STAGES

CONNECTING SCIENCE TO POLICY FOR HEALTHY SEAS

STAGES - Science and Technology Advancing Governance of Good Environmental Status

WORKSHOP REPORT

Needs for further research to support improved and more efficient monitoring programmes under MSFD

Brussels, 13-15 May 2013

www.stagesproject.eu

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no 308473. This publication reflects the views only of the author, and the European Union cannot be held responsible for any use which may be made of the information contained therein.

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1. Introduction and background

The STAGES project is a specific support FP7 action addressed to facilitate the implementation of the Marine Strategy Framework Directive (MSFD), and specifically to assist Member States with marine territories to achieve Good Environmental Status (GES) by 2020. The STAGES project has three key objectives:

- Make the knowledge generated through EU and national research funded activities with relevance to MSFD objectives widely accessible to policy and decision makers and to MSFD stakeholders (associated with Work Package 2);
- Identify the needs for further research to improve the scientific underpinning for the implementation of the MSFD (associated with Work Package 3);
- Provide concrete, pragmatic and ready-to-use recommendations on the development of an effective European science-policy platform to support implementation of the MSFD (associated with Work Package 4).

Framed in WP3, and in order to support requirements for Member States established in articles 8, and 11 of the Directive (assessment, determination of GES, establishment of environmental targets and monitoring programmes) STAGES is organising a series of three workshops with the following aims:

1. The identification of research needs with regard to the implementation of monitoring programmes (Task 3.3)
2. The identification of research needs with regard to the pressures and their impacts on marine ecosystems (Task 3.2)
3. The identification of research needs with regard to socio-economic analysis (Task 3.4)

2. Objectives of the workshop and expected results

The objectives of the Workshop on Monitoring Programmes for the MSFD were:

1. To share the State-of-the-Art knowledge on monitoring programmes for the MSFD
2. To identify knowledge gaps and associated uncertainties of monitoring programmes
3. To assess what would be necessary to adapt/upgrade monitoring programmes design to emerging knowledge and new technologies
4. To produce a list of needs for further research and methodological development to inform future research programme managers and/or decision makers

The expected results from the workshop included a synthesis of knowledge gaps and needs for

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further research to support improved and more efficient monitoring programmes under the MSFD. The workshop report will serve as the basis for the science policy reports on needs for further research for the implementation of MSFD that will inform future research programme managers/ decision makers. The outcome of the workshop will be included in the JRC-led guidance document on monitoring under MSFD.

3. Participants

CONTRIBUTION	NAME AND AFFILIATION OF PARTICIPANTS
Project STAGES	Marisa Fernández (CETMAR)
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Project STAGES	Øivind Bergh (JRC)
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D3	Mark Dickey-Collas (ICES)
D4	Florent Renaud (IMBE, France)
D5	João Ferreira (University of Lisbon, Portugal)
D6	Angel Borja (AZTI, Spain)
D7	Kjell Arne Mork (IMR, Norway)
D8	Jacek Tronczynski (Ifremer, France)
D9	Amund Maage (NIFES, Norway)
D10	Francois Galgani (Ifremer, France)
D11	Rene Dekeling (Ministerie van Infrastructuur en Milieu)

The workshop was formally inaugurated by the STAGES project officer, Ana Teresa Caetano. STAGES coordinator Marisa Fernández presented an overview of STAGES project. Øivind Bergh presented the objectives of the workshop and preliminary results of WP2 (knowledge identification and synthesis). This was followed by presentations from Joachim D ' Eugenio (DG ENV), Gert Verreet (OSPAR) and Laura Uusitalo (HELCOM).

Some of the experts were invited to represent the MSFD GES descriptors (D1 to D11) and to make a presentation to open discussions (see List of Participants). At the end of the workshop, Wendy Bonne briefly presented the JPI Oceans. The workshop was led by Kjell Nedreaas and Nicolas Hoepffner.

4. Methodology

The workshop took place on 13-15 May 2013, with a duration of two half a days (13 and 15) and a full day (14). The venue for the workshop was the 'Covent Garden' building (COV2 in short) of DG Research and Innovation of the European Commission, at Place Rogier, 16 in Brussels.

