. Additionally, monitoring programmes for eutrophication should take into account the possible links and synergies with monitoring for other descriptors and in particular for biodiversity, as addressed in chapter 5.1.3.

5.5 Contaminants monitoring (Descriptors 8 & 9)

5.5.1 Monitoring for MSFD Descriptors 8 + 9

MSFD Descriptor 8 “Concentrations of contaminants are at levels not giving rise to pollution effects” and Descriptor 9 “Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards”, are both targeting the issue of marine chemical pollution. Within the MSFD CIS (Swartenbroux et al., 2010) it has been recommended to consider them as closely linked.

The monitoring of chemical pollutants in the marine environment has in some regions a long history. Chemical monitoring was developed following the awareness of the increase of industrial emissions and recognition of the possible harmful effects caused by pollutants in the environment arising from discharges. As the type and quantities of emissions have changed and environmental legislation has led to reductions in pollution for certain substances and areas, the monitoring of contaminants needs to be adapted and focused to address present and upcoming risks that might affect the achievement of Good Environmental Status (GES).

The marine environment is particularly vulnerable to chemical pollution. A large number of different hazardous substances reach the marine environment through various input pathways (riverine, coastal, atmospheric and direct inputs through, e.g., ship traffic and offshore industries). Once introduced into the sea, contaminants can be redistributed or transported throughout the environment by human activity and natural physical and biochemical processes. Contaminants remain in the water and especially in the sediment, from which they can be resuspended. Many substances can also accumulate in biota and thus in the food web. Here they may reach ~~up to~~ levels which not only pose a significant risk to marine organisms but also to humans through the consumption of contaminated fish and seafood. Therefore, the knowledge and consideration of such processes in the marine environment is crucial in identifying input pathways which can lead to harm, in order to reduce or eliminate them. Monitoring the pressure deriving from chemical contaminants over time and space is a basic requirement for a quantitative assessment of the environmental status of the seas. Baseline assessments are necessary in order to monitor trends and prevent deterioration. An overview about the status of marine monitoring in Europe is available within the Task group 8 report (Law et al., 2010).

Furthermore, monitoring must support the identification and prioritization of risks to the different marine ecosystem compartments (water, sediment and biota). The identification of pollution sources and how their associated inputs change over time is also important to assess the effectiveness of the pollution mitigation strategies and to direct the further efforts needed to achieve GES.

Harmonization and collaboration are basic principles for cost effective monitoring. This guidance is of an intermediate nature, as approaches to be taken for MSFD monitoring are still evolving, due to strategic considerations and technological developments. Monitoring plans need to be proactive, not reactive and combined with risk assessments. Monitoring instruments and assessment criteria need to be sensitive and comparable.

Objectives

The monitoring of contaminants in the marine environment has the primary aim of assessing the "on-going chemical status" and related environmental targets in accordance with the MSFD strategies and management cycles.

The purpose of the Marine Strategy with regard to Descriptor 8 is to ensure that concentrations of contaminants are at levels not giving rise to pollution effects. The assessment of achievement of GES should be based upon monitoring programmes covering the MSFD indicators.

With regard to Descriptor 9, the Marine Strategy aims to warrant that contaminants in fish and other seafood for human consumption, present at sea, do not exceed levels established by Community legislation or other relevant standards. Monitoring programmes should therefore assess the levels of substances for

which maximum levels are established in fish, crustacean, molluscs and other marine products destined to human consumption and determine the number and frequency of contaminants exceeding those maximum regulatory levels.

The effective monitoring of time trends, the investigation of emerging issues and pollution incidents and the identification of contaminant pathways and sources are additional aims of the monitoring programme.

Comparability of monitoring programmes

The monitoring programmes of chemical pollutants must ensure comparability within and between different marine regions and/or subregions as an equal level of protection across Europe shall be achieved. While technicalities of monitoring can differ, due to different environmental conditions, the assessments must be comparable. This requires the harmonization of GES levels and of monitoring methods. The Regional Sea Conventions can provide frameworks that provide comparability and coherence among their monitoring programmes (e.g. between OSPAR and HELCOM). Yet, harmonization should not be understood as "all are doing the same" since different monitoring approaches may emerge under particular local conditions, e.g. when selecting the monitoring matrices. The key point would be then to ensure that results enable comparison of the environmental status across regions and/or subregions and give a similar level of protection and particularly whether will point policy-makers to consider possible measures needed. The implementation of quality assurance and quality control procedures at EU level is important in order to ensure comparability.

Interaction with other relevant EU legislation

The requirement of the WFD to reach a good chemical status, defined in terms of compliance with the environmental quality standards established for chemical substances at European level, also includes marine waters. The WFD Priority Substances, WFD EQS Directive (2008/105/EC)[107] and its amendment (2013/39/EC)[108] are covered under the WFD within the territorial waters (12 nautical miles), while River Basin Specific Substances, as part of the ecological status, are covered within the coastal waters of the first nautical mile.

The process of harmonizing WFD monitoring efforts is on-going within the WFD CIS. It was driven by the work of Member States experts in dedicated working groups (Analysis and Monitoring of Priority Substances, Chemical Monitoring group) under the Expert Advisory Forum and the WFD WG E. Specific guidance documents, also covering the respective issues of marine waters, have been prepared by these groups (e.g. CIS WFD Guidance documents No. 19[109], No 25[110], No 27[111]).The MSFD is covering the remaining marine waters in which EU Member States exert jurisdictional rights as well as those aspects in coastal waters not covered within the WFD. Therefore it is evident that there is need for a close interlinking and coordination of monitoring efforts between the two legal frameworks. This has been recognized and is

[107] Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:348:0084:0097:EN:PDF

[108] Directive 2013/39/EU of the European parliament and of the council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:226:0001:0017:EN:PDF

[109] Guidance on surface water chemical monitoring under the Water Framework Directive. EC 2009. https://circabc.europa.eu/sd/d/e54e8583-faf5-478f-9b1141da9e9c564/Guidance%20No%2019%20%20Surface%20water%20chemical%20monitoring.pdf

[110] Guidance on chemical monitoring of sediment and biota under the water framework directive. EC 2010. https://circabc.europa.eu/sd/d/7f47ccd9-ce47-4f4a-b4f0-cc61db518b1c/Guidance%20No%2025%20-%20Chemical%20Monitoring%20of%20Sediment%20and%20Biota.pdf

[111] Technical guidance for deriving Environmental Quality Standards. EC 2011. https://circabc.europa.eu/sd/d/0cc3581b-5f65-4b6f-91c6-433a1e947838/TGD-EQS%20CIS-WFD%2027%20EC%202011.pdf

being considered under the upcoming MSFD and WFD common implementation strategies. Where relevant, a common work program WFD-MSFD is being established in order to ensure that monitoring data are coherent and comparable across the two directives.

Descriptor 9 of the MSFD is directly based on the EU regulations for food safety[112] (1881/2006) including its amendments and information exchange and coordination shall be established. First steps in co-ordination should provide an efficient collaboration and information exchange. For example, one must identify and create synergies on biota sampling/analysis between MSFD/WFD and seafood legislation approaches.

Regulation and recommendations exist for the safety control in food, including actions when contamination is observed. Reporting procedures are also developed:

- Commission Regulation (EU) No 252/2012 of 21 March 2012 laying down methods of sampling and analysis for the official control of levels of dioxins, dioxin-like PCBs and non-dioxin-like PCBs in certain foodstuffs and repealing Regulation (EC) No 1883/2006 (Text with EEA relevance)[113]
- Commission Recommendation of 23 August 2011 on the reduction of the presence of dioxins, furans and PCBs in feed and food (Text with EEA relevance) (2011/516/EU)[114]
- Commission Recommendation of 17 March 2010 on the monitoring of perfluoroalkylated substances in food (Text with EEA relevance) (2010/161/EU)[115]
- Commission Recommendation on the monitoring of brominated flame retardants in food (Text with EEA relevance) (draft Brussels, XXX 10492)
- EFSA guidance documents, which contain data conversion and data validation
- Guidance on standard sample description for food and feed[116]
- Guidance on data exchange[117]

Regional Sea Conventions

The four Regional Sea Conventions in Europe have already established monitoring programs addressing chemical pollution, based on agreement between contracting parties. These programs are of different degrees of maturity but reflect the technical state-of-the-art as well as implementation opportunities in their areas. Monitoring programmes for a Europe-wide implementation of MSFD descriptors 8+9 should build upon the experience and knowledge gained through these frameworks and other existing marine protection policies. The MSFD should enhance further marine environmental protection developing cooperation also with third countries which are not a member of the EU.

Guidelines for monitoring of chemical contaminants within RSCs are available at:

OSPAR CEMP and JAMP

- JAMP Guidelines for monitoring contaminants in biota[118]
- JAMP Guidelines for monitoring contaminants in sediments[119]
- JAMP Guidelines for the analysis of PFCs in water[120]

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112 Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:364:0005:0024:EN:PDF
113 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:084:0001:0022:EN:PDF
114 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:218:0023:0025:EN:PDF
115 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:068:0022:0023:EN:PDF
116 http://www.efsa.europa.eu/it/efsajournal/doc/1457.pdf
117 http://www.efsa.europa.eu/it/search/doc/1895.pdf
118 JAMP Guidelines for Monitoring Contaminants in Biota (agreement 1999-2)
119 JAMP Guidelines for Monitoring Contaminants in Sediments (agreement 2002-16)
120 JAMP guidelines for the analysis of PFCs in water (agreement 2010-8)

- JAMP Guidelines for contaminant-specific biological effects monitoring[121]
- JAMP Guidelines for general biological effects monitoring[122]
- JAMP Guidelines for the integrated monitoring and assessment of contaminants and their effects[123]
- Background document and technical annexes for biological effects monitoring[124]

HELCOM

- Manual for monitoring in the COMBINE program[125]
- Baltic Sea Action Plan[126]
- CORESET[127]
- Mediterranean Action Plan, MEDPOL[128]

Data reporting

Technicalities of data reporting for Descriptors 8 + 9 should be harmonized at EU scale. This regards reporting units, data quality parameters and metadata. Data pathways should be coordinated and efficient, so that the best use of acquired data can be made. Structures and procedures present in regional conventions can help in harmonized data reporting.

Adaptive monitoring

The patterns of chemical pollution have changed over time and the type of pollutants and their dominant sources have changed. Most legacy pollutants are nowadays almost ubiquitous, although their use may have been banned or limited for decades. Monitoring programs need to take this into account and be adaptive, responding to new and emerging pollution issues. The design of the future monitoring should be based on the evaluation of whether or not the data collected by the existing monitoring programmes provide the sufficient and necessary information to protect the marine environment.

Risk approach and precautionary principle

Monitoring needs to be carried out in coastal and marine areas where chemical contaminants have been found to represent significant risks to the marine ecosystems, and the data provided by the monitoring should serve the needs posed by the MSFD. Monitoring should allow the necessary statistical data treatments and long-term time-trend data analysis. Early warning of upcoming issues, such as emerging contaminants, should be an integral part of the monitoring systems.

The precautionary principles requires that, in doubt, protective measures should be implemented. In particular the marine environment is vulnerable due to possible accumulation of contaminants in the specific foodchains and the irreversibility of impact on its ecosystems.

Even today, the pathways, sinks and processes of chemical pollutants into and within the marine environment are not fully understood. While there is available information from longstanding research for some issues, others, such as the pollutants in the deep sea, are still little investigated. Over the past years the focus has been on legacy contaminants which have mostly been banned or restricted for some time. It is necessary to screen chemical substances according to their physic-chemical properties and teir application and release pattern. Pharmaceuticals, substances with possible effects on endocrine systems or

[121] JAMP Guidelines for Contaminant-specific Biological Effects Monitoring (agreement 2008-9)
[122] JAMP Guidelines for General Biological Effects Monitoring (agreement 1997-7)
[123] Integrated guidelines (adopted on a trial basis 2012-2015)
[124] Background document and technical annexes for biological effects monitoring, Update 2013
[125] http://www.helcom.fi/groups/monas/CombineManual/en_GB/main/
[126] http://www.helcom.fi/BSAP/en_GB/intro/
[127] http://www.helcom.fi/projects/on_going/en_GB/coreset/?u4.highlight=CORESET
[128] http://www.unepmap.org/

other toxicological impacts should be considered. Guidance for compounds to be monitored in the future might also be, for high volume production chemicals, gained under REACH, a European Union regulation concerning the Registration, Evaluation, Authorisation and restriction of Chemicals. The identification of a substance as a Substance of Very High Concern (SVHC) and its inclusion in the REACH Candidate List creates certain legal obligations for the importers, producers and suppliers of an article that contains such a substance and could be a basis for the selection and identification of emerging substances to be monitored in future. The identification of problem substances in river basin districts, who might be of concern for adjacent seawater, could also form a starting point for the revision of substances currently included in monitoring programmes.

Integration of different monitoring purposes and use of research data

Coordination of monitoring between MSFD descriptors is strongly encouraged. With costs of logistics being an important factor in monitoring the marine environment, the combination of campaigns is beneficial. The early coordination and planning of cost-effective chemical monitoring in synergy with other MSFD descriptor monitoring is therefore needed.

Monitoring data, in particular for emerging issues or for pilot approaches, are also available from scientific institutions not necessarily directly connected to the MSFD CIS. Efficient communication with all possible data providers is important and data, e.g. from national research projects can complement MSFD monitoring programs.

5.5.2 Indicator 8.1.1 Concentrations of chemical contaminants

All EU Member States have programs for monitoring of chemical contaminants in their marine waters in place. The number and type of substances, the type of assessment criteria as well as the matrices and areas covered are different. Therefore a direct comparison between countries or regions is not yet always easily achievable. A common strategy at EU level is therefore needed.

A harmonized effort is required in order to provide data on:

- Environmental status – Checked against thresholds.
- Trends – Calculated from statistical relevant time series.
- Source identity and strengths – Comparable in order to allow prioritization of efforts.

The strategy for monitoring chemical contaminants should take the different distribution levels and pathways of legacy and emerging pollutants into account. As a result of this, there will be differences in the priority lists in different areas, depending on the different activities undertaken in each (such as industrial activities) and the inputs and volumes of regionally introduced substances. Modelling, i.e. the combination of all known parameters of the environmental system can be useful in order to plan the monitoring. This can regard the placement of monitoring stations, the frequency of sampling, the ability for trend detection and other, as e.g. the modelling of missing data in time series.

Substance selection

Prioritization is necessary in order to focus the efforts in monitoring on substances which can pose a risk to the marine environment. Efforts and approaches under the WFD are at the basis of this process and RSCs provide regional expertise. A three step procedure for the selection of chemical substances has been proposed during a specific workshop within the MSFD CIS on Eutrophication and Contaminants (Hanke & Hoepffner, 2012), considering three substance groups:

1. WFD priority substances (2008/105/EC + revisions)
2. WFD River Basin Specific Pollutants derived from national Member State prioritization processes
3. Specific substances of possible concern for the marine environment

While all WFD substances should be considered, their monitoring in the marine environment might not be performed for all, due to the absence of sources or the physicochemical characteristics of the substances. The availability of source information is crucial to the selection of substances for monitoring. Furthermore chemical screening procedures and biological effect monitoring can support the prioritization process. While river basin specific pollutants are to be identified by the national authorities, it has been recommended to follow harmonized approaches, which should also include the consideration of the coastal zone (Piha et al., 2010).

Joint efforts in substance prioritization at the appropriate organizational level will provide comparability, coherence and cost effectiveness. Legacy pollutants control and identification of emerging pollutants will require different monitoring strategies. It is important that MS identify clearly the substances that they need to monitor, so that they can be accommodated within the on-going monitoring programmes. The list will be amendable for revision and the addition or replacement of contaminants will depend on the outcomes of current and future monitoring. The monitored chemicals need to be specific for the region and inputs – a long list is not necessarily better than a short list with actual criteria.

Monitoring matrices

Each compartment of the marine environment (water, sediments, biota,…) provides specific information about the pollution status, trends and sources of toxic substances. Sampling a particular environmental compartment should be based on the anticipated pathway, fate and effect of each pollutant.

- Water: Marine water samples can help to evaluate inputs, provide fluxes and determine concentrations of hydrophilic and hydrophobic compounds. The concept of whole water, i.e. regarding suspended solids as part of the water sample, should be considered. Obtaining representative water samples in shallow and highly dynamic areas is problematic. For assessments at regional scale, the concentrations of specific substances in water masses can be of interest. Steady state concentrations may be encountered in deep sea basins without remarkable currents.
- Sediments: They are the repository for a large proportion of the hydrophobic contaminants introduced to the sea and are therefore useful to assess spatial distributions of chemicals, sources and to support studies of the effects of contaminants on organisms. Sediment cores can yield historic time-trend information relating to changing inputs for highly persistent substances. Obtaining representative sediment samples in areas with strong natural sediment relocation, dredging activities, sediment slides or tidal currents is problematic and should be avoided. Low sedimentation rates can hinder a sufficient temporal resolution for time trend analysis, while assessment of concentrations of specific chemical substances in surface deep-sea sediments can be of high marine environmental relevance, thus requiring appropriate approaches."
- Biota: Different species (as fish, shellfish, seabird eggs, cetaceans …) can be used for different monitoring scopes: chemical accumulation with trophic levels, assessment of temporal trends, and assessment of large-scale regional differences in contamination. Top predators can give indications of secondary poisoning, but species with significant long-distances migratory pattern may not be suitable for local or sub regional assessments. New deep-sea target species will have to be selected for monitoring environmental marine pollution in deep-sea marine ecosystems. Biota samples also may help to assess harm to living resources and humans, so they have the potential to be combined with biological effect measurements. The species selection should therefore include both those most relevant for human consumption and those most exposed due to their prey schemes or which at act integrators of marine pollution. Sessile filter feeders (with particular reference to bivalves) are, when available, an important monitoring matrices for assessments of concentrations of specific substances (i.e. MYTILOS, MYTIMED, MYTIAD and MYTIOR projects) (UNEP/MAP)[129].

Subsequent considerations will have to involve understanding the movement and transport of key contaminants within the given matrix and their transfer from one matrix to another, including the

[129] http://195.97.36.231/acrobatfiles/05WG282_Mytilos_eng.pdf

atmosphere. The marine environment is particularly relevant as it can act as sentinel for persistent substances spreading wide into the environment.

The selection of the monitoring matrix should be coherent with the matrix for which EQS have been derived or, if required, have to be developed for the preferred matrix (development is still needed as to the application of EQS to marine waters) providing the most instructive information. The selection of the monitoring matrix has implications on the monitoring frequencies on both scientific and cost grounds.

