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Short Communication

Marine monitoring in the European Union: How to fulfill the requirements for the marine strategy framework directive in an efficient and integrated way

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ABSTRACT

The Marine Strategy Framework Directive requires from European Union Member States to establish by 2014 ecological monitoring programmes covering all their marine waters and therefore extend existing monitoring and include additional elements. Principles of integrated monitoring and large scale approaches discussed in this communication could contribute to effective and cost efficient programmes.

Introduction

The Marine Strategy Framework Directive (MSFD)[2] requires all European marine waters to be in Good Environmental Status (GES) by 2020. GES is reached when 11 Descriptors (biodiversity, alien species, fish stocks, food-webs, eutrophication, sea-bed integrity, hydromorphology, contaminants in the sea, contaminants in seafood, litter and energy) do not deviate significantly from the undisturbed state.

In order to ensure that GES is reached and/or maintained EU Member States should set, among other things, and according to Article 11 of the MSFD, monitoring programmes by 2014. These programmes should take into account the indicative characteristics, pressures and impacts set in Annex III of the MSFD that includes several abiotic and biotic elements (Table 1). Some are characteristics of species, populations and communities while others are physicochemical characteristics and pressures. A related Commission Decision[3] lists 29 criteria and 56 indicators based on which GES should be defined. Ideally, monitoring programmes should be able to provide data for the calculation of the indicators set by the Commission Decision.

Monitoring can be defined as the systematic 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 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, processing of the samples in the laboratory 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 in although very much 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 [1].

Despite existing relevant European legislation, such as the Water Framework Directive (WFD)[4], the Environmental Quality Standards Directive (EQS)[5], the Habitats Directive (HD)[6], the Birds

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[2] 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.

[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] Directive 2008/105/EC of the European Parliament and of the Council 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 of the European Parliament and of the Council.

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

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Table 1
Monitoring elements required by marine related EU legislation.

MSFD monitoring element	Characteristics (if defined)	WFD	EQS	BD	HD	CFP
Phytoplankton, zooplankton	Species composition	+				
Angiosperms, macroalgae, zoobenthos	Biomass and species composition	+				
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						
Contaminants	Changes in concentrations and biological effects	+	+			
Oxygen		+				
pH						
Marine litter						
Underwater noise						
Microbial pathogens						
Non-indigenous species	Occurrence, distribution, abundance, translocations					
Selective extraction of species						+

Directive (BD)[7], the Data Collection Framework Regulation[8] for the Common Fisheries Policy (CFP) and other international agreements the coordination of monitoring programmes in the marine environment "is still in its infancy" [2]. According to OSPAR [3], many institutions are involved in monitoring efforts which would benefit in efficiency and costeffectiveness from better coordination. Considering that the marine territory of the EU is larger than its land territory, a considerable effort is needed to fulfill this legislative requirement in a meaningful and pragmatic manner. In this communication the concept of integrated monitoring is discussed and some large scale approaches are shortly reviewed.

A monitoring programme can be considered integrated when it provides data relevant to different MSFD descriptors, criteria and indicators, to different pieces of legislation, for more than one Member State and collected in comparable way.

Some elements of integration are obvious and simple to achieve. The same monitoring data could be, in some cases, useful for the assessment of different descriptors, e.g., data on zoobenthos abundance and taxonomic composition are useful for both the assessment of biodiversity (descriptor 1) and sea-bed integrity (descriptor 6).

At first sight, it might seem that many of the MSFD monitoring requirements are already covered by other EU legislation (Table 1) and that only the additional monitoring of some physicochemical elements (ice cover, mixing, residence time, siltation, pH) and pressures (abrasion, extraction, sealing, litter, energy, alien species) is needed. In reality, there are many more gaps. The WFD applies to coastal waters (up to 1 nautical mile from the baseline from which territorial waters are defined) and the EQS, for priority substances, to territorial waters (up to 12 nautical miles). The HD and BD apply where listed species and habitats occur while the CFP where fish stocks and fishing activities take place. The MSFD has a much wider geographical scope as it covers all marine waters under the sovereignty and jurisdiction of Member States of the EU (including territorial waters and Exclusive Economic Zones). It thus requires additional monitoring in areas where it was not previously required by EU law. Therefore, the extension of existing marine monitoring out of the coastal areas is a major challenge for EU Member States.