The workshop was organised into five sections corresponding to the five themes of GES descriptors:

1. Biodiversity Group with Descriptors 1 (Biodiversity), 2 (Non indigenous species), 4 (Marine food web) and 6 (Sea floor integrity)
2. Contaminants & Nutrients Group with Descriptors 5 (Eutrophication), 8 (Contaminants) and 9 (Contaminants in fish and other seafood)
3. Disturbances Group with Descriptors 10 (Marine litter) and 11 (Underwater energy, including noise)
4. Commercially exploited fish Group for Descriptor 3 (cCmmercially exploited fish and shellfish)
5. Hydrographical conditions Group for Descriptor 7 (Hydrographical conditions)

By using a questionnaire experts were asked in advance to identify research needs regarding monitoring programmes for each group of descriptors. The outcome of this consultation process was used in each workshop session to orientate discussions.

Participants were also provided with a list of documents as background information. These included:

Documents elaborated in the framework of the STAGES project:

- Synthesis of recommendations (per MSFD theme)
- Available outcomes of STAGES WP2

Other reports:

- Reports of the Marine Strategy Coordination Group, WG-GES (incl. reports from the JRC 2012 workshops), WG-DIKE, and WG-ESA, and relevant activities and outputs of the DG RTD-lead expert group on marine research infrastructures, as well as JPI Oceans
- RSC reports, ICES and JRC MSFD Task Group reports

The above mentioned background documents are available in the link:
https://www.dropbox.com/sh/pocs9iaaujqgehh/lce0soab86

4.1 Workshop dynamic and contents

The workshop included an introductory section, five technical sections corresponding to the five groups of GES descriptors and a final section to present and discuss conclusions (see agenda in the Annex).

Introductory section

- Welcome by DG Research & Innovation
- Brief overview of STAGES project and objectives of the workshop
- Presentation of DG Environment
- Presentations of Regional Sea Conventions highlighting the works carried out regarding monitoring programmes under MSFD in their sea/regions

Descriptor Groups Section

- One introductory presentation for each descriptor by the corresponding appointed expert including the following contents:

1. Short description of what would constitute an adequate monitoring programme for the descriptor: What, where and when to measure in order to collect all the data needed for a reliable assessment and classification of a marine area. Consider the risk assessment approach and the need for monitoring programmes to adapt to changing pressures. Also consider different types of monitoring according to its main purpose and (e.g. for state, targets, pressures etc.) and if/how these different types are relevant for the MSFD monitoring needs.

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2. For each descriptor(s), state if there exist proper GES definitions and/or targets to compare with the present measured/estimated value or if definitions of such goals/limits are lacking? Also include the inputs from the questionnaires.

3. Summarise the State-of-the-Art knowledge on monitoring programmes per regional waters for the MSFD descriptor(s) by indicating where (MSFD regions and subregions) there are monitoring programmes for each descriptor and where there is no or limited coverage.

4. Highlight monitoring efforts, if they exist, where there is clear coordination between different Member States (e.g. common vessels surveys, sharing of equipments, coordination of monitoring in time).

5. Highlight recent developments (after the publication of TG reports in 2010) that have the potential to facilitate, improve and reduce the cost of monitoring. These could include innovative approaches i.e. approaches that are less applied but seem promising (e.g. new sampling devices and data analysis systems).

6. Highlight efforts to achieve coherence between the approaches of Member States. Provide recommendations on the actions to take to ensure that data collected by different Member States would be possible to be merged in a common database that could be used to test different assessment approaches. Highlight good practices in data architecture and storage that could enhance interoperability.
7. Make a list of your task group's identified knowledge gaps and associated uncertainties of monitoring programmes. E.g. why a certain descriptor is not monitored in a certain area? Is there a lack of knowledge on what, when, where and how to monitor? Also include the inputs from the questionnaire.
8. Produce a prioritised list of needs for further research and methodological development, as you and your task group sees it, to inform future research programme managers and/or decision makers. Also include the inputs from the questionnaire
9. What monitoring strategy is needed in order to be in position to better define GES and targets in the near future?

- Orientated plenary discussion based on the outcomes of the consultation process
- Conclusions per theme

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Final section

General presentation and discussion of the outcomes on the needs for further research to support improved and more efficient monitoring programmes for all themes.

The participants presenting on the various GES Descriptors were requested to prepare the introductory presentations for the different Descriptors. The rest of participants were requested to contribute to the tasks/questions above. All the experts were asked to complete the questionnaire in advance of the workshop.