Monitoring locations

The grid of monitoring stations will depend on the purpose of the specific campaigns. Most monitoring stations will be part of WFD monitoring schemes. It has been recognized that the open and deep sea is much less covered by monitoring efforts than coastal areas. There is a need to include within monitoring programmes also these areas in a representative and efficient way, where risks warrant coverage.

A joint strategy for monitoring should include master stations, distributed spatial spread and other approaches, such as transect sampling, if applicable.

The selection of sites for the monitoring of contaminants in the marine environment is a direct function of the assessment of risks and the monitoring scope:

- Areas of concern identified on the basis of the review of the existing information and linked to WFD and RSC's assessments.
- Areas of known past and/or present release of chemical contaminants.
- Offshore areas where risk warrants coverage (aquaculture, offshore oil and gas activity, dredging, mining, dumping at sea...).
- Sites representative in monitoring of other sea-based (shipping) and atmospheric sources.
- Reference sites: For reference values and background concentrations.
- Representative sensitive pollution sites/areas at sub regional scale.
- Deep-sea sites/areas of potential particular concern

The selected sites should allow the collection of realistic number of samples (e.g. be suitable for sediment sampling, allow sampling a sufficient number of biota for the selected species during the duration of the programme…). Modelling tools can provide information for the best placement of monitoring stations with respect to ocean currents and input pathways.

MS should provide their proposed sampling locations and the reasons for monitoring. It is essential that the monitoring strategies are being coordinated at regional and/or subregional level. Coordination with monitoring for other descriptors is crucial for cost-effective approaches. The organization of cruises as a joint effort from different Member States might be an effective option.

Monitoring frequency

Monitoring frequencies will be determined by the purpose of the sampling effort. They can range from shorter time scales for seasonally variable input, to large time scales for sediment core monitoring. For trend determination the timescales will depend on the ability to detect trends considering the variability in the whole analytical process and the number of replicates. It can be possible to decrease the monitoring frequency in cases where established time series show concentrations well below levels of concern, and without any upward trend over a number of years. For multiannual parameters, opportunities for joint organization between Member States and between or within RSC should be considered.

Sampling and analytical methods

The WFD CIS provides a process for the identification and improvement of analytical methodologies for the purpose of WFD chemical monitoring. Depending on the substances, environmental matrix and the targeted concentrations it will be necessary to utilize analytical technologies of recent development. Therefore marine monitoring requires a close collaboration between monitoring authorities and scientific

institutions. Specific research programs or pilot projects may provide information on the relevant issues in a cost effective way.

The sample acquisition is often the most costly and resource intense step in marine monitoring. Technologies are evolving and can help to improve the overall monitoring process. Sampling and subsequent sample analysis should be considered as an integral process. Instrument development is on-going and approaches can therefore be updated for the benefit of detectability, accuracy and efficiency. Examples are multi ion-trap screening techniques which allow checking for a large number of substances in single measurements, large volume injection techniques and modern triple quadrupole instruments with high sensitivity and selectivity.

New technologies, such as transect sampling, Ferrybox systems, AUVs, Gliders, smart buoys, sensors, passive sampling, biological effect monitoring, chemical screening approaches, etc. can provide opportunities for cost effective data acquisition and for new types of datasets. This can concern both, the monitoring of contaminants itself, as also the acquisition of metadata, which can then trigger and direct the monitoring for contaminants (Expert Group on Marine Research Infrastructures, 2013).

Quality Assurance/Quality Control

Quality Assurance and Quality Control are of particular importance for chemical monitoring (see chapter 6). As standardized methodologies will not always be available, and a standardization procedure might not be compatible with the required timescales, the use of well-established proficiency testing schemes (QUASIMEME[130], IAEA, etc.), continuously adapted to the current needs, is crucial. Technical specifications for analytical measurements under the WFD are available through the Commission Directive (2009/90/EC)[131] and should be applied also under the MSFD.
However, specific marine characteristics (e.g. lower LODs, supporting and normalization parameters) must be considered , therefore procedures established by the RSCs (OSPAR, HELCOM, MEDPOL, ICES) should be considered and used.

5.5.3 Indicator 8.2.1. Effects of contaminants

Indicator 8.2.1 describes a specific indicator for pollution effects: “Levels of pollution effects on the ecosystem components concerned, having regard to the selected biological processes and taxonomic groups where a cause/effect relationship has been established and needs to be monitored “.

Due to the nature of chemical contamination, the MSFD and WFD approaches for control of chemical pollution need to be highly compatible between both policy frameworks. The purpose of the MSFD is to identify eventual environmental problems which hinder the achievement of GES and the identification of their cause and thus the sources of chemical contamination. Together with the WFD policy tools and the measures applicable under the MSFD, remediation, closure of sources and ending of contaminant input should then lead to an improvement and ideally finally the achievement of GES. This denotes that the identification of the cause, i.e. the substance or substance group is of high importance.

The applicability of current available biological effect based methodologies requires therefore further technical expert discussions. The aim should be to define a common approach, between MSFD and WFD, and to provide clear guidance to which methodologies are serving the aim of both Directives. The field of biological effect based methods is rapidly developing and frequent update on guidance is needed, providing a challenge for the science- policy interface.

[130] QUASIMEME programme, initiated in the 1990s under an EU project, which provides quality assurance services to participating laboratories.
http://www.quasimeme.org/
[131] Commission Directive 2009/90/EC of 31 July 2009 laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:201:0036:0038:EN:PDF

In the WFD context, effect based monitoring tools are currently not used for compliance checking but several methods can be very effective in excluding pollution above a certain level by screening, identifying areas for further monitoring and identification of emerging pressures.

An overview about available methodologies for monitoring of biological effects in marine biota, water or sediment has been provided through the MSFD task group report 8 (MSFD task group 8, 2010). Furthermore, under the WFD CIS working group E, a technical report about effect based monitoring tools has been developed and considers MSFD relevant tools (Wernersson et al., 2013).

ICES recently published a report on integrated marine environmental monitoring of chemicals and their effects (Davies & Veethak, 2012) that provides additional useful information and also includes background information on the effect based tools that are included in the proposal.

5.5.4 Indicator 8.2.2. Quantification of acute chemical spills, specifically of oil and its products, but not excluding others.

The MSFD is aiming at the protection of the environment against oil spills with a coherent coverage and equal level of protection for all European Seas. There are organizational frameworks and emergency response regimes in place in order to detect and combat acute spills.

While there should be no overlap or double work with existing provisions, the guidance on monitoring should here ensure that all aspects are being covered under the various frameworks, that monitoring information is exchanged between the networks and that potential for a cost effective integrated monitoring is used.

The descriptor contains two different criteria:

- Occurrence, origin, extent.
- Impact on biota physically affected.

Monitoring efforts can therefore use the following methods for quantification:

- Quantification of oil and other chemical spills and their size by observation and reporting.
- Satellite radar images, plane observation and imaging approaches.
- Backtracking of oil spills to their source by hind cast modelling.
- Fingerprinting using chemical analysis (GC-MS) and comparison with possible sources.
- Quantification of oil affected seabirds (OSPAR), aimed at chronic oil pollution events not acute ones.

While major oil spills can have extreme impacts on the marine environment, also frequent smaller spills and discharges can exert significant pressures and must be considered appropriately. These can derives from ship traffic, pipelines or platforms for oil and gas exploration or be related to other marine activities, such as e.g. construction of wind energy platforms. Chemical substances potentially being spilled at sea are referred to as “Hazardous and Noxious Substances (HNS)”. They are substances other than oil which, if introduced into the marine environment can create hazards to human health, harm living resources and marine life, damage amenities, or interfere with other uses of the sea.

The organizational frameworks under which the monitoring of oil and other chemical spills is being dealt with are: EMSA , [132]REMPEC[133], Helcom BRISK[134], OSPAR (see Bonn Agreement for the North Sea and surrounding areas), IMO HNS[135] and Bonn agreement[136]

[132] http://www.emsa.europa.eu/operations/cleanseanet.html
[133] http://www.rempec.org/
[134] http://www.brisk.helcom.fi/
[135] http://www.imo.org/OurWork/Legal/HNS/Pages/HNSConvention.aspx
[136] http://www.bonnagreement.org/eng/html/welcome.html

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

Council regulation (EEC) No. 315/93 and Commission Regulation EC 1881/2006 and its amendments provide for the protection of consumers from chemical substances in food. MSFD Descriptor 9 is referring to that regulation, but also to other relevant standards. Descriptor 9 is therefore providing the protection of human health from harm potentially deriving from the consumption of contaminated seafood. GES would be achieved if all contaminants are at levels below the levels established for human consumption. Therefore, distinction should be made between contaminants for which regulatory levels have been set and other contaminants of relevance in fish and other seafood. The assessment of the indicators should at least take account of the actual levels that have been detected, the frequency that levels exceed the regulatory levels, the number of contaminants for which exceeding levels have been detected in parallel and the origin of the contamination. An intake assessment taking into account the importance in the human diet of the species showing exceeding levels could also be taken into account.

Substances to be monitored

Monitoring of descriptor 9 only measures contaminants in fish and other seafood for which regulatory limits have been set in community legislation for public health reasons. Monitoring for other contaminants should focus on trend analysis. The significance of an increase for specific contaminants under descriptor 8 should be regarded as an important element for inclusion in monitoring under descriptor 9. Similarly, when results from monitoring in descriptor 8 indicate a very low likelihood for elevated levels in fish and seafood for human consumption, additional monitoring under descriptor 9 on these commodities is not justified.

Monitoring should at least consider the following contaminants for which regulatory levels have been laid down: Heavy metals (lead, cadmium, and mercury), polycyclic aromatic hydrocarbons, dioxins (including dioxin-like PCBs) and radionuclides. Additionally, further contaminants of relevance should be identified.

Species

The selection of the species to be used for monitoring should consider the following criteria:

- Species more prone to biomagnify/bio-accumulate specific classes of contaminants
- Species representative of the different trophic levels or habitats
- Species representative for entire (sub) region
- Species representing consumer habits

Moreover, in order to make monitoring results more comparable between (sub) regions, it would be advisable to select a limited number of target species from the most consumed species of fish and other seafood using the table in Annex II of the MSFD task group report 9 (MSFD task group 9, 2010).

Sample collection

Only unprocessed products should be sampled for the purpose of GES MSFD monitoring. A key element will be to analyse seafood in the sea from known locations. There is scope here for regional cooperation – e.g. one ship collecting fish samples in the North Sea from commercial fishing grounds, and all countries round the North Sea using those data.

The monitoring of contaminants in seafood is executed by the responsible authorities in charge, which often are different from the authorities implementing the MSFD and its associated monitoring. Here, cooperation with authorities and environmental institutions in charge of health monitoring is strongly encouraged. Topics for coordination are:

- Providing information on the origin of the samples: Sampling of fish and seafood at retail stage shall only be done when all necessary conditions (e.g. avoid cross contamination, traceability to (sub) region…) can be guaranteed
- Exploring synergies in the monitoring of marine top predators
- Exchanging information on data, approaches and methodologies between environmental monitoring institutions and human health risk related monitoring institutions

5.6 Litter monitoring (Descriptor 10).

This text may need to be adjusted accordingly to changes during the finalization of the "Guidance on Monitoring of Marine Litter in European Seas" EUR 26113 (Draft Report, to be completed by Nov 2013).

Characteristics and impact of marine litter are being considered by specific indicators under Descriptor 10 of the MSFD within the Commission Decision on criteria and methodological standards on GES of marine waters (Commission Decision 2010/477/EU). In 2010 a Technical Subgroup (TSG) for the further support of Descriptor 10 implementation was established. This Technical Subgroup Marine Litter (TSG ML) is led by DG ENV and chaired by IREMER, the EC Joint Research Centre and the German Environment Agency. The group consists of Member State delegates, the Regional Sea Conventions, relevant organizations and invited experts.

Harmonized monitoring is of importance due to the transboundary nature of marine litter and the need for comparable baselines across Europe and beyond. Therefore guidance for the harmonized monitoring of marine litter for the MSFD is being provided through documents developed by the group. The TSG-ML provided advice through the EU Report 25009 "Marine Litter – Technical Recommendations for the implementation of MSFD requirements"[137]. Within that report, the options and available tools for the monitoring of marine litter in the different environmental compartments and for litter in biota have been identified.

In order to close the identified gaps in the availability of specific methodology, the TSG developed a series of monitoring protocols for the use under MSFD. These protocols have been based on existing methodologies, harmonizing and adapting them where necessary and by developing new methodologies where none was available. These methodologies are compiled in the "Guidance on Monitoring of Marine Litter in European Seas" EUR 26113 (Draft Report, to be completed by Nov 2013) [link].

This document provides MS with the recommendations and information needed to plan the monitoring required by this aspect of the MSFD. This draft report is divided in 8 sections/chapters presenting a general overview of approaches and strategies dealing with marine litter monitoring and provides protocols for the monitoring: beach litter, floating litter, seafloor litter, litter in biota and micro litter. The need for harmonized reporting categories of litter items was met by establishing a master list of litter items for use in marine litter monitoring programmes of EU MS.

Key messages have been compiled to give orientation to MS about what needs to be considered for the implementation of a coherent monitoring of descriptor 10. The guidance on monitoring protocols should support MS in implementing harmonized monitoring programs for marine litter leading to the comparable data. The key messages regarding the overall approaches and strategies are as follows:

- Protocols are available for all indicators but with different levels of maturity;
- Protocols are available for most geographical areas. Greatest difficulty is with:
    - Litter in biota, where protocols have to be adjusted to match regional distribution of species
    - Microlitter, where much research is currently going on, and we consider it premature to suggest any protocol currently;
- For indicators where no mature protocol can be recommended, pilot studies using one of the less mature protocols are recommended. Our knowledge about the amount and distribution of Marine Litter in many of the environmental compartments is still insufficient. Pilot studies could guide us towards better design of future monitoring, and thus be cost-efficient in the long run;

[137] http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/22826/2/msfd_ges_tsg_marine_litter_report_eur_25009_en_online_version.pdf

- Data acquisition should be organized effectively and between MS authorities and scientific research projects;
- Data acquisition through research, beyond on-going research projects and monitoring efforts need to be identified and implemented;
- While some knowledge gaps can be expected to be closed already by current research in the coming years, there are still considerable gaps in research on marine litter. MSFD Marine litter research needs should be included in the further EU knowledge development programming (e.g. Horizon 2020).

It is important to remember that these different compartments indicate different pathways and sinks for marine litter, and do not substitute each other.

Regarding **beach litter** it is recommended that the standard coastal litter survey methods should, where possible, be applied at all levels from local to regional seas level in, order to enable comparisons within and between that regions.

For **sea floor**, monitoring of litter by trawling surveys on continental margins must be co-organized and coordinated within the two groups ICES/IBTS, covering NE Atlantic and Baltic Sea, and MEDITS covering Mediterranean and Black Sea. This will need to be organized within the EU through STEFC (Scientific, Technical and Economic Committee for Fisheries) and its Subgroup Research Needs (SGRN) with the support of the Data Center Framework (DCF) from DG MARE (Directorate-General for Maritime Affairs and Fisheries). The use of a central database for European trawl survey data (MEDITS, IBTS, ICES, DATRAS, etc.) may be used for collection of trawl survey data preceding a more specific litter data management system, still to be organised. Monitoring shallow waters and deep sea areas must be organized by Member States considering the importance of sites and costs. On-going monitoring programmes (marine reserves, pipeline surveys, harbours or bays cleanings) and specific monitoring in areas where risks are occurring may provide valuable support to collect data. Methods based on scuba diving or video imaging are therefore provided to support this, using harmonized protocols.

Floating litter: The monitoring of floating marine litter in selected coastal transects is recommended and should follow a protocol agreed on EU scale within the MSFD implementation process. The surveys should be based on visual monitoring by dedicated observers from ships-of-opportunity. The floating objects should be identified and counted within a predetermined corridor in order to allow the determination of object concentrations. Harmonized approaches are important in order to allow comparability of data. Other methodologies, such as aerial surveys and net tow surveys are available but provide different data. Automated approaches through acquisition and analysis of digital images are under development and can provide future alternatives.

Regarding **litter impact on biota** there is the need for further development based on the experience in some sub-regions (e.g. North Sea), to be adapted in other regions and on emerging knowledge about other impacts beside the ingestion of litter by marine organisms. The primary task for the implementation of appropriate monitoring for this indicator is to develop tools for investigating trends in ingested litter that cover all the MSFD marine regions. As no single species can provide full coverage over all Europe's marine sectors, a range of species is needed to monitor ingested litter. Some spatial overlap between regionally restricted monitoring species is desirable to link pollution measurements in the different areas. In addition the issue of entanglement of marine organisms in litter is the second main impact to be considered when dealing with criteria 10.2. Impacts of litter on marine life. Furthermore the Commission Decision 2010/477 states that the improvement of knowledge concerning impacts on marine life (affected species, species used as indicators, the standardisation of methods and the determination of thresholds) is also needed. In the draft guidance (chapter 6) more details are provided regarding the monitoring protocols for the monitoring of litter ingested by seabirds, sea turtles, and fish.

For **micro litter,** a review of existing approaches is presented which considers sampling design, methods of sample collection and identification of microparticles and the extent of current usage which is important for comparative purposes. In order to give guidance for monitoring of microplastics in marine habitats,

where possible, basic criteria and approaches are recommended; such that future quantitative estimates are as comparable as possible. However, microparticles represent an emerging area of scientific research and as yet there are few robustly tested and validated approaches. Hence, in addition to providing recommendations that will be feasible and effective for Member States at the present time, the draft guidance also identifies areas where methods need developing. It is therefore essential that approaches are reviewed as our understanding and the literature on this topic evolve.

Dealing with a topic under development through research efforts and by fast growing experience, this guidance should also afterwards be regarded as a living document and updated on a regular basis.

5.7 Noise monitoring (Descriptor 11)

5.7.1 Background

Two indicators were chosen in Commission Decision 2010/477/EU for Descriptor 11 (Noise/Energy): Indicator 11.1.1 on low and mid frequency impulsive sounds and Indicator 11.2.1 on continuous low frequency sound (ambient noise). The EU Marine Directors in 2010 established a Technical Subgroup (TSG) under the Working Group on Good Environmental Status (WG GES) for further development of these indicators (and other aspects of the Descriptor). In 2011, TSG (Underwater) Noise focused on clarifying the purpose, use and limitation of the indicators and described methodology that would be unambiguous, effective and practicable and delivered its first report in February 2012 (Van der Graaf *et al*., 2012).