Comparability of assessment approaches within and between marine regions and/or subregions is another important requirement of the MSFD and could be facilitated by the collection of data in a harmonized, or at least, comparable way. One way to achieve this is to follow the existing standards of the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN). Although at present these cover only a few descriptors (mainly for chlorophyll-a, phytoplankton and hard-substrate benthic communities) they should be considered and used if appropriate while the effort to develop more standards should be continued and intensified. Other related EU legislation provided very few and only rough monitoring guidelines. For example, the WFD sets some minimum requirements for monitoring frequency in coastal waters and allow EU Member States to develop their own methods to sample and assess the required parameters. As a result, a plethora of different national ecological assessment methods was developed that had to be compared with a sophisticated exercise (intercalibration) [4]. The variety of different ways of data collection could be a major difficulty in testing and demonstrating comparability of assessments and, if possible, should be avoided in the implementation of the MSFD. An important effort to develop common monitoring approaches is being pursued by some Regional Seas Conventions, particularly HELCOM and OSPAR. Examples include the OSPAR Ecological Quality Objectives [3], the COMBINE manuals [5] and the Joint Assessment and Monitoring Programming [6] but for many MSFD descriptors (e.g., energy, alien species) well developed and agreed monitoring guidelines do not exist. Moreover, the level of development and agreement of monitoring methods in the Mediterranean and the Black Sea is considerably inferior.

A secure way to ensure comparability of approaches and interoperability of monitoring data between two or more countries is to have joint monitoring cruises and making use of the same sampling instrumentation. Although pilot joint cruises sometimes take place in the frame of research projects (e.g., SESAME [7]) such cruises are not known to take place in a regular way or, if they exist, are uncommon. Different national or regional

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

[8] Council Regulation (EC) No 199/2008 of 25 February 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.

monitoring traditions and confidentiality issues could be factors prohibiting such collaborations. As the cost savings resulting from joint monitoring efforts could be important, the intensive monitoring requirements of the MSFD can be a trigger to reconsider such potentialities. A good example of the use of same or shared instrumentation exists in the North Sea where United Kingdom and The Netherlands have a collaborative monitoring programme and are jointly operating a buoy measuring the rapidly changing environmental conditions in Dutch coastal waters [8]. The main aim of this collaboration is to allow comparison of the measurements obtained from the standard methods employed in a shipbased monitoring programme with the automated in situ buoy data.

In addition to the principles of integration and taking into account the wide spatial application of the MSFD, marine monitoring could potentially gain in effectiveness by approaches that are able to collect data from wide geographic areas [1]. A short overview of some indicative approaches follows below.

The Continuous Plankton Recorder [9] is a sampling instrument designed to be towed from ships at approximately 10 m. Water passes through the CPR and plankton is filtered onto a slow-moving band of silk. CPR can sample larger areas than other phytoplankton and zooplankton devices such as bottles and nets. Data on biomass can be easily taken while taxonomic identification requires the same skills and human power as with any other sampling method. CPR has also been used to monitor microlitter in the water column [10] but not floating debris.

The very efficient transmission of sound in water allows for hydroacoustic monitoring surveys. Sonars can be used for the detection and assessment of underwater physical (depth, bottom roughness and hardness) and biological (abundance, size, behavior and distribution of biota) characteristics. They are already widely used both by fishermen and scientists for the investigation of fish populations. Furthermore, detectors of passive acoustic signal could be considered for monitoring marine mammals (abundance, movements and location of their habitats) [11].

Underwater video cameras can take images of both the seabed and water column and collect information on the structure of the sea-bed, composition and abundance of macroscopic biota and non-living items, such as litter. They are being used for counting *Nephrops* burrows [12] and to obtain macrobenthos quantitative data [13].

Video cameras as well as other instrumentation can be tethered to oceanographic vessels but also to volunteer ferries, cruise ships and merchant vessels (ships of opportunity). A particularly interesting application is the FerryBox [14], an automatic flow-through system pumping sea water on the side of the ship and propelling it in an internal loop at constant velocity to conduct various measurements.

Earth Observation from satellites carrying optical sensors provides information at unprecedented time scales over large and distant areas of the world ocean in a real cost-effective way, where only few observations can be conducted by traditional methods using oceanographic vessels. Information includes chlorophyll, total suspended matter, pigmented fraction of dissolved organic matter and phytoplankton functional groups. Data are accessible freely through space agencies or via specific web sites such as the Environmental Marine Information System from the Joint Research Centre [15]. Additional information on the physical and biogeochemical state of EU marine areas can also be retrieved from the marine component of the European Commission-coordinated initiative on Global Monitoring for the Environment and Security (GMES) that integrates data collected by satellites and model outputs as well as in situ observations [16].

Autonomous underwater vehicles are free-swimming torpedo-shaped devices remotely operated from the surface, most often powered by rechargeable batteries and/or buoyancy-based techniques (gliders). They can cover large distance at various depths to provide a 3D view of the water column. They can carry physical and bio-optical instruments and measure nutrients, contaminants, phytoplankton biomass, temperature and oxygen. Video cameras and detectors of passive acoustic signals can also be installed.

The above-listed large-scale approaches have several limitations in terms of application in certain depths and habitats, taxonomic resolution, costs and technical expertise required but are worth considering, particularly in relation with the principles of integrated monitoring.

In conclusion, marine monitoring is needed for several pieces of EU legislation and MSFD requires some additional ones. It should be integrated in order to also be cost effective and could be facilitated by large scale approaches.

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