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5. Results: identified gaps and needs for further research

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.

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Theme 1 - Biodiversity

Descriptors : D1: Biodiversity, D2: Non indigenous species, D4: Marine food web, D6: Sea floor integrity

General Considerations	List of Needs for Research Regarding Monitoring
List of knowledge gaps - Lack of information on many habitats/organisms - 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 considerably 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 harmonisation and comparability across regional seas - Lack of information about the genetic structure of population - Lack of information on socio-economic 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 harmonising sampling methods	**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 present 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 programmes on the status of populations, and monitoring programmes 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 automatised or semi-automatised tools **Possible research to implement at medium-term or requiring moderate investments** - Understand natural variation in biodiversity in order to design optimal monitoring programmes - Develop integrative methods enabling valorisation of incomplete and heterogeneous monitoring data - Understand resilience to develop global approach - Study cumulative effects - Develop habitat suitability mode - 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 harmonised identification of species across Europe: DNA barcoding / Metagenetics / Metagenomics - Develop technological matters - Build up taxonomic competence

Theme 1 - Biodiversity *cont.*

D1: Biodiversity

General Considerations	List of Needs for Research Regarding Monitoring
List of knowledge gaps - Lack of basic understanding of 'responsiveness' of the biological indicators - Lack of taking into account of nano and microbiology - 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	**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' to make biodiversity monitoring operational and to upscale it, realising economies of scale on a shorter timescale - 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	**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 indigeneous 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

Theme 1 - Biodiversity *cont.*

D4: Marine food web

General Considerations	List of Needs for Research Regarding Monitoring

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
	Possible research to implement at short-term
	- Study energy flows between benthic invertebrates and waterbirds
	- Adapt existing monitoring programmes to food webs characteristics
	
	Possible research to implement at medium-term or requiring moderate investments
	- 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
	  - that are 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 optimise monitoring programmes: Genetic or isotopic based research to under stand trophic position and relationships and to assess group-specific and community-specific indicators
	
	Long-term research or important investments
	- Technological development and miniaturisation 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	**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	List of Needs for Research Regarding Monitoring
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	**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 strategie 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 understanding of 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 complimentarity between assessment of chemical concentrations and biological effects - Increase information about links with other descriptors

Theme 2 - Contaminants and Nutrients *cont.*

D5: Eutrophication

General Considerations

List of knowledge gaps

- Lack of paradigm for aspects such as Harmful Algal Blooms (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
- 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 between 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

Possible research to implement at short-term

- Develop methods to include other characteristics in addition to Chlorophyl 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

Possible research to implement at medium-term or requiring moderate investments

- 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 chlorophyl from global algorithms
- Study the implications on the social costs of load reduction compared to benefits received

Long-term research or important investments

- 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.

Theme 2 - Contaminants and Nutrients *cont.*

D8: Contaminants

General Considerations	List of Needs for Research Regarding Monitoring
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: 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	**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 programmes 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 **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 - Better understand the ecological relevance and relationship between early warning signal at cellular level and the alteration of physiological function as reproduction, immunotoxicity and fitness - Better understand how contaminants are transferred across trophic levels **Long-term research or important investments** - Develop new genomic methods: Transcriptomics/ Ecotoxicology - Better understand links with microplastics and whether it acts as additional exposure vector for contaminants

D9: Contaminants in fish and seafood

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. **List of 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	**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 programmes outside 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	List of Needs for Research Regarding Monitoring
List of knowledge gaps - Lack of data on source of perturbation - Lack of thresholds or baseline	**Possible research to implement at short-term** - Develop harmonised protocols across Europe - Organise efficient data gathering **Possible research to implement at medium-term or requiring moderate investments** - Optimise 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	
List of 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	**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 harmonisation needed - Quantify microparticles in the environment (including sediments from submerged substrates and beaches, as well as surface water) - Optimise 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

Theme 3 - Disturbances *cont.*

D11: Introduction of energy, including underwater noise *cont.*

General Considerations

There are many kinds of anthropogenic energy that human activities introduce into the marine environment including sound, light and other electromagnetic fields, heat and radioactive energy. Among these, the most widespread and pervasive kind of anthropogenic energy is underwater sound. Therefore, initially there are only indicators for underwater noise, as defined in Commission Decision (CD) of 2010, which identified the main orientation for monitoring underwater energy - underwater noise of short duration (loud impulsive sounds such as from seismic surveys and piling for wind farms and platforms, as well as explosions) or long lasting (continuous noise as from shipping, dredging and energy installations). This choice was based on the TG11 report (Tasker et al., 2010), and further explained in the TSG Noise report of 2012 (Van der Graaf et al., 2012).