In December 2011, EU Marine Directors asked TSG Noise to provide monitoring guidance that could be used by MS in establishing monitoring schemes for underwater noise in their marine waters. The group was also asked to provide suggestions for (future) target setting and for addressing the biological impacts of anthropogenic underwater noise. The group was also asked to evaluate new information on the effects of sound on marine biota, with the view to considering indicators of noise effects.

In May 2013, TSG Noise published its second report, Monitoring Guidance for Underwater Noise in three parts (Dekeling *et al*., 2013a,b,c):

- Part I: Executive Summary & Recommendations,
- Part II: Monitoring Guidance Specifications, and
- Part III: Background Information and Annexes.

The two indicators are very different in their nature; in both cases it is not known what Good Environmental Status would actually be, primarily because there has been very little work on ecosystem-scale effects of underwater noise. Effects are known at individual and small group scale, but not at greater (MSFD) scales. Consequently the first stages of the implementation of monitoring schemes is to establish current conditions.

5.7.2 Impulsive sound

In the case of high intensity, low and mid-frequency impulsive sounds, the monitoring will be in the form of a register of activities generating such sounds. The spatial scale of the register is blocks of sea of approximately 10NM (16 km) x 6NM (11 km), with a temporal scale of a day. Thus if an activity generating these impulsive sounds occurs, it is assumed to affect an area of this size for one day. These scales are approximately those of the known effects on individual harbour porpoises. Dekeling *et al*. (2013b) provide further details of the register that will essentially work through collation of information that should be available already in the licensing and management activities undertaken by Member States. The register will be both “forward-looking” and “backward-recording”. This is because it is generally not known precisely what activity will occur on what days. The forward-looking register will enable early identification of areas where activities will occur; this in turn might allow management of those activities should there be a need for such control. The backward-looking record will allow a better understanding of the predictions contained in the forward-looking register (developers very often predict an “extreme scenario” in their environmental impact assessments and licence applications), and would better enable studies of actual effects on biota (such as changes in dispersion of marine mammals).

Seismic survey, pile-driving, explosives, sonars working at relevant frequencies and some acoustic deterrent devices are the most important sound-sources that should be considered for inclusion in the register. Possibly there are additional sources that could be of concern (boomers, sparkers, scientific echo sounders). Since a registry that leaves out part of the sound sources is not useful if the aim is to address cumulative effects of all sources of impulsive noise, and therefore TSG Noise recommended that information on all sources should be included in the registry. Data on explosions and from activities of

which the sole purpose is defence or national security should if possible be included in the register, on a voluntary basis, but TSG Noise notes that this is a national policy issue.

The main items in the register needed to derive pulse-block days (the number of days that in an area (block) a certain threshold (pulse) is exceeded) as required in the text of the Commission Decision, are:

- Pulse-generating activity
- Day
- Location
- Source level

TSG Noise has defined recommended thresholds for various activities. Further work will be required in Member States to tune the administrative systems to allow a consistent feed of information to the register. Experience so far indicates that it is very labour intensive to extract relevant information from existing systems – a degree of automation would improve this. More mundane details such as defining where the coast is on the coarse spatial scale being used also needs to be undertaken. It will also be important to develop systems for common noise registers in regional seas since marine life does not respect human boundaries and noise in one area could affect populations living in other areas throughout regional seas.

Many further steps will be needed to assess whether or not disturbance caused by these impulsive sounds might affect species at the population level. This will require considerable further research for even the most studied species at present and the consequences will vary with species. Some modelling approaches may aid understanding.

5.7.3 Ambient sound

Monitoring of trends in ambient sounds at the two 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1µPa RMS; average noise level in these octave bands over a year) most characteristic of shipping will require the establishment of a network of hydrophones. These will need to sample at the scale of regional seas, making it necessary for Member States to work together starting at the network design stage. Some modelling will be required; this will need information from the hydrophone network and there will also need to be some model-verification based on measurements. TSG Noise has also examined and made recommendations on technical issues such as the averaging method that might best be used, the need to avoid biasing results through noise generated by the recording (or anchoring) system and the most appropriate forms of modelling.

It is likely to take decades to detect a statistically significant trend (if such exists) in these ambient sounds, TSG Noise therefore recommends that Member States measure actual levels (taking a wider overview of each regional sea through a combination of modelling and mapping). This will enable Member States to choose the most appropriate approach when setting up monitoring.

Van der Graaf *et al.* (2012) describes standards that measurement equipment should comply with, along with comments about possible shortcomings of commercially available equipment. Dekeling *et al*. (2013c) similarly describes the standards and definitions needed to clarify what is an appropriate model and what is not.

Dekeling *et al*. (2013b) recommends an initial set of rules for the placement of measurement devices (in order of importance):

1- If there are only few measurement stations per basin, these should be at suitable locations for validating the model prediction used for interpolation and extrapolation. Monitoring may be more cost effective if existing stations are used for monitoring other oceanographic features.
2- In deep water, place the devices in areas of low shipping density. The range at which to shipping lanes result in elevated noise levels may be greater in deep water as low frequency sound can propagate long distances.

3- Place one hydrophone close to the bottom. If budgets allow for a second hydrophone, it should be placed at the depth where the lowest value for the yearly averaged sound speed is expected and in deep water that depth should be preferred over the seabed or the sea surface.
4- Consider special topography and bathymetry effects e.g. when there are pronounced coastal landscapes or islands/archipelagos it may be considered to place hydrophones on opposite sides,
5- In waters subjected to trawling, use locations that are protected from fishing activities or locations where trawling is avoided due to bottom features (e.g. underwater structures/wrecks);
6- Consider, and if possible avoid being close to, the possible presence of other sound producing activities that might interfere with measurements e.g. offshore activities like oil- and gas exploration or construction activities. Areas of particularly high tidal currents may also have elevated noise levels.

It should be recognised that although monitoring of noise in air has been conducted in Europe for several decades, very little has been carried out until recently with respect to underwater sound. Much will be learned once monitoring starts and no doubt schemes will need to be adapted to resolve any issues that arise.

5.8 Monitoring and assessment of anthropogenic pressures

As traditional environmental monitoring has focused on the state of the environment, the requirement of the MSFD to understand the amount and distribution of anthropogenic pressures has given new challenges to Member States in their setting up of monitoring programmes. This section aims to provide ideas and good practices for monitoring of anthropogenic pressures and assessing their amounts and distribution in marine environment.

5.8.1 Relationships of pressures and environmental status

Environmental indicators have often been categorized by the PSR (pressure-state-response) model. It implies that human activities exert *pressures* on the environment, which can induce changes in the *state* of the environment that societies *respond* to with environmental and economic policies (OECD, 1993).

The relationship of a pressure and an environmental status depends always on the context: what status one is looking at. If the objective is to assess the state of biodiversity (MSFD descriptors 1, 4 and 6), the pressures can, for instance, be non-indigenous species or concentrations of nutrient or contaminants. However, if the objective is to assess water quality (MSFD descriptors 5 and 8), the pressures are more likely the amount of nutrient or contaminant input. Hence, the objective of the assessment steers the definition of 'anthropogenic pressure' and this should be kept in mind when selecting parameters for the monitoring programme.

Different anthropogenic pressures affect different species, habitats or ecosystem functions. The links between pressure(s) and status need to be established in order to make a proper assessment whether GES has been reached or maintained. The pressure-status links can be direct or indirect, strong or weak and there can be various degree of confidence in these links. Loads of scientific knowledge has accumulated on the magnitude of the impacts of pressures on various ecosystem components and some papers have compiled this to a useful form (e.g. Halpern et al. 2007, 2008, 2009; OSPAR 2009, Selkoe et al. 2009, Ban et al. 2010, Coll et al. 2012, Korpinen et al. 2012, Andersen et al. 2013).

5.8.2 Selection of monitored parameters

In the existing marine monitoring programmes there are only a limited number of parameters that monitor directly anthropogenic pressures. Majority of pressure monitoring comprise water or sediment quality (or inputs of nutrients, organic matter and contaminants) or fishing mortality of commercial stocks, whereas other pressures are being followed on the basis of the underlying human activities. For example, the smothering of benthic communities by disposed dredged material is not monitored directly but the amount of disposed material is used as a proxy for the pressure. Similarly, physical disturbance of seabed by demersal trawling is not monitored directly (i.e. measuring the depth and width of sediment disturbance) but the trawling activity is used as a proxy for the pressure. When possible, those "proxies" have to be calibrated by monitoring the depth and sea-floor-nature (through measurements, models or expert advice). Some pressures may be even very difficult to quantify, such as fishing mortality by ghost nets, or require specific models, such as material gradients in riverine plumes.

In the absence of some pressure parameters, it is recommended to use proxies that capture the intensity and the spatial coverage of the pressure. The challenge with proxies is that they often capture only a part of the whole range of the anthropogenic pressure. For instance, physical damage to a seabed habitat (e.g. siltation) can occur because of various construction works, demersal trawling, side-effects of sand extraction and riverine inputs of agricultural silt. All the four sources of siltation would have different intensity scales and units and therefore their combining them to a common metrics will likely be difficult. A practical solution is to monitor them separately and aim at integration in the assessment phase.

5.8.3 Selecting spatial and temporal scales for pressure monitoring

Likewise in the status monitoring, also pressure monitoring should take into account the spatial and temporal scales of a pressure and its impact. Human activities have different needs for marine space: shipping and fishing are practiced over vast areas, wind farms occupy medium-sized areas and construction of a peer on a shore occupies only a small area. Moreover, pressures spreading with water motion (e.g. contaminants) act in significantly larger scales than point-like pressures such as dredging or shooting an animal. The implications to monitoring are obvious: large-scale pressures require wider monitoring, whereas point-like pressures should focus on areas of their known occurrence.

Temporal aspects of the monitoring of pressures need to consider the consistency of the pressure (continuous, regular, single events) and the lasting of the impact (decades, years, months, etc). While the continuous pressures can be monitored in any time, others may require specific planning of the timing of monitoring.

5.8.4 Using existing information for pressure assessments

Assessments of anthropogenic pressures do not require always specific monitoring activities but existing information from permitting and inspection authorities and various stakeholder organisations. Human activities requiring permits in many sea areas are dredging, disposal of dredged matter, extraction of sand and gravel, all marine and coastal constructions and installations, aquaculture as well as discharges from industry and waste water treatment plants. Fishery registers (log books, catch/landing registers, VMS records, fleet registers) are a source of information supporting pressure assessments. Other sources of information are, for instance, port and shipping organisations, boating and angler associations, energy companies and organisations as well as municipal authorities holding land use maps.

In many countries pressure data is scattered and no efforts have been made to compile the data into a single dataset. Planning of pressure databases is an important step and the use GIS-based databases is a good option.

5.8.5 Case Baltic Sea: HELCOM work on indicators and assessments of anthropogenic pressures

The most severe environmental problems in the Baltic Sea are eutrophication, contamination and changes in food web structure. The Contracting Parties of HELCOM have therefore focused the development of pressures indicators to inputs of nutrient and hazardous substances as well as fishing and shipping.
Inputs of nitrogen and phosphorus to the sea have been compiled from sea-based activities, atmospheric deposition and waterborne inputs from the entire catchment area in the HELCOM Pollution Load Compilation (PLC) activities (e.g. HELCOM, 2012). At the moment the sixth PLC assessment is being prepared. In addition to the input figures, the PLCs have made source allocation calculations and adjusted the inputs to annual riverine flows in order to take account of differences in precipitation. The PLC results form the basis of the nutrient reduction targets and the annual load indicator follows the reaching of the targets.

Hazardous substances have been traditionally assessed in the Baltic Sea on the basis of their concentrations in sediment, fish, mussels and top predators. Complete input estimates have not been possible so far but temporal trends of atmospheric deposition of metals and dioxins as well as waterborne inputs from industry and some rivers have been compiled from the Baltic Sea area (e.g. Bartnicki et al. 2010, HELCOM, 2012). Discharges of radioactive substances from nuclear power plants, research facilities and other sources have been compiled by the HELCOM MORS EG since 1984.

HELCOM coordinates surveillance flights for the detection of illegal oil spills in the marine area. Oil surveillance with fixed-wing aircraft have been carried out since 1988 and the European Maritime Safety Agency supports this activity nowadays by satellite surveillance. The intensity of shipping is assessed

annually on the basis of the Automatic Identification System which gives information of the routes as well as types of the ships for the assessment.

Dredging and disposal of dredged matter are reported to HELCOM annually. Annual assessments include distribution of the activities, volume and contaminant analyses.

HELCOM published in 2010 the Baltic Sea Pressure Index (BSPI) which combined all known anthropogenic pressures in the sea region (HELCOM 2010, Korpinen et al. 2012). The BSPI is a spatial assessment in a 5 km x 5 km grid and consisted of pressures such as various fisheries, dredging, extraction of sand and gravel, disposal of dredged matter, construction projects, inputs of nutrients, organic matter and hazardous substances, etc. Altogether 52 pressure data layers were included in the index.

HELCOM core indicators have been developed to allow coordinated assessments of the state of the marine environment and pressures on it. Among the core indicators, there are however only a couple of so-called pressure indicators. Number of drowned marine mammals and waterbirds in fishing gears was recommended as a core indicator, even though it was known that monitoring of the fishery bycatch is difficult and often prone to low confidence. Oiling of water birds was considered a pre-core indicator requiring more scientific validation.

With the new (draft) HELCOM monitoring and assessment strategy, HELCOM is moving towards more comprehensive assessments of human pressures. The objective is to provide more concrete tools for decision-makers to aim at GES.

6. QUALITY ASSURANCE AND CONTROL

6.1 Importance and scope of quality aspects

The accuracy and comparability of the data collected is a key requirement for the assessment and description of environmental status and for the assessment of anthropogenic influences and required measures. Quality assurance (QA) and quality control (QC) measures ensure that monitoring results of stated quality are obtained across Europe and at any time.

QA/QC should provide confidence in the whole analytical process, for all monitoring parameters, from monitoring at national, regional as well as at European scale. When designing projects it is important to decide the level of accuracy needed in the study, considering all steps from sampling to reporting. Monitoring should provide data representative of the location and time of sampling. In particular, it is extremely important to perform reliable and reproducible high-quality analyses over decades. Therefore, such analyses require well-documented procedures and experienced analysts, as well as participation in intercalibrations (i.e. ring tests, such as for chemical or taxonomical analyses where different laboratories participate).

QA/QC seems to be limited to methods and technical specifications. However, it is important **for the whole monitoring chain**: from defining MSFD targets, related indicators and parameters in order to determine the monitoring requirements to designing and performing the monitoring programme in order to collect and assess the monitoring data. The monitoring data should enable meaningful assessment of status in time and space. Beginning with an assessment of the existing monitoring programme an iterative process will enable further modification and revision programme. Monitoring programmes should be adapted to new insights by ensuring that time series remain as much intact as possible. Exchange of best practices, intercalibration and harmonisation activities will forward this process and highlight any deficiencies and inadequacies. This will result in comparable monitoring approaches based on commonly agreed monitoring principles.

QA and QC also apply to data storage and exchange. This includes common data management standards and technical and semantic interoperability between data management systems. There are important international initiatives, such as Seadatanet (SDN) which aims at giving countries, interest groups etc. access to national data sets, where the presentation of the data is standardised. Emodnet and My Ocean are being developed to be able to make products from the data extracted through SDN, such as sea bottom maps and ecological maps.

6.2 Existing QA/QC guidelines, tools and practices

Within RSC areas and national monitoring programmes quality assurance guidelines are provided for monitoring and should be taken into account. These guidelines give detailed descriptions of sampling and analytical procedures relating to hydrographic, chemical and biological parameters. In addition there is a large number of national and international standards and specifications available for sampling and further chemical, physical and biological analyses.

Guidelines:

HELCOM: Combine Manual[138] - Manual for Marine Monitoring in the COMBINE Programme of HELCOM; Guidelines on quality assurance for monitoring in the Baltic Sea[139], for monitoring of eutrophication and effects, contaminants and the effects of contaminants. QA/QC issues are also highlighted in the CORESET project.

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[138] http://www.helcom.fi/groups/monas/CombineManual/en_GB/main/

[139] http://www.helcom.fi/groups/monas/CombineManual/PartB/en_GB/main/

OSPAR: CEMP Monitoring Manual[140] – JAMP Guidelines for Monitoring of hazardous substances, biological effects of hazardous substances, nutrients and eutrophication effects; JAMP guidelines on Quality Assurance for biological monitoring in the OSPAR area (agreement 2002-15)[141].

Black Sea Commission (BSC): Guidelines for Quality Control of Biological Data – Phytoplankton[142]; Guidelines on Quality Assurance and Quality Control of Chemical Oceanographic Data Collections (recommended by AG PMA to be accepted by the BSC as the first draft, unpublished yet on BSC website).

ICES Techniques in Marine Environnemental Sciences[143]

International Standards: ISO 17025[144], ISO 17043[145], EN 16101[146], ISO 11352[147]

WFD Guidance Documents No. 19[148], 25[149]

Interlab trials:

QUASIMEME[150] - proficiency testing programme for the analysis of pollutants in sea water, marine sediments and biota

BEQUALM[151] - Biological Effects Quality Assurance in Monitoring Programmes

MESL[152] - Marine Environmental Studies Laboratory in Monaco

EPTIS[153] - WFD PT schemes

PT-WFD network [154]

Certified Reference Materials (CRMs):

COMAR[155] - International database for certified reference materials

MESL[156] - Marine Environmental Studies Laboratory in Monaco

A critical overview of existing matrix Certified Reference Materials related to WFD monitoring needs is provided by Ricci et al (2012).