The indicators mentioned in the CD are:

11.1. Distribution in time and place of loud, low and mid frequency impulsive sounds
— Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1µPa 2 .s) or as peak sound pressure level (in dB re 1µPa peak) at one metre, measured over the frequency band 10 Hz to 10 kHz (11.1.1)

11.2. Continuous low frequency sound
— Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1µPa RMS; average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate (11.2.1).

In May an interim monitoring guidance will be available, explaining the initial approach for Member States setting up the monitoring programmes for the two indicators that are prescribed in the CD (Dekeling et al., 2013).

This monitoring guidance will address, for example,

- For impulsive noise:
  - additional data to be collected for impulsive noise (to enable assessment of impact)
  - thresholds for taking up sources in a register
- For ambient noise:
  - further clarification about monitoring trends and levels
  - information describing the combined use of modelling and measurements for monitoring of ambient noise
  - implications of different averaging methods and initial advice on method to be used
  - specifications for equipment, data storage and processing
- The TSG Noise advice is, if possible, to include data from military activities in the impulsive noise register (since a registry that leaves out part of the sound sources is not useful as a register that aims to address cumulative effects of noise)

The monitoring of these two indicators will serve to determine the pressure on the environment and will help enable Member States to set a baseline

There is still insufficient knowledge on the effects of impulsive noise at the ecosystem level; for the effects of increased ambient noise level there is very little information available at all and almost none that can be used for any quantitative assessment. Most Member States have therefore chosen not to set any concrete limit or target at the ecosystem level.

The two indicators described will serve to determine the pressure on the environment and will enable Member States to set a baseline.

Indicator name	Com dec	Category	Status	Development Needs
Impulsive noise	11.1.1	Common	Under Development	Yes, see the 2013 TSG Noise report
Ambient noise	11.2.1	Common	Under Development	Yes, see the 2013 TSG Noise report

No HELCOM indicators directly related to D11.

Mediterranean/Black Sea-PERSEUS: No, due to general lack of information.

The indicators have been described in the TG11 Report on Underwater Noise and other forms of energy and in the EC 2010 decision and clarification was provided in the TSG Noise reports. However, no targets and limits are available, for noise, electromagnetic values and discharge of heat.

Monitoring will only address the pressure on the environment but not limits or targets.
For monitoring impulsive noise it is not essential to develop new technology and techniques, however, systems/registers required to collect and assess these data needs further development.

For monitoring ambient noise it will be necessary to measure and model the sound field. Much fundamental knowledge about measuring, processing and storing the data is available but with presently available technology collecting field data about ambient noise will be costly.

Also for ambient noise, the monitoring organisation to actually measure, process, store and evaluate data still needs to be developed, organised and built, and for most (if not all) Member States, this cannot build on existing monitoring systems. A possible exception is the international programme LIDO (Listen to the Deep Ocean Environment). This programme, coordinated by the Laboratory of Applied Bioacoustics of the Technical University of Catalonia aims to apply and extend developed techniques for passive acoustic monitoring of underwater sounds, including natural, biological and man-made noise. Data from monitoring stations is transferred to shore, processed and made available on a real-time basis, including by means of a publicly available web-application. For more information about LIDO see the website www.listentothedeep.com.

Since for both impulsive noise and ambient noise no existing monitoring or registration system is available, it makes sense to investigate to what extent these monitoring or registration systems can be developed at EU-scale/regional scale. There is one example- the BIAS project that aims at developing a monitoring system in the Baltic Sea.

Mediterranean/Black Sea-PERSEUS: Methodological sources are scarce, based on scientific publications or assessments using pressure indicators data (but see above mentioned LIDO programme).

Acoustic devices are available. However, with presently available technology, the costs of actual measurements at sea are high - dedicated moorings need to be used, deployed and recovered at sea, and data storage and transfer of data to shore may be difficult and processing and analysis of data is still labour intensive.