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140 http://www.ospar.org/content/content.asp?menu=00120000000135_000000_000000
141 http://www.ospar.org/content/content.asp?menu=00120000000135_000000_000000
142 www.blacksea-commission.org
143 http://www.ices.dk/publications/our-publications/Pages/-ICES-Techniques-in-Marine-Environmental-Sciences-.aspx
144 http://www.iso.org/iso/catalogue_detail.htm?csnumber=39883
145 http://www.iso.org/iso/catalogue_detail?csnumber=29366
146 http://webstore.ansi.org/RecordDetail.aspx?sku=BS+EN+16101%3A2012
147 http://www.iso.org/iso/catalogue_detail.htm?csnumber=50399
148 https://circabc.europa.eu/sd/d/e54e8583-faf5-478f-9b11-41fda9e9c564/Guidance%20No%2019%20-%20Surface%20water%20chemical%20monitoring.pdf
149 https://circabc.europa.eu/sd/d/7f47ccd9-ce47-4f4a-b4f0-cc61db518b1c/Guidance%20No%2025%20-%20Chemical%20Monitoring%20of%20Sediment%20and%20Biota.pdf
150 http://www.quasimeme.org/
151 http://www.bequalm.org/
152 http://www.iaea.org/monaco/page.php?page=2122
153 http://www.eptis.bam.de/en/eu_wfd/index.htm
154 http://www.pt-wfd.eu/
155 http://www.comar.bam.de/en/
156 http://www.iaea.org/monaco/page.php?page=2122

Training:

MESL - Marine Environmental Studies Laboratory in Monaco

6.3 QA/QC practices in the RSCs and in Member States

6.3.1 Mediterranean Region

Marine pollution monitoring is a legal obligation of the Contracting Parties of the Barcelona Convention (art. 12 of the Convention and art. 8 of the LBS Protocol) and much effort has been made in the Mediterranean region to generate accurate data on marine pollution. For this purpose the UNEP/MAP – MED POL[157] collaborates with the MESL of the International Atomic Energy Agency[158]. The MESL is closely collaborating with the Secretariat and the Parties strengthening the QA/QC for the analysis of trace elements and organic pollutants (PHs, PCBs and Pesticides) in Mediterranean laboratories participating in national monitoring programmes. QA/QC for the analysis of nutrients and Chl-a is organized with the assistance of QUASIMEME. Additionally, for the implementation of the WFD the Mediterranean Geographical Intercalibration Group (GIG) tested comparability of the methods applied by different Member States. National institutes exchanged data sets, applied different national methods and compared the resulted status class for macroinvertebrates, macroalgae, marine Angiosperms and phytoplankton. This was an *ad hoc* comparison exercise and not a QA/QC exercise *per se* but has the potential to evolve to a typical QA/QC procedure for the implementation of the MSFD with proficiency tests and training courses. Such tests and courses could potentially be coordinated by a European and/or international body such the Joint Research Centre and/or UNEP-MAP. In the Mediterranean there is a large experience of QA/QC of hydrographical data (D7) following the IOC/UNESCO QA/QC rules. National bases of oceanographic data occur in all Mediterranean Member States. During the last decade, a number of biological effects intercomparison exercises have been conducted, on behalf of MED POL by University of Alessandria (IT). For litter and noise there are dedicated technical sub-groups at the EU level. In the Mediterranean, contracting parties could promote QA/QC activities possibly in the context of UNEP/MAP.

6.3.2 Black Sea Region

Similar to the Mediterranean, the obligations of the Contracting Parties to the Convention on the Protection of the Black Sea Against Pollution is to monitor marine pollution in order to protect and preserve the marine environment. In order to ensure compatibility and comparability of the data reported to the BSC, the national laboratories responsible for monitoring of pollution parameters through the BSC Secretariat collaborate with International Atomic Energy Agency. The MESL provides the laboratories in the Black Sea region with test materials for trace elements and organic pollutants in sediments and biota, ensuring thus the QA/QC of data for marine pollutants corresponding to the MSFD descriptors 8 and 9.

For Chl-a and nutrients in water column (D5), with the financial support of the BSC, responsible laboratories from the six Black Sea countries receive certified test materials from QUASIMEME.

Black Sea GIG groups were established for the quality elements in the implementation of WFD in the two Black Sea EU countries. Specific intercalibration exercises were organized for phytoplankton, macroalgae and macrozoobenthos. The exercise continues at present in the frame of two projects funded by EC (MISIS for Romania, Bulgaria and Turkey and EMBLAS for Georgia, Russian Federation and Ukraine), aiming to organize joint surveys that will help in revision of national and regional monitoring and assessment programmes.

[157] www.unepmap.org

[158] www.iaea.org

For hydrographical data, research institutions from the Black Sea region participated in SeaDataNet and My Ocean; specific national oceanographic data centres were established in the region (e.g. Bulgarian National Oceanographic Data Centre[159] as part of Pan-European Infrastructure for Ocean & Marine Data Management). My Ocean is still providing oceanographic data (temperature, salinity, current velocity) in real time to the BSC.

6.3.3 OSPAR

OSPAR has adopted a QA policy which acknowledges the importance of reliable information as the basis for effective and economic environmental policy and management regarding the OSPAR Convention area (see OSPAR JAMP 2010-2014[160], Section 1, § 20). This policy requires that QA procedures should be applied to the whole chain of JAMP activities, from programme design through execution, evaluation and reporting to assessment. It recognises, nevertheless, that QA should be appropriate for the purpose of the assessment or monitoring activity to which it relates – that is, sufficient but not over-elaborate. OSPAR has agreed that steps should be taken to improve its QA procedures with the aim of ensuring that all necessary procedures are in place and sufficient for the purpose. Where the QA of data is such that it is not fit for purpose of delivering assessments that are comparable between Contracting Parties, this should be reported to the Coordination Group (CoG). CoG will then determine the most effective ways and means to address any shortcomings.

OSPAR has developed through the JAMP various technical guidelines on monitoring which include the various quality assurance and quality control issues. OSPAR participates in proficiency testing schemes such as QUASIMEME and BEQUALM and cooperates with ICES on QA/QC questions. OSPAR periodically reviews its technical guidelines to ensure that they reflect the state of the art and regularly reviews the general QA arrangements in place. The latest updated review[161] was published in 2011 and gives an overview and reference to QA procedures currently in place for all relevant data streams.

6.3.4 HELCOM

The updated Monitoring and Assessment Strategy which is expected to be adopted by HELCOM Heads of Delegations in mid-June 2013, states in point 3.1. :

“it is recommended that sampling should be carried out using certified methods and analyses of the samples are carried out by laboratories that adhere to quality assurance procedures according to EN ISO/IEC 17025 (General requirements for the competence of testing and calibration laboratories), or ISO 9001 (Quality management systems – Requirements) or by laboratories performing close to these standards)”

According to chapter 8 on quality assurance of the same revise strategy robust QA and QC is required and accreditation is recommended. QA requirements have to be set for each one of the activities which go from programme design, execution and evaluation to assessment and reporting. QA programme should ensure that the data are fit for the purpose, e.g. that they satisfy the detection limits and levels of accuracy compatible with the objectives of the monitoring programme.

QA constitutes an elementary part of HELCOM monitoring activities. These activities are based on commonly agreed and updated methodologies and procedures described in guidelines (e.g. HELCOM COMBINE Manual) and international and European standards. The Contracting States are committed to follow these commonly adopted guidelines, standards, protocols, etc.

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[159] http://www.bgodc.io-bas.bg
[160] http://www.ospar.org/content/content.asp?menu=00170301000000_000000_000000
[161] http://www.ospar.org/v_publications/download.asp?v1=p00556

All institutes/laboratories submitting data to HELCOM databases should participate in regular national and international intercalibration exercises and proficiency testing schemes arranged e.g. by national authorities and/or under QUASIMEME, ICES or HELCOM.

QA/QC is carried out in the COMBINE[162] manual for the monitoring of the status of the Baltic Sea and in the PLC for the monitoring of the pressures. In this manual the guidelines on QA are intended to assist laboratories in starting up and operating their quality assurance systems. They can also serve as inspiration for laboratories with existing quality systems.

The quality assurance guidelines contain six sections plus one section with definitions and one with annexes:

Section	Title	For whom is it relevant?
1	Introduction	Administrative managers, quality managers, technical managers, analysts
2	Quality system	Administrative managers, quality managers, technical managers, analysts
3	Specifying analytical requirements	Administrative managers, quality managers, technical managers, analysts
4	Validation of procedures	Technical managers, analysts
5	Routine quality control	Quality managers, technical managers, analysts
6	External quality system	Administrative managers, quality managers, technical managers, analysts
Annexes		Quality managers, analysts

According to the Helsinki Convention, Contracting Parties shall ensure that measurements and calculations of emissions from point sources to water and air and of inputs from diffuse sources to water and air are carried out in a scientifically appropriate manner.

Contracting Parties fully commit themselves to following the guidelines, protocols etc. adopted by the Commission and its Committees[163]. The laboratories providing data to PLC should have a quality assurance system that follows the requirements of EN ISO/IEC 17025.

6.3.5 Quality Assurance for the German Marine Monitoring Programme of the North and Baltic Sea (GMMP)

According to national and international monitoring requirements, all laboratories operate quality management systems according ISO/IEC 17025. The Quality Assurance Panel at the Federal Environment Agency (UBA), as an independent institution not directly involved in the marine monitoring, coordinates all QA/QC activities within the GMMP and organizes workshops on specific topics aiming at harmonization of methodologies. It promotes cooperation and exchange of experience between German monitoring laboratories. Moreover, together with national experts, it developed Standard Operating Procedures (SOP) for selected biological methods, a template of a Quality Manual tailored to the requirements of the GMMP and templates for other quality management documents. Currently, an information system is under development. It should serve as platform for the exchange of information, data and QA/QC tools and support cooperation between the GMMP laboratories.

[162] http://www.helcom.fi/groups/monas/CombineManual/PartB/en_GB/main
[163] http://www.helcom.fi/stc/files/Guidelines/PLC5/PLC_4qualityassurance.pdf

7. GOOD PRACTICES

Good monitoring practices include the procedures that Member States follow during the conception, preparation, implementation and reporting of the programmes.

Step I – Design and preparation. Good practices:

1. Take into account the overarching principles, particularly those concerning regional coordination;
2. Adopt the most effective methodologies, considering:
   i. that methodologies should be as less intrusive as possible and therefore be balanced between required efficiency levels and the need to minimize impacts on marine ecosystems and do not interfere with conservation requirements.
   ii. a cost benefit approach and, where appropriate, should demonstrate the kind of positive impacts, namely through indirect benefits to the civil society.
   iii. that adopted methodologies should collect data required for the most sensitive indicators, as appropriate.
   iv. That adopted methods should, ideally, have known and adequate for their purpose detection limits, accuracy and precision.
3. During the adoption of methodologies, seek for synergies with different ongoing monitoring programmes that are covered by other policies or legal instruments.
4. Include, at the extent possible, in the adopted methodologies, the promotion of the marine environmental consciousness through general education-oriented initiatives and the involvement of citizens in monitoring.

Step II –Implementation and reporting. Considering the recommendations for implementation and reporting, good practices:

1. Endeavor to ensure that all monitoring programmes within a region or subregion context are sustained - particularly when it has not been possible to fully achieve regional or subregional coordination during step I – by sharing results and workshops, *inter alia*.
2. Establish appropriate mechanisms for detecting, within the first six years cycle, where and when a monitoring programme needs an adjustment in the light of new scientific developments.

7.1 Core indicators requiring region wide coordinated monitoring

A regional agreement on common indicators for the assessment of environmental status that require comparable data across contracting parties is an important step towards coordinated monitoring programmes. The core indictors agreed in HELCOM represent a good practice.

Core indicators are the essential indicators which are required to assessment the status of the marine environment against GES. HELCOM (2012a) describes core indicators as those indicators that aim to allow the assessment of the current status and the tracking of progress towards achieving GES. They are designed to measure the distance from the current environmental status of the Baltic Sea to GES and the HELCOM ecological objectives, goals and vision. The core indicators are also linked to other EU directives and follow agreed specifications, i.e. they are:

1. compiled and updated by Contracting Parties.[164]

2. science-based: Each indicator describes a scientifically sound phenomenon. [164]

3. linked to anthropogenic pressures: Status indicators should be linked to anthropogenic pressures and indirectly reflect them, where appropriate, and additional pressure indicators are used and they directly reflect anthropogenic pressures and are tightly linked to human activities.

[164] Indicator Fact Sheet procedure (HELCOM MONAS 7/2004, paragraph 5.12, LD 9, of the Outcome of the Meeting).

4. related to and allow for policy response: The indicator measures part of or fully an ecological objective and/or a descriptor of good environmental status. [164]

5. suitable with assessment tools: The indicator can be used with the assessment tools but the assessment tools will be open for modifications as necessary.

6. suitable with BSAP/MSFD, making best use of the synergies with other Directives and according to the HELCOM Monitoring and Assessment Strategy: The indicator reflects a component contained in the HELCOM system of the vision, goals and ecological objectives and/or MSFD descriptor.

7. qualitative or quantitative with a textual background report: Indicators, either qualitative or quantitative, are numeric, based on measurements or observations and validated models; they must also have a quantitative target level reflecting the lowest boundary of good environmental status. They also contain a textual background report with interpretation of the indicator results. The report should be published on the HELCOM web site and ultimately should take the form of the three-layered indicator report (cf. preliminary core eutrophication indicator reports) with the main page containing a status map and the main message aimed at decision makers; the second page containing trend information, e.g. for different sub-basins; and the third page containing technical background information and information on the confidence of the assessment.[165]

8. Baltic Sea wide: The HELCOM indicators should cover the whole sea area. [166]

9. commonly agreed: The finalised indicators and their interpretation are commonly agreed among the HELCOM Contracting Parties and HELCOM MONAS is the HELCOM body that should approve the publication of the core indicator reports on the HELCOM web page.

10. frequently monitored and updated: Data underlying the indicators are collected within the HELCOM coordinated monitoring (HELCOM COMBINE, MORS-PRO, PLC) and the indicator reports will be updated preferably annually or at intervals suitable for the measured factor. [164]

11. accompanied by harmonised methodology: Data in an indicator will be collected using harmonised monitoring, quality assured analytical methods, as well as harmonised assessment tools, according to the relevant HELCOM guidelines or EU standards, such as methodological standards or guidelines for GES under the MSFD to be delivered by the EC and other relevant international standards. [164]

12. accompanied by confidence evaluation: The indicator and the data must be assessed using common criteria and this confidence evaluation is to be included in the indicator report.

7.2 Towards a joint coordinated monitoring system in the Baltic Sea

A practical approach in designing effective monitoring strategies is demonstrated by the recently adopted Monitoring and Assessment Strategy[167]. It includes the following principles for a joint coordinated monitoring system:

a) increased joint initiatives such as surveys, campaigns, cruises and shared stations,
b) use of remote sensing and autonomous measuring devices to complement ship cruise data and thereby enhanced data coverage and shared data products,
c) use of modelling to combine data and produce optimised data layers,
d) sharing of infrastructure, and

[165] Outcome of HELCOM MONAS 12/2009, paragraph 6.13.
[166] Some biological indicators may be spatially limited due to distribution limits or sensitivity of species and/or biotopes. Such indicators should be flexible to include several species which measure the same phenomenon (e.g. phytobenthos indicator would include eelgrass, bladderwrack, charophytes and other species, e.g. functional indicators).
[167] http://www.helcom.fi/groups/monas/en_GB/monitoring_strategy

e) quality gains from specialization of countries and national institutes

In addition, for sampling in the open sea using research vessels, there is potential for cost-efficiency gains by temporal sharing of monitoring activities between the countries and, if possible, between thematic programmes. The countries bordering a sub-basin should coordinate their monitoring cruises and make arrangements for e.g. taking turns in sampling certain areas or sharing responsibilities of monitoring of certain parameters with the idea that monitoring methods are harmonised and all data will end up in a common pool and can be used by all. Effectively this means that each country will have available not only its own data but also data produced by eight other countries. The principles described in this approach are in line with the monitoring recommendations presented in chapter 3.

Moreover, there is potential to increase efficiency and harmonisation through:

a. joint surveys, cruises and campaigns: they enable full cooperation in practice, harmonization of practices, efficient exchange of knowledge and best practices as well as full use of monitoring infrastructure
b. increasing automatisation of monitoring and running the programmes or devices cooperatively and
c. increasing thematic specialisation: increased thematic specialization of the Contracting Parties or their institutes could increase cost-efficiency.

7.3 Observations made by the public: ”human sensors”

Monitoring of some parameters can be made more extensive as well as intensive and simultaneously cost-efficient by complementing conventional monitoring with public observations. However, limitations in the use of data collected by non-experts should always be considered. The suitable for public observation parameters should be carefully chosen to allow ensuring validation, QA/QC routines and some confidence in the observations made. They should, preferably, be visible by eye and should be of interest of the public. These include observations of birds, mammals, reptiles, fish, macroscopic vegetation, litter, algal bloom events and exceptional events in general.

The current and rapidly developing mobile technology makes it possible to submit observations, including photos, on the spot. The received information is then processed, stored in databases and presented e.g. on maps on the internet. Good examples include:

NatureGate[168] mobile app is available now for iOS and Android devices and it works in eight languages. The app can be used as an identification handbook and a tool to share observations. Baltic Sea flora and fauna will be added to the app in the nearest future.

Creek Watch[169] is an iPhone application that enables people to help monitor the health of local watersheds. The Creek Watch App uses four pieces of data: the amount of water (empty, some, or full), the rate of flow (still, moving slowly, or moving fast) and the amount of trash (none, some or a lot) as well as a picture of the waterway.

Levävahti[170] (“algal bloom watch”) is an app for iOS, Android and Symbian and makes it possible to collect and share information on algal bloom events and health of bladder wrack vegetation. The app is available only in Finnish language. The user may rank the intensity and extent of algal blooms and the condition of bladder wrack belt in four categories and share photos.

Marine LitterWatch[171] is a citizen science based application in Eye on Earth of the European Environmental Agency that aims to help fill data gaps in beach litter monitoring required by the MSFD.

More applications for smartphones and tablets (under iOS and Android environments) for monitoring marine biodiversity will be developed by the **DEVOTES** project.

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168 http://www.luontoportti.com/suomi/en/
169 http://creekwatch.researchlabs.ibm.com/
170 http://www.jarviwiki.fi/wiki/Lev%C3%A4vahti
171 http://www.eyeonearth.org/en-us/Blog/Pages/BlogPost.aspx?pID=59

Other existing citizen science activities include:

The **ARTPORTALEN**[172] web-site in Sweden for species sightings data where photos from amateur observers are generating species occurrences, after been validated.

The bird counts in the Netherlands done by skilled volunteers and organized by **Vogelbescherming**[173]

7.4 The Monitoring and Assessment programme (TMAP) of the Trilateral Cooperation on the Protection of the Wadden Sea

The TMAP[174] is the common monitoring programme for the Wadden Sea. The programme covers the entire Wadden Sea area including islands and offshore areas and spans a broad range, from physiological processes over population development to changes in landscape and morphology. It was designed in 1994 following the ecosystem-based approach (Kellermann et al. 1994) and is in operation since 1997.

It is considered a good practice as it is agreed between the three countries sharing the Wadden Sea (The Netherlands, Germany and Denmark), includes common package parameters, supports the management of the Wadden Sea as a single ecological entity, combines the requirements of the WFD, the HD and the BD, supports reporting against these Directives and the World Heritage status. It is also well documented through an online monitoring manual[175], data are exchanged via dedicated data units in each country, results in regular trilateral assessments such as the Quality Status reports[176] and provides government advice on the implementation of protection concepts[177].