Theme 3 - Disturbances *cont.*

D11: Introduction of energy, including underwater noise *cont.*

Knowledge Gaps

Both the TG11-report of 2010 as the TSG Report of 2012 addressed 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.

Most Member States have not provided a very specific description of GES or concrete limits and targets. Member States are required to review their marine strategies six years after the initial establishment, which means by 2018. The knowledge gaps for noise must be solved to enable Member States to specify GES

Impulsive noise: although direct effects are better understood than 20 years ago and for some species these direct effects 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

Possible research to implement at short-term

- 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.

Possible research to implement at medium-term

- Development of sound maps, integrating acoustic models, source information and environmental parameters to describe actual sound levels and trends.

Long-term research or important investments

- 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).
- 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 pres sure 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

D3: Commercially exploited fish and shellfish

General Considerations	List of Needs for Research Regarding Monitoring
List of knowledge gaps - 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 Spawning Stock Biomass Maximum Sustainable Yield (SSBMSY), for stocks with only secondary indicators. - Small number of species considered in the assessments - Data on by-catch not available or insufficient	**Possible research to implement at short-term** - 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 e.g. Manila clam, king crab; snow crab, pacific oyster - Collate information on by-catch - Study interactions between D1, D3, D4 and D6 **Possible research to implement at medium-term or requiring moderate investments** - 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 - Analyse that SSBMSY probably cannot be achieved simultaneously for all stocks due to interactions between them. - Study impacts of selectivity on stocks **Long-term research or important investments** - Develop new methods: new genomic methods e.g. short nucleotide polymorphism (SNPs) - Develop and adapt the "productivity and susceptibility" approach (PSA): this could be one way to identify which populations should be surveyed and resources prioritised

Theme 5 - Hydrographical Conditions

D7: Alteration of hydrographical conditions

General Considerations	List of Needs for Research Regarding Monitoring

Vague understanding of the scope of this descriptor: extensive gap in data and knowledge 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 into account
- Lack of knowledge on cumulative effects assessment methodologies for geomorphological complex situations
- Lack of information about the relationship between hydrographical data and human pressures
	Possible research to implement at short-term
	- 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 programme (both cruises and mooring maintenance)
	
	Possible research to implement at medium-term or requiring moderate investments
	- 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
	
	Long-term research or important investments
	- Develop operating models to characterise 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
	- Create an integrated global earth observation system

6. General Conclusions

Although a number of gaps and needs that deserve further research were identified during the workshop, it was generally agreed that substantial and valuable progress in the MSFD related knowledge and GES understanding had taken place in the last few years as a result of initiatives promoted by the EU Commission and at Regional and Member State level. This includes the JRC and ICES task groups, the work developed in the frame of RSC, research funded under the 6th and 7th Framework Programmes, Life programme and others and MSFD pilot projects. The importance of building on the outcomes of such initiatives and the need to make better use of existing knowledge and resources was emphasised.

Despite the fact that the workshop focused on identifying needs for research to improve Monitoring Programmes for GES assessment, it was not possible to approach such objective without discussing/highlighting significant lacks in general (fundamental) knowledge. Thus, a number of gaps in knowledge that affect the accuracy of GES definition and the subsequent monitoring programmes to assess GES were identified: e.g. lack of definitions of habitats/biotopes/landscapes and lack of information of certain habitats, particularly deep-sea habitats.

Gaps were also identified in relation to pressures and anthropogenic impacts, in particular the synergies among different impacts. The different impacts may be well studied and understood individually, whereas the combined and cumulative effects are poorly understood.

Long time series are also generally lacking, and the understanding of the natural dynamics of the environment is therefore limited. The establishment and maintenance of such time series is desirable, and therefore there is a need for establishing and maintaining long time series.

When assessing gaps by descriptors a considerable overlap between the needs for development and improvement of monitoring efforts regarding the different descriptors was evident.

The ongoing development of new monitoring methods and new technologies for monitoring implies that monitoring effort is a dynamic exercise. This includes physical and chemical methods as well as as well as, for instance, genomics based methods for monitoring biological parameters. This applies to the efficiency of the monitoring, the accuracy of the output of the monitoring, and to the economy of the monitoring exercises.

Genomic-based methods represent a revolution to taxonomy, and to our understanding of biodiversity. This is of relevance to all biological descriptors and advances in this area will support the development of the concept of GES. Additional research efforts are needed regarding the development of metagenomics, molecular-based methods for routine implementation of population and

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species diversity assessment, next generation sequencing technologies and genetic or isotopic based research.The need for taxonomic expertise remains, and is essential to get the full use of the methodology development.