7.5 The BSH North Sea Summer Surveys

The North Sea Summer Surveys (NSSS) performed by the German Federal Maritime and Hydrographic Agency (BSH) are presented as an example of "good practice" because of their advantages, like the synoptic sampling of parameters related to different descriptors and disciplines together on the same grid to make the data publically available and to use them for many purposes and directives, can be transferred easily also for local surveys in coastal water.

In 1998 the BSH started its annual NSSSs which cover the entire North Sea with seven coast to coast East-West sections between 54° and 60°N and additional stations between 54°N and the entrance of the English Channel. The surveys are realised at a time when thermal stratification is expected to be at its maximum and phytoplankton production has passed its maximum. With the exception of the first survey in 1998 all surveys served a fixed grid of vertical CTD casts combined with a rosette water sampler. Between these fixed stations a towed CTD-system was deployed which oscillated between surface and bottom to record the distribution of relevant oceanographic parameters with high resolution in space and time (24 Hz). Both CTD-systems are sampling temperature, salinity, fluorescence (chlorophyll-a, yellow substance), and oxygen concentration. Additionally, ship-mounted temperature-, salinity- and optical sensors provided data at about 4 m depth. In order to sample the transition area between North Sea and Atlantic the survey was expanded to 62.5°N since 2010.

The water samples taken at the stations with the rosette sampler and additional specialised samplers (glass bowls, MERCOS sampler etc.) are analysed for different physical and chemical parameters like nutrients,

172 http://www.artportalen.se/
173 http://www.vogelbescherming.nl
174 http://www.waddensea-secretariat.org/monitoring-tmap/about-tmap
175 http://www.waddensea-secretariat.org/monitoring-tmap/manual-guidelines
176 http://www.waddensea-secretariat.org/monitoring-tmap/tmap-results-qsr
177 http://www.waddensea-secretariat.org/management/wadden-sea-plan-2010

organic contaminants, trace metals, artificial nuclides, dissolved oxygen, pH, chlorophyll and salinity for CTD calibration. At selected stations also bottom samples were taken by box or Gemini corer. Due to limited capacities on board some parameters can only be sampled bi-annually.

Because the NSSS covers the whole North Sea the data allow the calculation basin wide budgets (e.g. for heat and salt) and the detection of source regions for significant changes and signals. The great variety of parameters sampled on the same grid are used for several applications after processing and calibration. The data are delivered to the German Oceanographic Centre (DOD)[178] and to the ICES Data Centre[179]. Surface data for selected parameters are implemented in the MERMAID[180] data base (ESA) for the validation of satellite-borne Ocean Colour data and products. The data are used for several North Sea status reports and local assessments, for the ICES Report on Ocean Climate, for OSPAR and MSFD reporting, for the detection of climate change signals in the North Sea and the development of adaption strategies as well as for the validation of operational circulation and ecosystem models and climate models. Further on, the analysis of different parameters and the information about their spatial distribution generally improves the information about processes and changes in the marine environment due to synergetic effects.

[178] http://www.bsh.de/en/Marine_data/Observations/DOD_Data_Centre/index.jsp
[179] http://www.ices.dk/marine-data/dataset-collections/Pages/default.aspx
[180] http://hermes.acri.fr/mermaid/home/home.php

8. LINK WITH THE SOCIOECONOMIC COMPONENT

8.1 Methods for the economic and social analysis of the use of marine waters and for the cost assessment of the degradation of the marine environment.

The MSFD requires an economic and social assessment (Article 8.1(c)) of the use of marine ecosystems and of the cost of degradation of the marine environment. For this purpose, the EU Working Group on Economic and Social Assessment (WG ESA) published a guidance[181] where two key issues are highlighted i.e. the identification of the different uses of the marine environment in terms of their economic and social importance and pressures and the qualitative or (ideally) quantitative estimation of the cost of degradation of the marine environment. For the economic and social analysis of the use of marine water the guidance proposed two approaches (but several others may be considered), i.e. the ecosystem services and the marine water accounts. In respect to the cost assessment of the degradation of the marine environment the ESA guidance proposed three approaches: the ecosystem services approach, the thematic approach and the cost-based approach. Marine ecosystem services are further discussed in the following paragraph.

8.2 Ecosystem services approach

The most recent policies to conserve biodiversity have adopted the arguments of protecting and maintaining ecosystem services, as a complement to the protection of designated habitats and species. In the CBD the principal framework for expressing the "usefulness" of biodiversity is through the concept of ecosystem services. They illustrate the link between, on the one hand, the interactions of species with each other and with the physical environment; and on the other, the well-being of people, whether in terms of wealth, nutrition or security[182]. The EU Biodiversity Strategy to 2020 emphasizes the link between biodiversity and ecosystem services. Action 5 (under Target 2) of the Strategy calls Member States to map and assess the state of ecosystems and their services in their national territory by 2014. According to Article 1 of the MSFD, marine strategies should enable the sustainable use of ecosystem services by present and future generations. Many ecosystem services cannot be directly quantified and thus we must rely on indicators or proxy data for their quantification. To monitor, assess and analyse the trend of each of these indicators specific data need to be collected. The trend of such indicators is related to any improvement or degradation of the environmental status and of the capacity of the system to provide social and economic benefits.

In a recent systematic review, conducted in the JRC (Liquete et al., in press), existing scientific literature related to marine and coastal ecosystem services (MCES) was analysed with the aim of extracting and classifying indicators used to assess and map MCES. The cascade model was followed in this review, which can link marine biodiversity and ecosystems to human wellbeing through the flow of ecosystem services (Haines-Young & Potschin, 2010; De Groot et al., 2010). In the cascade model, the biophysical structure and processes of an ecosystem determine its functions that underpin the CAPACITY of an ecosystem to provide goods and services. The part of those functions that eventually contributes to human well-being is considered the FLOW of ecosystem services, and may be translated into specific societal BENEFITS (Liquete et al., in press).

The most important findings and MCES indicators reported by Liquete et al. (in press) are summarized below (a complete list of the 476 indicators found by this study is available in the accompanying supplementary material):

Food provision, in particular fisheries, is the most analysed MCES. Some of the most meaningful indicators of this service include:

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[181] EU Working Group on Economic Assessment, Economic and Social Analysis for the Initial Assessment for the Marine Strategy Framework Directive: the Guidance document (Brussels, 2010).

[182] http://www.cbd.int/iyb/doc/prints/factsheets/iyb-cbd-factsheet-ecoservices-en.pdf

- Capacity: abundance or biomass of commercial marine living resources, fish diversity, food web structure, sea food quality.
- Flow: catches (preferably with spatial distribution), landings, number of viable fisheries.
- Benefit: income from fisheries, jobs, community dependence and perception on fisheries. The value of fish, commonly used as an indicator, should take into account not only market values but also subsidies. Alternative non-monetary values could be related to human diet quality.

Indicators related to water purification mainly focus on the presence of excess nutrients (eutrophication) or suspended particulate matter (Hyytiainenet al. 2009; Plutchak et al. 2010), with few examples of other pollutants (Souza et al. 2011). The benefit part of the assessments is characterized by a large variety of valuation techniques.

Coastal protection indicators refer to the presence of biotic structures that disrupt the water movement, the coastal exposure, public awareness, and avoided or replacement costs.

The list of available indicators for recreation and tourism covers many relevant aspects of this service especially on the benefit side, e.g. estimated economic value of/income from tourism and recreation, perceived benefit from recreational activities or for the presence of a marine protected area, visitors and travel cost, willingness-to-pay to enjoy a natural area.

A substantial number of studies refer to life cycle maintenance, which is most often interpreted as a fishing support service.

Climate regulation is most often addressed in terms of ecosystem services through the carbon cycle, with nearly no reference to nitrogen climate active gases. The value of the uptake of carbon by the ocean is effective only when it is stored for extended periods (years) or sequestered from contact with the atmosphere. Specific habitats, such as seagrass beds, are important for carbon storage making considerable contributions to the global carbon stocks despite their limited geographical range and extent (Duarte & Cebrián 1996, Donato et al. 2011). Indicators tracking the state and temporal trends of such habitats provide valuable information for the assessment of this MCES. In the context of the cascade model, capacity indicators include all measures of stock and concentration; flow is monitored through uptake, accumulation or sequestration rates; and benefit is usually estimated with the market value of carbon. However, some indicators convert the uptake of carbon (primary production) to a monetary value without consideration for the fate of the carbon fixed, even if most of this carbon is not stored or sequestered (IPCC, 2007).

MCES such as weather regulation, air quality regulation, biological regulation, water provision and cultural MCES are relatively poorly assessed.

While we used to consider socio-economic analysis in a wider scale, in many cases, the marine ecosystem goods and services are site-specific, hence there is a need to collect site (sub region)-related socio-economic data rather than in regional scale. This should allow for an analysis of the marine environment cost degradation in relation the country's economy (including coastal county's data) as it is presented in a paper of Wesławski et al. (2006).

8.3 Collection of socioeconomic data for the Common Fisheries Policy and other potential data sources

There is an important tradition and know-how in collecting and reporting social and economic data for the Common Fisheries Policy. The DCF requires that Member States collect biological, technical, environmental and socio-economic data. According to the Commission Decision 2010/93/EU economic data are clustered in three categories: Fleet, aquaculture and fish processing. The fleet category includes 14 variables' groups and 30 economic variables; the aquaculture category includes 15 variables' groups and 22 economic

variables and the fish processing category 12 variables' groups and 17 variables. All economic variables have to be collected for active vessels.

Economic variables combined with social data, such as gender and age, could provide more informative socioeconomic indicators. The outcome report of the STECF-13-01[183], which revised the proposed DCF for the 2014-2020, consolidates the necessary social variables needed for the policy-making process on fisheries, aquaculture and fish processing sectors. Additionally, it proposes some modifications on the socio-economic variables listed in the Commission Decision 2010/93/EU. The detailed list of variables and proposed modifications can be found in Annex XI.

Both the estimation of the cost of degradation of marine environment and the economic and social analysis of the use of waters require certain type of datasets. The potential data sources include DG MARE, EEA, EUROSTAT, national account and input-output tables, International Maritime Organisation (IMO) and RSCs.

[183] Scientific, Technical and Economic Committee for Fisheries (STECF) – Review of proposed DCF 2014-2020 Part 2 (STECF-13-01). (ed. Ebeling M. W., F. Natale & H. Doerner). 2013. Publications Office of the European Union, Luxembourg, EUR 25825 EN, JRC 79209, doi:10.2788/84694, 88 pp.

9. OUTLOOK AND NEEDS FOR FURTHER RESEARCH

There are numerous on-going or planned marine monitoring activities in Member States and RSCs. Still, the MSFD requires additional efforts to be implemented in a meaningful manner and gives an opportunity to review, revise and integrate existing activities. Efforts towards integration have already started and good practices have been highlighted in this document. Members States and RSCs should take them into account when finalizing and reporting their monitoring programmes in 2014 and are encouraged to consider cooperation in common cruises and sharing of capacities and know-how. Member States should also make the most of existing monitoring activities, e.g. ensure that monitoring under the DCF serves also to collect data for as many descriptors as possible.

The review of current MSFD related research programmes demonstrated that there is a wealth of on-going research and there are high expectations for delivering applicable outputs. However, gaps in basic knowledge and applied tools will continue to exist in the near future.

Gaps and needs for further research differ between descriptors depending on their level of maturity in respect to the methods, indicators and existing datasets. Based on STAGES Workshop[184] some deficits and gaps concerning the majority of descriptors and could be grouped as:

- Lack of adequate data and time-series (e.g. on distribution of marine organisms, traceability of seafood, catches and by-catches for a number of non-targeted species, quantitative information on intermediate size litter-particles 0-2,5cm).
- Lack of baseline knowledge (e.g. information on specific habitats-deep sea, knowledge of biology and ecology of invasive species).
- Gaps on indicators relevant to answer MSFD objectives or describe GES and correspondent monitoring parameters (e.g. indicators for specific habitats and species communities).

The identification of the gaps drives future research on monitoring. Such research could be implemented directly when appropriate methods are available to support monitoring for MSFD. In case of not available methods or data, additional investment and research is required to ensure a medium- or long –term implementation of efficient monitoring.

Possible research on monitoring that could be implemented at short-term for the majority of MSFD descriptors includes:

- Development of analytical methods and assessment tools.
- Development of cost effective monitoring methods for the required parameters to be monitored per descriptor.
- Planning of new research projects or adaptation of existing projects (e.g. national, RSCs) to acquire the necessary data for monitoring programmes based on the specification of each descriptor's parameters.
- Establishment of consistent reference points, standard operational procedures and coherent monitoring methods that would generate comparable outcomes.

Medium or long term future research on monitoring requiring additional investment includes:

- Investment on understanding the complex ecosystem functions that are related to MSFD descriptors and design optimal monitoring programmes based on such functions as well as on the impact of pressures on those functions.
- Investment on studying the effects of measures on the monitoring parameters and consequently on the monitoring programmes and planning of adaptive monitoring programmes able to incorporate such effects.

[184] STAGES Workshop on "Needs for further research to support improved and more efficient monitoring programmes under MSFD". Brussels, 13-15 May 2013. http://www.stagesproject.eu/

- Standardization and adoption of molecular monitoring techniques (e.g. DNA barcoding, metagenetics) for relevant indicators.
- Study of cumulative and synergistic effects of pressures and development of relevant assessment methodologies.
- Investment on development and miniaturization of sensors and on automatic data collection systems.
- Investment on common data platforms and on integration of observations from different surveys and sources.
- Compilation of geo-referenced monitoring data (GIS data) should become self-evident as this is a pre-requisite when applying the ecosystem based approach to planning and management of marine areas, e.g. by applying MSP and ICM.

A more detailed preliminary output of the STAGES Workshop regarding the needs for future research on monitoring per MSFD descriptor with a temporal prioritization of the needs is presented in Annex XXII. Readers are encouraged to consult the final conclusion of the STAGES workshop when they will be available on the project's website.

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Annex II: List of abbreviations

ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area	HELCOM	Helsinki Commission for Baltic marine protection
BD	Birds Directive	ICCAT	International Commission for the Conservation of Atlantic Tuna
BQE	Biological Quality Element	ICES	International Council for the Exploration of the Sea
CBD	Convention on Biological Diversity	ICM	Integrated Coastal Management
CFP	Common Fisheries policy	MPA	Marine Protected Area
CRM	Certified Reference Material	MSFD	Marine Strategy Framework Directive
DCF	Data Collection Framework (Council Regulation (EC) 199/2008)	MSP	Maritime Spatial Planning
DLS	Data Limited Stocks	MSY	Maximum Sustainable Yield
EEZ	Exclusive Economic Zone	OSPAR	Oslo/Paris convention for the Protection of the Marine Environment of the North-East Atlantic
EIA	Environmental Impact Assessment	QA	Quality Assurance
EQS	Environmental Quality Standards Directive	QC	Quality Control
GES	Good Environmental Status	RSCs	Regional Seas Conventions
GFCM	General Fisheries Commission for the Mediterranean	STECF	Scientific technical and economic committee for fisheries
GIG	Geographical Intercalibration Group	UNCLOS	United Nations Convention on the Law of the Sea
HD	Habitats Directive		

Annex III Species listed in one or more of the Annexes of the Habitats Directive and which are considered 'marine' species for Article 17 reporting[185] (from MSFD CIS, 2012).

NB1: This list needs to undergo further review and revision (esp. for fish).

NB2: Highlighted species would be very unusual/vagrant in EU waters. Other species, such as the Otter *Lutra lutra*, occur in marine waters in part of their range.

*= priority species

SPECIES NAME	COMMON NAME	HD ANNEX II	HD ANNEX IV	HD ANNEX V
Mammals				
Cetaceans				
Balaenoptera acutorostrata	Minke whale		IV	
Balaenoptera borealis	Sei whale		IV	
Balaenoptera edeni	Bryde's whale		IV	
Balaenoptera musculus	Blue whale		IV	
Balaenoptera physalus	Fin whale		IV	
Delphinapterus leucas	Beluga		IV	
Delphinus delphis	Common dolphin		IV	
Eubalaena glacialis	Northern right whale		IV	
Globicephala macrorhynchus	Short-finned pilot whale		IV	
Globicephala melas	Long-finned pilot whale		IV	
Grampus grisus	Risso's dolphin		IV	
Hyperoodon ampullatus	Northern bottle-nose whale		IV	
Kogia breviceps	Pygmy sperm whale		IV	
Kogia sima	Dwarf sperm whale		IV	
Lagenorhynchus acutus	Atlantic white-sided dolphin		IV	
Lagenorhynchus albirostris	White beaked dolphin		IV	
Lagenodelphis hosie	Fraser's dolphin		IV	
Megaptera novaeangliae	Humpback whale		IV	
Mesoplodon bidens	Sowerby's beaked whale		IV	
Mesoplodon densirostris	Blainville's beaked whale		IV	
Mesoplodon europaeus	Gervais' beaked whale		IV	
Mesoplodon mirus	Ture's beaked whale		IV	

[185] http://circa.europa.eu/Public/irc/env/monnat/library?l=/habitats_reporting/reporting_2007-2012/reporting_guidelines/guidelines-finalpdf/_EN_1.0_&a=d

SPECIES NAME	COMMON NAME	HD ANNEX II	IV	V
Monodon monoceros	Narwhale		IV	
Orcinus orca	Killer whale		IV	
Peponocephala electra	Melon-headed whale		IV	
Phocoena phocoena	Harbour porpoise	II	IV	
Physeter macrocephalus	Sperm whale		IV	
Pseudorca crassidens	False killer whale		IV	
Stenella coeruleoalba	Striped dolphin		IV	
Stenella frontalis	Atlantic spotted dolphin		IV	
Steno bredanensis	Rough-toothed dolphin		IV	
Tursiops truncatus	Bottle-nosed dolphin	II	IV	
Ziphius cavirostris	Curvier's beaked whale		IV	
Seals				
Cystophora cristata	Hooded seal			V
Erignathus barbatus	Bearded seal			V
Halichoerus grypus	Grey seal	II		V
*Monachus monachus**	Mediterranean monk seal	II	IV	
Phoca (Pagophilus) groenlandica	Harp seal			V
*Phoca (Pusa) hispida botánica**	Ringed seal	II		V
Phoca vitulina	Common seal	II		V
Reptiles				
*Caretta caretta**	Loggerhead turtle	II	IV	
*Chelonia mydas**	Green turtle	II	IV	
Dermochelys corlacea	Leatherback turtle		IV	
Eretmochelys imbricata	Hawksbill turtle		IV	
Lepidochelys kempii	Kemp's Ridley turtle		IV	
Fish				
Acipenser gueldentaedtii	Russian sturgeon			V
*Acipenser naccarii**	Adriatic sturgeon	II	IV	
Acipenser nudiventris	Ship sturgeon			V
Acipenser stellatus	Stellate sturgeon			V
*Acipenser sturio**	Atlantic sturgeon	II	IV	
Huso huso	Beluga/European sturgeon	II		V
Alosa agone	Twaite shad	II		V

SPECIES NAME	COMMON NAME	HD ANNEX II	IV	V
Alosa alosa	Allis shad	II		V
Alosa caspia caspia	Caspian shad	II		V
Alosa fallax	Twaite shad	II		V
Alosa immaculate	Pontic shad	II		V
Alosa maeotica	Black Sea shad	II		V
Alosa tanaica	Azov shad	II		V
Aphanius fasciatus	Mediterranean Killifish	II		
Alpanius iberus	Spanish toothcarp	II		
Anaecypris hispanica	Jarabugo	II	IV	
Coregonus spp.	White fish.houting			V
Coregonus albula	Vendace			V
Coregonus lavaretus	Lavaret			V
*Coregonus oxyrhynchus**	Houting	II	IV	
Lampetra fluviatilis	River lamprey	II		V
Petromyzon marinus	Sea lamprey	II		
Pomatoschistus canestrinii	Canestrini's goby	II		
*Valencia hispanica**	Valencia toothcarp		IV	
Salmo salar[186]	Atlantic salmon	II		V
*Valencia letourneuxi**	A toothcarp	II	IV	
Invertebrates				
Gibbula nivosa	A trochid mollusc	II	IV	
Corallium rubrum	Red coral			V
Centrostephanus longispinus	Long-spined urchin		IV	
Lithophaga lithophaga	European date mussel		IV	
Patella ferruginea	Ribbed Mediterranean limpet		IV	
Pinna nobilis	Pen shell		IV	
Scyllarides latus	Mediterranean slipper lobster			V
Plants				
Lithothamnium coralloides	Maerl			V
Phymatolithon calcareum	Maerl			V

[186] Covered under Annex II and V of Habitats directive only for fresh water

Annex IV Seabirds and waterbird species for which Special Protection Areas should be considered under the Birds Directive (Annex I and migratory species).

The list is based on MSFD CIS (2012) and is further developed by adding two wader species *(Charadrius alexandrines* and *Recurvirostra avosetta*).

Alca torda
Alle alle
Aythya marila
Bucephala clangula
Bulweria bulwerii
Calonectris diomedea
Cepphus grylle
Charadrius alexandrines
Clangula hyemalis
Fratercula arctica
Fulmarus glacialis
Gavia arctica
Gavia immer
Gavia stellata
Hydrobates pelagicus
Larus argentatus
Larus audouini
Larus canus
Larus fuscus
Larus genei
Larus glaucoides
Larus hyperboreus
Larus marinus
Larus melanocephalus
Larus michahellis
Larus minutus
Larus ridibundus
Melanitta fusca
Melanitta nigra
Mergus merganser
Mergus serrator
Morus bassanus
Oceanodroma castro
Oceanodroma leucorhoa
Pelagodroma marina
Phalacrocorax a. desmarestii
Phalacrocorax aristotelis
Phalacrocorax carbo
Phalaropus fulicarius
Phalaropus lobatus
Podiceps auritus
Podiceps cristatus
Podiceps grisegena
Podiceps nigricollis
Polysticta stelleri
Pterodroma feae
Pterodroma madeira
Puffinus assimilis
Puffinus griseus
Puffinus mauretanicus
Puffinus puffinus
Puffinus yelkouan
Recurvirostra avosetta
Rissa tridactyla
Somateria mollissima
Stercorarius longicaudus
Stercorarius parasiticus
Stercorarius pomarinus
Stercorarius skua
Sterna albifrons
Sterna caspia
Sterna dougallii
Sterna hirundo
Sterna nilotica
Sterna paradiseae
Sterna sandvicensis
Uria aalge
Uria aalge ibericus

Annex V. Seabirds monitoring activities and efforts for region wide coordination in the Baltic Sea

HELCOM core set of indicators (HELCOM, 2012. Development of a set of core indicators: Interim report of the HELCOM CORESET project. PART B: Descriptions of the indicators. Balt. Sea Environ. Proc. No. 129 B.) includes four indicators related to birds: number of drowned mammals and waterbirds in fishing gears, white-tailed eagle productivity, abundance of waterbirds in the wintering season, and abundance of waterbirds in the breeding season. The first one still lacks monitoring while the second one is almost operational and the two others are still lacking Baltic-wide coordination and extent.

White-tailed eagles are presently breeding along the coasts of the whole Baltic Sea, and are monitored in a network of national projects with harmonized methodology. Monitoring of nests is done in all coastal areas of the Baltic Sea with circa 300 nests in Sweden, 300 in Finland and 230 in Germany. There are no large gaps in the monitoring, but the compilation of data has not been done yet, except from Finland, Germany and Sweden. Currently data on breeding attempts, breeding success and brood size are collected at as many nests as possible in the coastal zone (15 km zone landwards). Early season air surveys are made to find breeding attempts in Sweden. These are later followed up by nest visits to check success and number of young.

Monitoring of sea eagle reproduction in Sweden is included in the National Environment Monitoring Programme since 1989 as indicator of effects from chemical pollutants. In Finland, the monitoring is done by WWF working group. In Western Pomerania, Germany, data are collected by voluntary ornithologists, co-ordinated by the "Project group for large bird species" under the auspices of the Agency for Environment, Nature Conservation and Geology. The first years of the data sets are as follows: in Sweden 1964, in Germany 1973, in Finland 1970.

Monitoring of the a**bundance of wintering populations of seabirds** is a part of international waterfowl monitoring in several member states. Some kind of annual data collection (mainly coastal) is currently being made. Offshore monitoring is being conducted with longer intervals but plans for more regular monitoring (every 3-5 years) exist in at least some member states. Currently not all wintering grounds are covered and the monitoring methods differ between the offshore monitoring and national monitoring practices.

The indicator is proposed to be based on key seabird species, which have functional significance in the marine ecosystem. The species provisionally selected for the indicator and categorized by their functional groups are the following:

Species (winter populations)	**Functional group**
Black-throated diver *Gavia arctica*	Coastal pelagic fish feeder
Red-throated diver *Gavia stellata*	Coastal pelagic fish feeder
Great crested grebe *Podiceps cristatus*	Coastal pelagic fish feeder
Goosander *Mergus merganser*	Coastal pelagic fish feeder
Red-breasted merganser *Mergus serrator*	Coastal pelagic fish feeder
Razorbill *Alca torda*	Offshore pelagic fish feeder
Common guillemot *Uria aalge*	Offshore pelagic fish feeder
Black guillemot *Cepphus grille*	Offshore pelagic fish feeder
Velvet scoter *Melanitta fusca*	Subtidal offshore benthic feeder
Common scoter *Melanitta nigra*	Subtidal offshore benthic feeder

Long-tailed duck *Clangula hyemalis*	Subtidal offshore benthic feeder
Eider *Somateria mollissima*	Subtidal offshore benthic feeder
Tufted duck *Aythua fuligula*	Subtidal coastal benthic feeder
Greater scaup *Aythua marila*	Subtidal coastal benthic feeder
Goldeneye *Bucephala clangula*	Subtidal coastal benthic feeder
Mute swan *Cygnus olor*	Subtidal herbivorous benthic feeder
Mallard *Anas platyrhynchos*	Subtidal herbivorous benthic feeder
Coot *Fulica atra*	Subtidal herbivorous benthic feeder

Monitoring of **the distribution of wintering seabirds** should be monitored in areas of suitable habitat for each species separately and keeping in mind the naturally occurring spatio-temporal variation, areas at times of sea ice coverage and oxygen depletion should be avoided.

HELCOM suggests to include surveys of wintering seabirds with special emphasis on shallow offshore areas into the HELCOM Waterbird Monitoring which should fall under the COMBINE regulations.

As a minimum requirement for a Baltic-wide monitoring programme for wintering waterbirds key habitats, which may be regarded as holding significant proportions of the European wintering populations should be assessed. Monitoring should take place at times of highest occurrence (mid-winter) following standard procedures.

In additional to surveying (principally transect surveying) individual animal tracking could be applied as a tool for scientific research to explore distribution. While the first provides large scale information the latter may provide important additional background information for the interpretation of detected changes in distribution. Habitat association can be inferred by comparing the animal's locations with available habitat within the bird's potential range or directly by use of data loggers providing environmental data on prevailing oceanographic conditions. Moreover, animal tracking delivers high quality information on the individual, such as its activity and status which are important variables aiding in the interpretation of distribution and habitat association.

Currently there is almost a complete lack of internationally co-ordinated monitoring data on waterbirds, in offshore areas. Until today there have been only two Baltic wide studies on seabird distribution. In 1992, the first survey (ship transects) covering all major offshore areas was carried and this was followed up by international surveys from both aeroplane and ships in 1993.

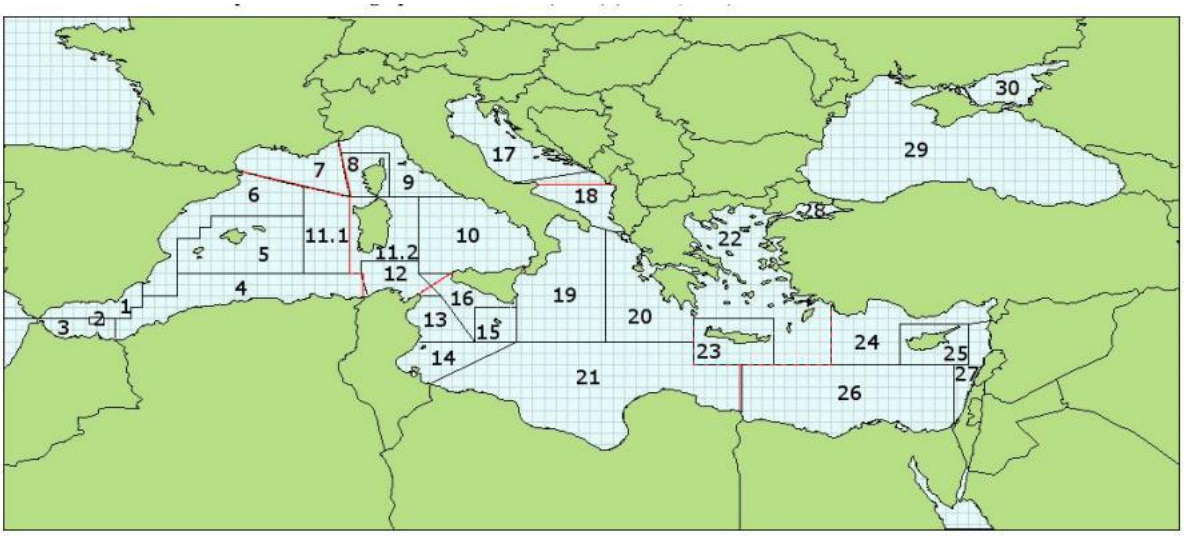
In 2006 the SOWBAS (Status of wintering Waterbird populations in the Baltic Sea) project was launched and carried out co-ordinated surveys of waterbirds in all Baltic waters during 2007-2009. Other counts of wintering waterbirds in the Baltic Sea stem from the midwinter counts of Wetlands International. These counts generally cover birds of the coastal zone and lagoons, while offshore areas are surveyed only infrequently.

In addition there are several national monitoring projects for the identification of IBAs and SPAs as well as regional projects including spatial-assessment of seabirds at sea such as the Baltic LIFE project.

Germany, for example, conducts as part of the "Seabirds at Sea" programme since the year 2000 ship- and airplane-based transect surveys assessing the distribution and abundance of seabirds within the German Baltic Sea area. Moreover, the German Federal Agency for Nature Conservation (BfN) commissions since 2009 a seabird monitoring within the framework of Natura 2000 with special focus on the German EEZ. Additional research includes for example airplane-based transect counts in deep waters of the Baltic Sea.

Breeding waterbird censuses (Archipelago Bird Census) have been conducted in Finnish coasts, comprising up to 48 archipelago areas, annually since 1986. Totally 32 archipelago bird species are monitored. Breeding pair numbers are mainly based on nest counts. It is recommended that at least in Sweden and in Estonia, where a tradition for breeding seabird census exist, an integration of methods and a plan for target species could be made.

Annex VI. GFCM Geographical Sub-Areas (GSAs).



---- *FAO Statistical Divisions (red)* ---- *GFCM Geographical Sub-Areas (black)*

01 - Northern Alboran Sea	07 - Gulf of Lions	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus Island
02 - Alboran Island	08 - Corsica Island	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant
03 - Southern Alboran Sea	09 - Ligurian and North Tyrrhenian Sea	15 - Malta Island	21 - Southern Ionian Sea	27 - Levant
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - South of Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Island	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic	23 - Crete Island	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant	30 - Azov Sea

Annex VII. Overview of Mediterranean stock assessments for GSAs within European waters

(x = stock assessed by EWGs of STECF since 2008; greycolour = stock assessed by the SAC of GFCM in 2011 and 2012). In addition, large pelagic stocks are usually assessed by ICCAT at large scale level : eastern Atlantic and Mediterranean for bluefin tuna (*Thunnus thynnus*) and Mediterranean for swordfish (*Xiphias gladius*).

Species	EU Mediterranean GSA																	
Fish	1	5	6	7	9	10	11	12-16	15-16	16	17	18	19	20	22	23	25	29
Boops boops																		
Engraulis encrasicolus	x		x		x					x	x			x	x			x
Galeus melastomus					x													
Lophius budegassa		X	x	x					x									
Merlangius merlangus																		x
Merluccius merluccius	x	X	x	x	x	x	x		x		x	x						
Micromesistius poutassou	x		x		x													
Mullus barbatus	x	X	x	x	x	x	x		x		x	x					x	
Mullus surmuletus		X			x													
Pagellus bogaraveo																		
Pagellus erythrinus					x				x									
Phycis blennoides					x													
Psetta maxima																		x
Raja asterias																		
Raja clavata																		
Sardina pilchardus	x		x		x					x	x			x	x			
Scyliorhinus canicula																		
Solea solea											x							
Spicara smaris																	x	
Sprattus sprattus																		x
Trisopterus minutus					x													
Shellfish	1	5	6	7	9	10	11	12-16	15-16	16	17	18	19	20	22	23	25	29
Aristaeomorpha foliacea					x	x	x	x	x			x						
Aristeus antennatus	x		x		x	x												
Nephrops norvegicus	x	X	x		x							x						
Octopus vulgaris		X																
Parapenaeus longirostris		X	x		x	x	x		x			x						
Squilla mantis					x	x					x	x						

Annex VIII. SAC provisional shared stocks list (Rome, 2006) *(Appendix H - Report of the ninth session of the Scientific Advisory Committee of the GFCM, Rome, Italy, 24-27 October 2006)*

English common name	Scientific name	Area	Countries
Dolphin fish	*Coryphaena hippurus*	Western Mediterranean.	Italy, Malta, Spain and Tunisia
Horned octopus	*Eledone cirrhosa*	Adriatic Sea	Albania, Croatia, Italy and Serbia-Montenegro
Musky octopus	*Eledone moschata*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Anchovy	*Engraulis encrasicolus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Anchovy	*Engraulis encrasicolus*	Aegean Sea	Greece and Turkey
Anchovy	*Engraulis encrasicolus*	Gulf of Lions	France and Spain
Shortfin mako	*Isurus oxyrhinchus*	All Mediterranean	All countries
Porbeagle	*Lamna nassus*	All Mediterranean	All countries
European squid	*Loligo vulgaris*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Blackbellied angler	*Lophius budegassa*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Monkfish or angler	*Lophius piscatorius*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Hake	*Merluccius merluccius*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Hake	*Merluccius merluccius*	Gulf of Lions	France and Spain
Hake	*Merluccius merluccius*	North Tyrrhenian and Corsica	Italy and France
Hake	*Merluccius merluccius*	Sicily Channel	Italy, Tunisia, Libya and Malta
Blue whiting	*Micromesistius poutassou*	Adriatic Sea	Albania, Croatia, Italy and Serbia-Montenegro
Blue whiting	*Micromesistius poutassou*	North Tyrrhenian and Corsica	Italy and France
Red mullet	*Mullus barbatus*	Western Mediterranean	Corsica and Sardinia
Red mullet	*Mullus barbatus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Striped red mullet	*Mullus surmuletus*	Western Mediterranean	Corsica and Sardinia
Norway lobster	*Nephrops norvegicus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Norway lobster	*Nephrops norvegicus*	North Tyrrhenian and Corsica	Italy and France

English common name	Scientific name	Area	Countries
Black spot seabream	*Pagellus bogaraveo*	Alboran Sea and the Straits of Gibraltar	Spain and Morocco
Common pandora	*Pagellus erythrinus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Common spiny lobster	*Palinurus elephas*	Western Mediterranean	Corsica and Sardinia
Common spiny lobster	*Palinurus elephas*	Sicily channel	Tunisia and Italy
Pink spiny lobster	*Palinurus. mauritanicus*	Sicily channel	Tunisia and Italy
Deepwater rose shrimp	*Parapenaeus longirostris*	Adriatic Sea	Albania, Croatia, Italy and Serbia-Montenegro
Blue shark	*Prionace glauca*	All Mediterranean	All countries
Sardine	*Sardina pilchardus*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Sardine	*Sardina pilchardus*	Aegean Sea	Greece and Turkey
Atlantic mackerel	*Scomber scomber*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Common cuttlefish	*Sepia officinalis*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Common sole	*Solea vulgaris*	Adriatic Sea	Albania, Croatia, Italy, Slovenia and Serbia-Montenegro
Sprat	*Sprattus sprattus*	Adriatic Sea	Croatia, Italy, Slovenia
Albacore	*Thunnus alalunga*	All Mediterranean	All countries
Bluefin tuna	*Thunnus thynnus*	All Mediterranean	All countries
Swordfish	*Xiphias gladius*	All Mediterranean	All countries

Annex IX. Proposed priority list of species for which stock assessment should be performed in each calendar year (STECF, 2013)