There is a strong need to develop innovative monitoring tools and this is especially true in the case of non-indigenous species, where innovative tools to provide real time information could improve our ability to act. Advances are needed in the technological development and miniaturisation of sensors to increase the automatic data collection. New passive samplers and new phytoplankton assessment tools that account for shifts in species composition and frequency of blooms in the status assessment scoring are also required. There are also benefits coming from further development of remote sensing and satellite modelling.

Offshore and deep-sea monitoring related issues deserve special attention as the coverage in monitoring of open sea and deep sea environments is generally less dense than in the coastal environment. Research focused on the development of cost-effective off shore and deep sea sampling, observation, monitoring and data transmission methodologies and devices is needed as well as a monitoring strategies.

Given the ambition of the MSFD goals and coverage and the current economic scenario, the importance of making the better use of existing monitoring efforts and resources was emphasised. Co-utilisation/optimisation of monitoring efforts (e.g. cruises), should be developed/encouraged across the different Member States and regions as well as efforts/strategies to collect physical, chemical and biological data that can feed the different GES descriptors. In addition to cost-efficiency, this could facilitate the use of more advanced technology in an economically sustainable way.

Support to evolving monitoring strategies aimed at optimal integration of various monitoring tools is desirable as well as the promotion and development of opportunistic data acquisition (ferry boxes, ships of opportunity) especially for deep areas/canyon that would allow a long-term cost efficient monitoring.

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Annex:
STAGES Workshop on needs for further research to support improved and more efficient monitoring programmes under MSFD

Monday 13th May	
13:30	Introductory Session
13:30-13:40	Welcome by DG Research and Innovation *Ana Teresa Caetano (STAGES Project Officer, DG Research and Innovation)*
13:40-13:50	Brief overview of STAGES *Marisa Fernández (STAGES coordinator, CETMAR)*
13:50-14:00	WP2 Prelimainary results regarding research related to MSFD Monitoring Programmes *Øivind Bergh (STAGES Project, IMR)*
14:00-14:10	Objectives of the workshop *Kjell Nedreaas (STAGES project, IMR)*
14:10-14:30	Presentation of DG Environment *Joachim D'Eugenio (DG Environment)*
14:30-14:45	Presentation of the Regional Seas Commission *Gert Verreet (OSPAR)*
14:45-15:00	Presentation of the Regional Seas Commission *Laura Uusitalo (HELCOM)*
15:00	Theme 2
15:00-16:00	D9 Contaminants in fish and seafood *Amund Maage (NIFES)*
16:00-16:30	Coffee Break
16:30-17:30	D10 Marine Litter *Francois Galgani (IFREMER)*
17:30-18:30	D11 Energy and Noise *René Dekeling (Ministry of Infrastructure and the Environment)*
19:00	Dinner

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Tuesday 14th May	
THEME 1	
09:00-10:00	D1 Biodiversity *Lene Buhl Mortensen (IMR)*
10:00-11:00	D2 Non Indigenous Species *Sergej Olenin (Klaipeda University)*
11:00-11.30	Coffee Break
11:30-12:30	D4 Marine Food Webs *Florent Renauld (IRD)*
12:30-13:30	D6 Sea Floor Integrity *Angel Borja (AZTI)*
13:30-14:30	Lunch
THEME 2	
14:30-15:30	D5 Eutrophication *João Ferreira (University of Lisbon)*
15:30-16:30	D8 Contaminants *Juan Bellas (IEO)*
16:30-17:0	Coffee Break
THEME 4	
17:00-18:00	D3 Commercially exploited fish and seafood *Mark Dickey-Collas (ICES)*
THEME 3	
18:00-19:00	D7 Hydrogrpahical Conditions *Kjell Arne Mork (IMR)*
20:00	Dinner

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Wednesday 15th May	
CONCLUSIONS AND OUTCOMES	
08:30-09:30	Drafting of main conclusions for the five Themes *(Drafting Group)*
09:30-10:00	Coffee Break
10:00-12:30	General presentation and discussion of the outcomes on the needs for further research
12:30-13:00	Summing up and closure of the workshop
13:00-14:00	Lunch

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