GSA	CODE	Common name	Species	YEAR		
				2013	2014	2015
1	PIL	Sardine	*Sardina pilchardus*	1		
1	ARA	Blue and red shrimp	*Aristeus antennatus*			1
1	HKE	Hake	*Merluccius merluccius*	1		1
1	DPS	Pink shrimp	*Parapenaeus longirostris*	1		
1	MUT	Red mullet	*Mullus barbatus*		1	
5	ARA	Blue and red shrimp	*Aristeus antennatus*		1	
5	MUR	Striped red mullet	*Mullus surmuletus*	1		
5	HKE	Hake	*Merluccius merluccius*		1	
5	NEP	Norway lobster	*Nephrops norvegicus*		1	
5	DPS	Pink shrimp	*Parapenaeus longirostris*	1		
5	MUT	Red mullet	*Mullus barbatus*	1		
6	PIL	Sardine	*Sardina pilchardus*		1	
6	HKE	Hake	*Merluccius merluccius*			
6	ANK	Black-bellied angler	*Lophius budegassa*		1	
6	DPS	Pink shrimp	*Parapenaeus longirostris*	1		
6	MUT	Red mullet	*Mullus barbatus*	1		
6	ARA	Blue and red shrimp	*Aristeus antennatus*		1	
7	PIL	Sardine	*Sardina pilchardus*	1		
7	ANE	Anchovy	*Engraulis encrasicolus*		1	
7	HKE	Hake	*Merluccius merluccius*		1	
7	ANK	Black-bellied angler	*Lophius budegassa*		1	
7	MUT	Red mullet	*Mullus barbatus*		1	
9	PIL	Sardine	*Sardina pilchardus*	1	1	
9	HKE	Hake	*Merluccius merluccius*			
9	MUT	Red mullet	*Mullus barbatus*		1	
9	DPS	Pink shrimp	*Parapenaeus longirostris*		1	
9	NEP	Norway lobster	*Nephrops norvegicus*		1	
9	ARS	Giant red shrimp	*Aristaeomorpha foliacea*	1		
10	HKE	Hake	*Merluccius merluccius*	1		
10	DPS	Pink shrimp	*Parapenaeus longirostris*	1		
10	MTS	Spottail mantis	*Squilla mantis*		1	

10	MUT	Red mullet	*Mullus barbatus*		1	
11	HKE	Hake	*Merluccius merluccius*	1		
11	MUR	Striped red mullet	*Mullus surmuletus*	1		
11	MUT	Red mullet	*Mullus barbatus*	1		
11	ARS	Giant red shrimp	*Aristaeomorpha foliacea*		1	
11	DPS	Pink shrimp	*Parapenaeus longirostris*		1	
15+16	ANE	Anchovy	*Engraulis encrasicolus*		1	
15+16	PIL	Sardine	*Sardina pilchardus*		1	
12-16	ARS	Giant red shrimp	*Aristaeomorpha foliacea*			
12-16	DPS	Pink shrimp	*Parapenaeus longirostris*			
12-16	NEP	Norway lobster	*Nephrops norvegicus*	1		
15+16	ARA	Blue and red shrimp	*Aristeus antennatus*	1		
15+16	PAC	Common Pandora	*Pagellus erythrinus*			
12-16	HKE	Hake	*Merluccius merluccius*			
15+16	MUT	Red mullet	*Mullus barbatus*			
15+16	MUR	Striped red mullet	*Mullus surmuletus*	1		
15+16	OCC	Common octopus	*Octopus vulgaris*		1	
4,5, 11-16	DOL	Common dolphinfish	*Coryphaena hippurus*	1		
17	ANE	Anchovy	*Engraulis encrasicolus*	1		
17	PIL	Sardine	*Sardina pilchardus*	1		
17	HKE	Hake	*Merluccius merluccius*		1	
17	MUT	Red mullet	*Mullus barbatus*		1	
17	MTS	Spottail mantis	*Squilla mantis*		1	
17	SOL	Common sole	*Solea solea*	1		
18	ANE	Anchovy	*Engraulis encrasicolus*	1		
18	HKE	Hake	*Merluccius merluccius*	1		
18	MUT	Red mullet	*Mullus barbatus*		1	
18	MTS	Spottail mantis	*Squilla mantis*		1	
18	DPS	Pink shrimp	*Parapenaeus longirostris*		1	
19	DPS	Pink shrimp	*Parapenaeus longirostris*	1		
19	ANE	Anchovy	*Engraulis encrasicolus*	1		
19	HKE	Hake	*Merluccius merluccius*	1		
22+23	ANE	Anchovy	*Engraulis encrasicolus*	1		
22+23	PIL	Sardine	*Sardina pilchardus*		1	
22+23	HKE	Hake	*Merluccius merluccius*	1		
22+23	MUT	Red mullet	*Mullus barbatus*		1	

25	MUR	Striped red mullet	*Mullus surmuletus*		1	
25	MUT	Red mullet	*Mullus barbatus*		1	
TOTAL STOCK NUMBER				31	32	

Annex X. FAO GFCM Priority species' list

Scientific name	3 Alpha Code	English common name
Acipenser gueldenstaedtii	APG	Danube sturgeon (=Osetr)
Acipenser stellatus	APE	Starry sturgeon
Acipenser sturio	APU	Sturgeon
Anguilla anguilla	ELE	European eel
Aristaeomorpha foliacea	ARS	Giant red shrimp
Aristeus antennatus	ARA	Blue and red shrimp
Auxis rochei	BLT	Bullet tuna
Boops boops	BOG	Bogue
Coryphaena hippurus	DOL	Common dolphinfish
Eledone cirrosa	EOI	Horned octopus
Eledone moschata	EDT	Musky octopus
Engraulis encrasicolus	ANE	European anchovy
Euthynnus alletteratus	LTA	Little tunny (=Atl.blackskipj)
Huso huso	HUH	Beluga
Isurus oxyrinchus	SMA	Shortfinmako
Katsuwonus pelamis	SKJ	Skipjack tuna
Lamna nasus	POR	Porbeagle
Loligo vulgaris	SQR	European squid
Lophius budegassa	ANK	Blackbellied angler
Lophius piscatorius	MON	Angler (=Monk)
Merlangius merlangus	WHG	Whiting
Merluccius merluccius	HKE	European hake
Micromesistius poutassou	WHB	Blue whiting (=Poutassou)
Mullus barbatus	MUT	Red mullet
Mullus surmuletus	MUR	Surmullet
Nephrops norvegicus	NEP	Norway lobster
Octopus vulgaris	OCC	Common octopus
Orcynopsis unicolor	BOP	Plain bonito
Pagellus bogaraveo	SBR	Blackspot(=red) seabream
Pagellus erythrinus	PAC	Common pandora
Palinurus elephas	SLO	Common spiny lobster
Palinurus mauritanicus	PSL	Pink spiny lobster

Parapenaeus longirostris	DPS	Deepwater rose shrimp
Pomatomus saltatrix	BLU	Bluefish
Prionace glauca	BSH	Blue shark
Psetta maxima	TUR	Turbot
Sarda sarda	BON	Atlantic bonito
Sardina pilchardus	PIL	European pilchard (=Sardine)
Sardinella aurita	SAA	Round sardinella
Scomber scombrus	MAC	Atlantic mackerel
Sepia officinalis	CTC	Common cuttlefish
Solea solea	SOL	Common sole
Sprattus sprattus	SPR	European sprat
Thunnus alalunga	ALB	Albacore
Thunnus thynnus	BFT	Atlantic bluefin tuna
Trachurus mediterraneus	HMM	Mediterranean horse mackerel
Trachurus trachurus	HOM	Atlantic horse mackerel
Xiphias gladius	SWO	Swordfish

ANNEX XI Socio-economic variables required by the Common Fisheries Policy

Table 1: List of economic variables included in the Commission Decision 2010/93/EU for the collection, management and use of data in the fisheries sector for the period 2011-2013.

Fleet		
Variable Group	**Variable**	**Unit**
Income	Gross value of landings	Euro
Income	Income from leasing out quota or other fishing rights	Euro
Income	Direct subsidies	Euro
Income	Other income	Euro
Personnel costs	Wages and salaries of crew	Euro
Personnel costs	Imputed value of unpaid labour	Euro
Energy costs	Energy costs	Euro
Repair and maintenance costs	Repair and maintenance costs	Euro
Other operational costs	Variable costs	Euro
Other operational costs	Non-variable costs	Euro
Other operational costs	Lease/rental payments for quota or other fishing rights	Euro
Capital costs	Annual depreciation	Euro
Capital value	Value of physical capital: depreciated replacement value	Euro
Capital value	Value of physical capital: depreciated historical value	Euro
Capital value	Value of quota and other fishing rights	Euro
Investments	Investments in physical capital	Euro
Financial position	Debt/asset ratio	%
Employment	Engaged crew	Number
Employment	FTE (full-time equivalent) National	Number
Employment	FTE harmonized	Number
Fleet	Number of vessels	Number
Fleet	Main LOA (LOA: a group of vessels with the same length class)	Metres

Fleet	Mean vessel's tonnage	GT
Fleet	Mean vessel’s power	kW
Fleet	Mean age	Years
Effort	Days at sea	Days
Effort	Energy consumption	Litres
Number of fishing enterprises/units	Number of fishing enterprises/units	Number
Production value per species	Value of landings per species	Euro
Production value per species	Average price per species	Euro/Kg
Aquaculture		
Income	Turnover	Euro
Income	Subsidies	Euro
Income	Other income	Euro
Personnel costs	Wages and salaries	Euro
Personnel costs	Imputed value of unpaid labour	Euro
Energy costs	Energy Costs	Euro
Raw material costs	Livestock costs	Euro
Raw material costs	Feed costs	Euro
Repair and maintenance costs	Repair and maintenance	Euro
Other operational costs	Other operational costs	Euro
Capital costs	Depreciation of capital	Euro
Capital costs	Financial costs, net	Euro
Extraordinary costs, net	Extraordinary costs, net	Euro
Capital value	Total value of assets	Euro
Investments	Net investment	Euro
Debt	Debt	Euro
Raw material volume	Livestock	Ton

Raw material volume	Fish feed	Ton
Volume of sales	Volume of sales	Ton
Employment	Number of persons employed	Number
Employment	FTE National	Number
Number of enterprises	Number of enterprises	Number
Fish processing		
Income	Turnover	Euro
Income	Subsidies	Euro
Income	Other income	Euro
Personnel Cost	Wages and salaries of staff	Euro
Personnel Cost	Imputed value of unpaid labour	Euro
Energy costs	Energy costs	Euro
Raw material cost	Purchase of fish and other raw material for production	Euro
Other operational costs	Other operational costs	Euro
Capital costs	Depreciation of capital	Euro
Capital costs	Financial costs, net	Euro
Extraordinary costs, net	Extraordinary costs, net	Euro
Capital value	Total value of assets	Euro
Net Investments	Net Investments	Euro
Debt	Debt	Euro
Employment	Number of persons employed by gender	Number
Employment	FTE National by gender	Number
Number of enterprises	Number of enterprises	Number

Table 2: Social data needed for policy-making process on fisheries, aquaculture and fish processing sectors according to the report of STECF-13-01[3].

Variable Group	Variable
Demographic	Gender
Demographic	Age
Demographic	Nationality / Citizenship / (Ethnicity?)
Individual level	Employment status (Permanent/ Temporary)
Individual level	full/part-time
Individual level	Year-round / seasonal
Individual level	Outside employment
Enterprise/Business/Boat level	Type (e.g. corporate vs. family owned)
Enterprise/Business/Boat level	Number of paid crew/ employees (Variable indicating size of vessel/ business)
Enterprise/Business/Boat level	Number of unpaid labourers (Variable indicating dependence of families on the vessel/enterprise)

Table 3: Economic indicators included in Commission Decision 2010/93/EU[187] and the modifications proposed by STECF-13-01[3].

Variable group	Variable	Proposed Modifications
Fleet		
Income	Indirect subsidies	New variable
Capital costs	Annual depreciation	Annual depreciation will be substituted by two indicators: depreciation cost and interest cost
Capital value	Value of physical capital; depreciated replacement value	Replaced by "Value of physical capital; current value".
Capital value	Value of physical capital; depreciated historical value	Not needed. Can be calculated from other variables
Financial position	Debt/asset ratio	To be replaced by two new variables: "Debt" and "Total assets"
Employment	Engaged crew	Except of the Total in number variable will be generated five more regarding the classification of engaged crew: i) by gender, ii) by age, iii) by region, iv) by employment status, v) by education level
Employment	Number of unpaid labor	New variable
Aquaculture		
Employment	Number of persons employed	Number of persons employed would be collected: i) by gender and per species and technique, ii) by age, iii) by region, iv) by employment status, v) by education level
Employment	Number of unpaid labor	New variable
Fish processing		
Volume of raw material	per species	

ANNEX XII Knowledge gaps and future research needs on monitoring, with a temporal prioritization per theme of descriptors and per descriptor, as a preliminary result from the STAGES workshop.

Results are presented firstly by theme as general considerations followed by specific gaps and recommendations for the descriptors included on each theme ordered in short-term-, medium-term and long term recommendations.

Theme 1 - Biodiversity

Descriptors

- D1: Biodiversity
- D2: Non indigenous species
- D4 Marine Food Web
- D6: Sea floor integrity

General considerations – Theme 1

List of knowledge gaps

- Lack of information on many habitats/organism
- Lack of definition of habitats/biotopes/landscapes for most marine environments
- Lack of knowledge on the range of natural variability in spatial and temporal distribution and abundance of most species and communities
- Lack of long term data series
- Important lack of data concerning offshore issues: the available data is limited to coastal waters, which in many cases is furthermore scarce, disperse and heterogeneous.
- Lack of information on deep-sea habitats
- Lack of information on biotope and species specific effects of pressures from different human activities
- Lack of knowledge on the impact mechanisms between human activities, anthropogenic pressures and impacts on the ecosystem, including synergistic, cumulative, and antagonistic impacts
- Lack of knowledge on resilience of the system and the rate of recovery after disturbance
- Lack of relevant indicators of GES for habitats/biotopes for most habitat/communities and landscape elements
- Lack of basic understanding of 'responsiveness' of the biological indicators
- Need to distinguish climate change between anthropogenic impacts
- Lack of reference lists; cf. the lack of agreement on the definition of the term habitat: European classification limited to physical parameters for distinguishes types of pelagic habitats
- Lack of harmonization and comparability across regional seas
- Lack of information about the genetic structure of population
- Lack of information on socio-economics issues related to, and pressures acting on, the marine environment in order to improve the cost effectiveness of policies and measures
- No baseline for some ecosystems
- Lack of methodological knowledge
- Coordination gap for harmonizing sampling methods

List of needs for research regarding monitoring

Possible research to implement at short-term

- Development of projects and studies on habitats, identification, mapping, and analysis of its structure and functioning
- Identification of habitat/biotopes presents in different marine environments (from shallow to deep sea, soft to hard bottom), at European level (some national initiatives exist, but need to be coordinated/agreed/tested at European scale)
- Research programs on the status of populations, and monitoring programs of pressures with reliable and accepted internationally methodologies
- Development of analytical methods and assessment tools
- Development of methodological standards
- Development of cost-efficient monitoring methods for communities, importance of automatized or semi-automatized tools

Possible research to implement at medium-term or requiring moderate investments

- Understand natural variation in biodiversity in order to design optimal monitoring programs
- Develop integrative methods enabling valorisation of incomplete and heterogeneous monitoring data
- Understand resilience to develop global approach
- Study cumulative effects
- Develop habitat suitability model
- Develop innovative monitoring tools

Long term research or important investments

- Identify new relevant indicators especially based on data from genomic methods
- Develop metagenomics for a faster, accurate and harmonized identification of species across Europe: DNA barcoding / Metagenetics / Metagenomics
- Develop technological matters
- Build up taxonomic competence

D1: Biodiversity

List of knowledge gaps:

- Lack of basic understanding of 'responsiveness' of the biological indicators
- Lack of taking into account of nano- and micro-biology
- Lack of knowledge on the processes and functional relationships in the marine environment, taking into account differences in temporal and spatial scales
- Lack of information on the causes of long-term changes identified with monitoring

List of needs for research regarding monitoring

Possible research to implement at short-term

- Define GES for the identified habitats/biotopes based on densities, biomass and morphological attributes to some representative organisms or an index that mirrors the health status.
- Develop projects and studies on benthic and pelagic habitats, identification, mapping, and analysis of its structure and functioning.
- Implement automatic analysis methods of analysis for plankton samples, to carry out an objective analysis (not influenced by expertise in taxonomic identification) of certain plankton attributes, such as size structure and taxonomic composition

Possible research to implement at medium-term or requiring moderate investments

- Develop innovative monitoring tools to provide real-time information: e.g. remote sensing for plankton composition, use of ferry boxes, ROV, acoustic, molecular approaches, etc.
- Develop molecular-based methods for population and species diversity assesment for routine implementation.
- Develop population genetics studies: DNA barcoding / Metagenetics, Short Nucleotide Polymorphisms

Long term research or important investments

- Develop 'business models' for upscaling and operationalisation of biodiversity monitoring, realising economies of scale on a shorter timescale. Input here is to come at short term
- Develop next-generation sequencing technologies

D2: Non indigenous species

List of knowledge gaps

- Lack of information on mechanisms of introduction and spread, including natural dispersal mechanisms of introduced species after arrival and establishment in a new area
- Loss of taxonomic expertise
- Lack of information on distribution of marine non indigenous species in relation to environment for many areas, bottom types and organism groups
- Lack of information on the range of natural variability in spatial and temporal distribution and abundance of most species and communities

List of needs for research regarding monitoring

Possible research to implement at short-term

- Develop tools to get faster and more accurate identification of habitat/biotopes presents in different marine environments (from shallow to deep sea, soft to hard bottom).

Possible research to implement at medium-term or requiring moderate investments

- Implement automatic analysis methods of analysis for plankton samples, to carry out an objective analysis (not influenced by expertise in taxonomic identification) of certain plankton attributes, such as size structure and taxonomic composition
- Study the changes to the functioning of marine ecosystems subjected to an impact of invasive alien species.
- Conduct studies to assess how invasive species affect marine ecosystem services and socio-economic benefits.
- Develop innovative monitoring tools to provide real-time information: e.g. remote sensing for plankton composition, use of ferry boxes, ROV, acoustic, molecular approaches, etc.
- Development for routine implementation of molecular-based methods for non indigenous species ID

Long term research or important investments

- Study the natural dispersion mechanisms of each invasive species
- Develop relevant hydrodynamic models for understanding the processes of natural dispersion
- Facilitate long-term maintenance of databases adapted to our defined needs – linked to other parameters

D4: Marine food web

List of knowledge gaps

- Difficulty in obtaining the productivity of the top predators (such as sharks or marine mammals)
- Difficulty in interpreting the productivity of a few species, by themselves
- Difficulty in extending the evaluation to the medium and lower trophic levels

List of needs for research regarding monitoring

<u>Possible research to implement at short-term</u>

- Study energy flows between benthic invertebrates and waterbirds
- Adapt existing monitoring programs to food webs characteristics

<u>Possible research to implement at medium-term or requiring moderate investments</u>

- Develop indicators:
  - of population status: total mortality index, exploitation rate, or average length.
  - to describe communities from a functional point of view: the size spectrum, or the proportion of piscivores in the community.
  - integrative for trophic connections and energy fluxes
- Improve models of food webs by incorporating new understanding from research in order to improve operationality
- Use models to optimize monitoring programs: Genetic or isotopic based research to understand trophic position and relationships and to assess group-specific and community-specific indicators.

<u>Long term research or important investments</u>

- Technological development and miniaturization of sensors are needed to increase the automatic data collection

D6: Sea floor integrity

List of knowledge gaps

- Lack of information on deep-sea habitats
- Knowledge gaps refer to habitats modelling, size distribution, ecosystem structure, species response to impacts, and sensitive or opportunistic species

List of needs for research regarding monitoring

Possible research to implement at short-term

- Define agreement on habitats description (EUNIS)
- Study relations between pressures and microbiology

Possible research to implement at medium-term or requiring moderate investments

- Develop new devices and data transmission for the observation and study of deep sea habitats

Long term research or important investments

- Integrate information from different sources and surveys

Theme 2 – Contaminants and nutrients

Descriptors:

D5 eutrophication

D8 contaminants

D9 contaminants in seafood

General considerations – theme 2

List of knowledge gaps

- Lack of knowledge on open seas and deep-sea species
- Lack of information about links with other descriptors
- Lack of indicators
- Lack of information on biological effects, and cumulative impacts
- Lack of baseline and thresholds

List of needs for research regarding monitoring

Possible research to implement at short-term

- Develop thresholds and determination of adequate standards for marine waters
- Quantify contaminants fluxes and inputs
- Develop monitoring methodologies: passive sampling, new biological effects techniques, analytical methodologies
- Develop a cost-effective deep sea sampling and a research strategy to offshore issues
- Increase knowledge on new substances
- Develop marine ecotoxicology data, including for emerging contaminants, and
- increase knowledge on bioavailability and effects of emerging contaminants

Possible research to implement at medium-term or requiring moderate investments

- Better understand the life cycle of contaminants between water and biota is needed
- Understand causal relationship and mechanistic processes between contaminants and their effects
- Develop biological effect techniques particularly for new and immunotoxic substances
- Develop validated biological effects assessment methods

Long term research or important investments

- Better understand cumulative effects of different pollutants
- Study links between sources, pathways and fate of contaminants
- Screen for risk assessment of relevant mixtures of emerging pollutants and existing contaminants
- Develop new genomic methods: Transcriptomics/ Ecotoxicology
- Study the complimentarily between assessment of chemical concentrations and biological effects
- Increase information about links with other descriptors

D5: Eutrophication

Main knowledge gaps

- Lack of paradigm for aspects such as HAB and biodiversity - models useful but restricted
- Lack of information on the relative role of natural and anthropogenic nutrient loading
- Lack of improved knowledge on the extension and impact of eutrophication on marine ecosystems
- Lack of information on effect of top-down control and other food-web interactions in regulation of algal biomass
- Lack of information on the temporal variability of the discharges from the different sources, and rivers
- Lack of information on nutrient discharges from diffuse sources
- Recovery pathways to oligotrophication
- Lack of knowledge on causative factors of HAB (Harmful Algal Blooms)
- Lack of knowledge of the frequency and distribution of phytoplankton blooms (toxic or not) needed to make a proper assessment of this indicator.
- Lack of information to distinguish climate change and anthropogenic impacts
- Lack of information related to the social costs of load reduction, particularly in agriculture, i.e. product costs and negative externalities such as unemployment
- Lack of genomic methods

List of needs for research regarding monitoring

<u>Possible research to implement at short-term</u>

- Develop methods to include other characteristics in addition to Chl a, such as changes in community composition, occurrence of nuisance and toxic species that result from changes in nutrient ratios, and increased duration and frequency of blooms which result from increases in nutrient loads
- Develop new phytoplankton assessment tools that account for shifts in species composition and frequency of blooms in the status assessment scoring
- Support to evolving monitoring strategies aimed at optimal integration of various monitoring tools

<u>Possible research to implement at medium-term or requiring moderate investments</u>

- Research on Harmful Algal Blooms: Identification of the role of mechanisms such as upwelling relaxation events, cyst formation etc in HAB formation, and the extent to which these events are manageable;
- Develop a regional algorithm that allows reducing the uncertainty in the calculation of satellite chlorophyll from global algorithms.
- Study the implications on the social costs of load reduction compared to benefits received

<u>Long term research or important investments</u>

- Research value, resilience and recovery of marine ecosystems: This includes research exploring potential recovery pathways from eutrophic to non-eutrophic states
- Develop algorithms for phytoplankton composition identification using remote sensing and satellite modelling
- Develop metagenomics in identification of species microarrays
- Develop biological trait analysis for phytoplankton, species analysis, analysis of harmful toxins.

D8: Contaminants

List of knowledge gaps

- Lack of knowledge on off-shore and deep-sea environment: the coverage in monitoring of open sea and deep sea environments is generally less dense than in the coastal environment. It is not even among different marine regions; particularly with regards to non-EU/EEA states
- Lack of technical advice in off shore monitoring including sampling and analytical methodologies, selection of appropriate matrices
- Lack of knowledge on risk assessment for EQS derivation, particularly for biota and sediment matrices: Mainly based on the properties of the chemical substance and do not consider key processes involved in the exposure and effect assessments
- Lack of information about other groups of pollutants, as those set out in the WFD, or others that may be relevant to the marine environment
- Lack of satisfactory and homogenous methods to measure concentration in the water
- Lack of knowledge on assessment criteria of the biomarker responses in certain target species used in integrated monitoring programmes of marine pollution

List of needs for research regarding monitoring

Possible research to implement at short-term

- Develop methods to quantify contaminants fluxes and inputs
- Study how to monitor and assess acute pollution beyond local effects
- Develop tools to monitor marine ecotoxicology data, including for emerging contaminants
- Study bioavailability and effects of emerging contaminants
- Develop integrated surveillance programs including, at least, different compartments of the ecosystem for the study of pollutant concentrations and associated biological responses
- Develop project to study how to include new groups of contaminants, and tissue level biomarkers (histolopatology and gametogenesis), as well as embryo-larval bioassays in sediment pollution monitoring.
- Study higher trophic levels contamination
- Establish passive sampling for cost-efficient quantification of hydrophobic contaminants in marine waters

Possible research to implement at medium-term or requiring moderate investments

- Develop new passive samplers to develop preconcentration of samples at sea
- Develop responsible adaptation of marine monitoring strategies for ‘ubiquitous’ contaminants
- Understand better ecological relevance and relationship between early warning signal at cellular level and the alteration of physiological function as reproduction, immunotoxicity and fitness
- Understand better how contaminants are transferred across trophic levels

Long term research or important investments

- Develop new genomic methods: Transcriptomics/ Ecotoxicology
- Understand better links with microplastics and whether it acts as additional exposure vector for contaminants

D9: Contaminants in fish and seafood

General considerations:

It is noted that no single 'species' can be used across European waters, as a global indicator for all Member states. One part of the system is not 'manageable' considering the species mobility: the mussel watch approach might be a way to address both the issue of (1) side effects resulting from finfish mobility limiting global explanation and further management, (2) a single species used across European waters

Main knowledge gaps

- Lack of baseline studies to establish an accurate reference of the levels of undesirable substances in seafood, although some standards do exist
- Lack of knowledge on some substances like organic chemical contaminants for many species or pharmaceutical substances
- Lack of information on links between monitoring results and causes of these high levels
- Lack of good understanding of the life cycle of contaminants between water and fish
- Lack of seafood traceability
- Lack of useful tools to predict improvement effects of measures taken to assess the efficiency of these measures

List of needs for research regarding monitoring

Possible research to implement at short-term

- Develop specific and ongoing monitoring of the concentrations of contaminants in fishery products traceable to its source.
- Analyse additional contaminants, sampling in a wider range, and including more marine commercial species

Possible research to implement at medium-term or requiring moderate investments

- Develop monitoring programs cutside coastal areas monitoring of seafood contamination

Long term research or important investments

- Study of effects of world wide pollution and long range transport

Theme 3 – Disturbances

Descriptors:

- D10 marine litter
- D11 Introduction of energy, including underwater noise

General considerations:

Main knowledge gaps

- Lack of data on source of perturbation
- Lack of thresholds or baseline

List of needs for research regarding monitoring

Possible research to implement at short-term

- Develop harmonized protocols across Europe
- Organise efficient data gathering

Possible research to implement at medium-term or requiring moderate investments

- Optimize monitoring (standards/baselines; data management/quality insurance; extend monitoring protocols to all MSFD sub regions)
- Define the meaning of "harmful"
- Encourage research on the impacts of perturbations on ecosystems and identify potential indicator species
- Develop models

Long term research or important investments

- Identify /quantify sources
- Develop automated monitoring systems and impact indicators

D10: Marine litter

Main knowledge gaps

- Lack of coherence of data on marine litter
- Lack of data on offshore area
- Lack of quantitative information on intermediate size litter (particles 0 - 2.5 cm)
- Lack of data on microplastics: sources, repartition, impacts on ecosystem
- Lack of alternative species where Fulmars are not found in sufficient numbers

List of needs for research regarding monitoring

Possible research to implement at short-term

- Develop conversion factors number/weight/volume
- Determinate litter degradation rates
- Increase knowledge in microplastics: size to be specified and harmonised, protocols inter-calibration and harmonization needed
- Quantify microparticles in the environment (including sediments from submerged substrates and beaches, as well as surface water)
- Optimize information collection network regarding the impact indicators, in complement of the scientific and technical basis that exist
- Develop designs which are stastistically powerful enough

Possible research to implement at medium-term or requiring moderate investments

- Develop monitoring plans using video or photo images, which will assess the litter on rocky and deep bottoms.
- Develop tools to assess the landscape and/or cognitive effect of litter on society, mainly affecting tourism and the development of water activities, in order to assess the economic and social damage to the affected areas

Long term research or important investments

- Develop opportunistic data acquisition for deep areas/canyon (cost of data acquisition important), allowing a long term monitoring
- Determine the possible origin of the litter and dispersion vectors by studying their distribution and the coupling with particle drift models or identifying characteristics of the waste

D11: Introduction of energy, including underwater noise

Main knowledge gaps

Knowledge gaps are in the field of biology, effects of noise and actual levels of sound in the oceans. Some of these knowledge gaps will be addressed by the monitoring itself (because the proposed indicators will describe the pressure on the environment, i.e. the noise generated by impulsive sources will be registered, and data on ambient noise levels and trends will become available as result of the monitoring programmes.

The TG11 report described other forms of energy that may need attention in the future. Until now, focus has been on noise: there are many kinds of anthropogenic energy that human activities introduce into the marine environment including sound, light, electromagnetic fields, heat and radioactive energy, but among these inputs, the most widespread and pervasive has been increasing levels of anthropogenic sound. Consideration of the other issues that are not addressed with the present choice of indicators, for example high-frequency impulsive noise, effects of light, electromagnetic fields, will also be needed and this may be further addressed by TSG later this year.

Impulsive noise: although direct effects are better understood than 20 years ago and for a some species these direct effect can be quantified to some extent (e.g. disturbance/injury thresholds), data is only available for a limited number of species. Furthermore, it not clear whether other parameters (particle motion) are needed; and ecological significance of such effects (e.g. disturbance) is still unclear;

- The actual pressure and baseline levels of impulsive noise generating activities are not known on large scale;
- There are almost no data on baseline, nor historical data on low frequency ambient noise levels in European waters; there is still little information concerning the contribution of anthropogenic activities to ambient noise levels, although a description of ambient noise due to shipping was made already in 1962 by Wenz;
- There is some descriptive information on possible detrimental effects of increased ambient noise levels but no quantitative data that may be used to accurately describe the possible effect;
- Mitigation potential of silencing technologies and in general efficacy of mitigation.

List of needs for research regarding monitoring

<u>Possible research to implement at short-term</u>

- Organisation of efficient data gathering (register) for impulsive noise, preferably at EU or regional scale;
- Organisation of efficient measuring/data gathering for ambient noise, preferably at EU -or regional scale;
- Technology to store and transfer measurement data in a cost effective way.

<u>Possible research to implement at medium-term</u>

- Development of sound maps, integrating acoustic models, source information and environmental parameters to describe actual sound levels and trends.

<u>Long term research or important investments</u>

- Increase knowledge of direct effects of impulsive sounds (sonar and acoustic deterrents, seismic, piling, explosions). This should address behavioural effects (e.g., leading to avoidance or

abandonment of preferred habitat, which may happen at low exposure levels and therefore may be relevant at the population/ecosystem level); injury may still be relevant for some activities.

- Effects of impulsive sounds at population/ecosystem level. There are proposals for frameworks to expand from direct/individual effects of disturbance to population/ecosystem level effects, e.g. the PCAD-model (population consequences of acoustic disturbance)
- Research on effects of impulsive sound especially on fish species concerning reproduction and behavioural changes
- Effects of increased ambient noise level, addressing masking potential but also other stress effects /Assessment of relevance of masking for population/ecosystem effects;
- Verification of most relevant parameters to describe sound (not restricting to presently used pressure parameters but also velocity parameters/particle motion)- ultimately international standards would be needed
- For future impact assessments/risk assessment it may be needed to have improved knowledge on seasonal presence and abundance of marine life
- Mitigation potential, e.g. silencing technologies, including assessment of actual mitigation potential of such technologies;
- Assessment of mitigation effectiveness, not limited to technological solutions but including evaluation of other current measures and (exclusion zones/periods, passive acoustic monitoring, ramp-up, including a cost-benefit assessment.

Theme 4 - **Commercially exploited fish**

Descriptor: D3 Commercially exploited fish and seafood

List of knowledge gaps

A main problem could be that data refer to landings, not catches

- Lack of data for some stocks: there are available primary or secondary indicators only for few stocks
- Lack of reference points and targets, consistent with SSBMSY, for stocks with only secondary indicators.
- small number of species considered in the assessments
- Data on by-catch not available or very insufficient

List of needs for research regarding monitoring

<u>Possible research to implement at short-term</u>

- Determine a method to select the scale to monitor and to respond to dynamics of fish populations:
- All exploited populations
- Dominant populations
- Dominant fisheries
- Study the impact of discard ban on the monitoring
- Determinate targets
- Establish consistent reference points, as well as to develop additional indicators (e.g. related to mixed-fisheries characteristics) is highlighted.
- Conduct studies with fish populations for which there is little information, such as deep-sea fish, to obtain information on their fishing mortality rates and biomass indices. Shellfish are another group with scarce data. Transboundary monitory assessment needs should be clarified
- Invasive species that are exploited should be monitored eg Manila clam, king crab; snow crab, pacific oyster
- Collate information on by-catch
- Study interactions between D1, 3, 4 and 6

<u>Possible research to implement at medium-term or requiring moderate investments</u>

- Integrate the criteria and indicators of biological disturbance by fishing, which are related to the level of fishing pressure, particularly ensuring a fishing mortality (F) at or below the maximum sustainable yield (MSY), in complex situations, such as mixed fisheries and cases of important ecosystem interactions
- Analyze that SSBMSY probably cannot be achieved simultaneously for all stocks due to interactions between them.
- Study impacts of selectivity on stocks

<u>Long term research or important investments</u>

- Develop new methods: new genomic methods e.g. short nucleotide polymorphism (SNP's)
- Develop and adapt the "productivity and susceptibility" PSA approach: this could be one way to identify which populations should be surveyed and resources prioritized

Theme 5 - **Hydrographical conditions** Descriptor: D7 Alteration of hydrographical conditions

There is a vague understanding of the scope of this descriptor, extensive gaps in data and knowledge and need for realistic and quantifiable indicators.

Main knowledge gaps

- Lack of long time series, in several areas
- Lack of reference, baseline:
- Lack of knowledge on targets or limits for natural information, especially in open waters: changes in hydrography are expected to occur in enclosed seas, bays, etc.
- Lack of definition of permanent alterations to ecosystem functioning as there are many factors to take account of
- Lack of knowledge on cumulative effects assessment methodologies for geomorphological complex situations
- Lack of information in the relationship between hydrographical data and human pressures

List of needs for research regarding monitoring

<u>Possible research to implement at short-term</u>

- Define permanent vs. temporary / permanent vs. natural variability
- Define when and where pressures are significant and permanent alteration to ecosystem functioning
- Develop monitoring methods:
- remote sensing- satellite data
- high frequency radar system
- oceanographic cruises
- uplooking Acoustic Doppler Current Profiler (ADCP)
- Moorings systems
- Ships of opportunity
- Connecting monitoring with modelling
- Gliders and floats
- Develop projects in order to maintain ship availability: this is crucial in order to maintain the monitoring program (both cruises and mooring maintenance)

<u>Possible research to implement at medium-term or requiring moderate investments</u>

- Adapt available methodologies to offshore conditions
- Determine targets and limits
- Determine the relationship between hydrographical data and human pressures: studying the human impact need to know the natural level/situation
- Develop 'risk-based' approach

<u>Long term research or important investments</u>

- Develop operating models to characterize the hydrographical conditions on short scales and infer if these can be affected by infrastructure development.
- Develop cumulative effects assessment methodologies for geomorphological complex situations
- Study regional scale modelling
- develop model of possible anthropogenic activities

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Abstract

The Marine Directors of the European Union (EU), Acceding Countries, Candidate Countries and EFTA Countries have jointly developed a common strategy for supporting the implementation of the Directive 2008/56/EC, "the Marine Strategy Framework Directive" (MSFD). The main aim of this strategy is to allow a coherent and harmonious implementation of the Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Marine Strategy Framework Directive. In particular, one of the objectives of the strategy is the development of non-legally binding and practical documents, such as this technical guidance on monitoring for the MSFD. These documents are targeted to those experts who are directly or indirectly implementing the MSFD in the marine regions. The document has been prepared by the Joint Research Centre of the European Commission (JRC) with the contribution of experts from Member States, Regional Seas Conventions and ICES and following consultation of the Working Group on Good Environmental Status.

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