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Development of innovative tools for understanding marine biodiversity and assessing good environmental status: the EU project DEVOTES

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The Marine Strategy Framework Directive (MSFD) was issued in 2008, by the European Parliament and the European Council, for “establishing a framework for community action in the field of marine environmental policy” (Marine Strategy Framework Directive; MSFD, 2008/56/EC). Member States (MSs) therefore join together in their commitment to protect, preserve and, where practicable, restore the quality of the marine environment across Europe. The MSFD requires MSs to take the necessary measures to achieve or maintain Good Environmental Status (GES) in the marine environment, by the year 2020 at the latest.

The MSFD states that “in view of the dynamic nature of marine ecosystems and their natural variability, and given that the pressures and impacts on them may vary with the evolution of different patterns of human activity and the impact of climate change, it is essential to recognise that the determination of good environmental status may have to be adapted over time”. Further, the same section states: “Accordingly, it is appropriate that programmes of measures for the protection and management of the marine environment be flexible and adaptive and take account of scientific and technological developments”.

To assess GES, the MSFD requires the study of 11 descriptors (D), of which biological diversity is the first (Figure 1; Cochrane *et al.*, 2010). GES is defined as regarding the structure, functioning and processes of marine ecosystems, together with natural physiographic, geographic and climatic factors, and physical and chemical conditions including those derived from human activities. However, it is recognised that the dynamic interactions of human activities within ecosystems, which also are undergoing climate-driven changes, still are only partly understood. GES is further described in narrative terms (Borja *et al.*, 2010; Cardoso *et al.*, 2010) and its scientific basis outlined in Mee *et al.* (2008). This concept of environmental status, within the MSFD, therefore is a challenging issue and provides multiple opportunities for European marine research, in order to support the ecosystem-based approach to environmental management, which the MSs have undertaken to implement (Borja, 2006).

Biodiversity (D1), as a central MSFD descriptor, is one of the key factors which support ecosystem resilience and the sustainable provisioning of goods and services, which in turn contribute to the performance of economic systems and human

well-being (Holmlund and Hammer 1999; Worm *et al.*, 2006; Costanza *et al.*, 2007). Many indicators of biodiversity exist, most are mutually complementary, and representing different aspects of the multidimensional concept of biodiversity. However, to be informative at a societal level, biodiversity indicators need to be combined within integrated monitoring, modeling and decision-making frameworks (Vačkář *et al.*, 2012). Indicators of biodiversity should be used to translate biodiversity loss and degradation directly into policy responses. Regulatory policies based on such integrated knowledge-based mechanisms directly empower those who implement them to manage the risks of human exploitation of biodiversity and the environment in general, and to minimise the degradation of available ecosystem services.

A set of assessment criteria has been appointed for each of the MSFD descriptors for GES, and a further set of indicators has been developed for each of the criteria. In order for this assessment system to be applied to the issues outlined above, a conceptualisation of how the MSFD descriptors, criteria and indicators operate, at the various scales, and how they feed into management, is essential.

The implementation of the MSFD must benefit from experience gained via the RSCs and Water Framework Directive (Hering *et al.*, 2010). Each of the four European Regional Seas has some unique characteristics and is governed by their own RSC (i.e. OSPAR, HELCOM, Barcelona and Bucharest). These RSCs have started to implement ecosystem health assessments, based upon the principles of the MSFD (HELCOM, 2010a; OSPAR Commission, 2010). Additionally, international institutions have also implemented working groups on some descriptors (ICES, 2011) and different biodiversity and sustainability indicators are being developed by international networks (i.e. Canada Healthy Oceans Network, CHONe: <http://chone.marinebiodiversity.ca/>). Furthermore, EU member states, following the guidelines of the MSFD, are also conducting an initial assessment of the environmental status of the marine waters, which should be ready to the EC by July 2012. Nonetheless, a common issue has been raised throughout this process: the need for consistent harmonized approaches and principles in setting the GES criteria and targets across the four European Regional Seas.

For a better understanding of these concepts, recently a FP7 project, called DEVOTES (DEVELOPMENT OF innovative TOOLS for understanding marine biodiversity and assessing good Environmental Status) has been approved by the European Commission. The overall goal of DEVOTES is to better understand the relationships between pressures from human activities and climatic influences and their effects on marine

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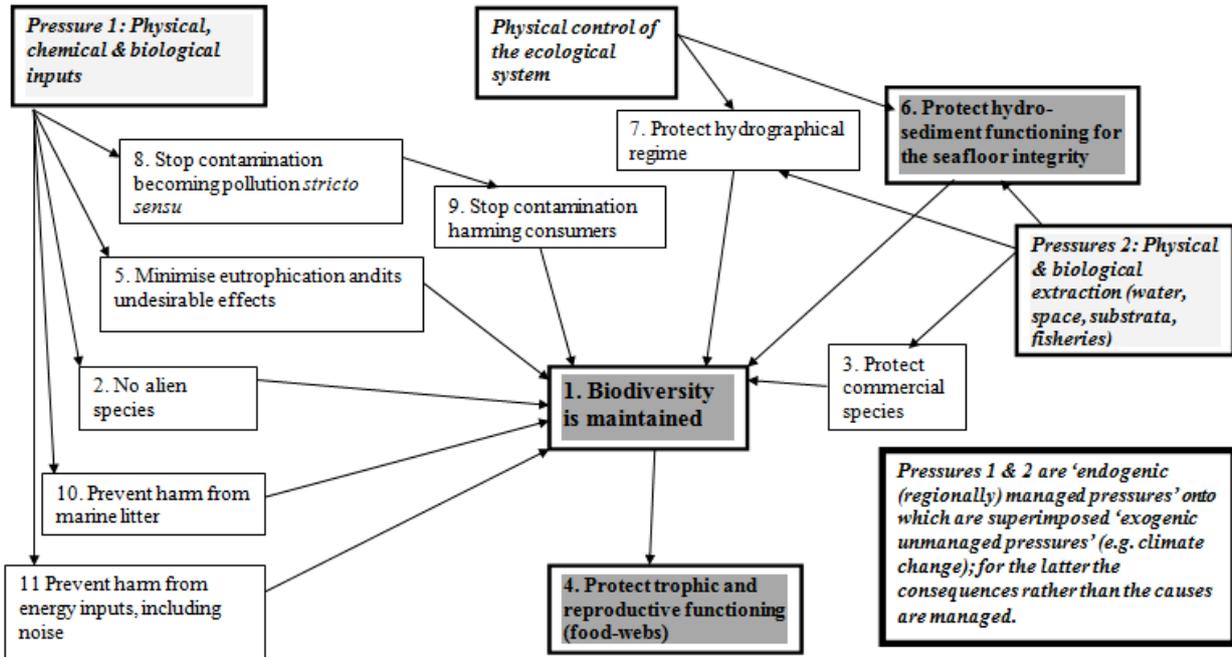


Figure 1. A conceptual model showing interlinks between managed and unmanaged pressures and the 11 qualitative descriptors covered by the MSFD (Borja *et al.*, 2010). Boxes with light grey shading are pressures, and boxes with dark grey shading are the descriptors investigated in DEVOTES (1, 4 and 6), indicators of marine biodiversity or relate closely to impacts of human activities and climatic influences on biodiversity.

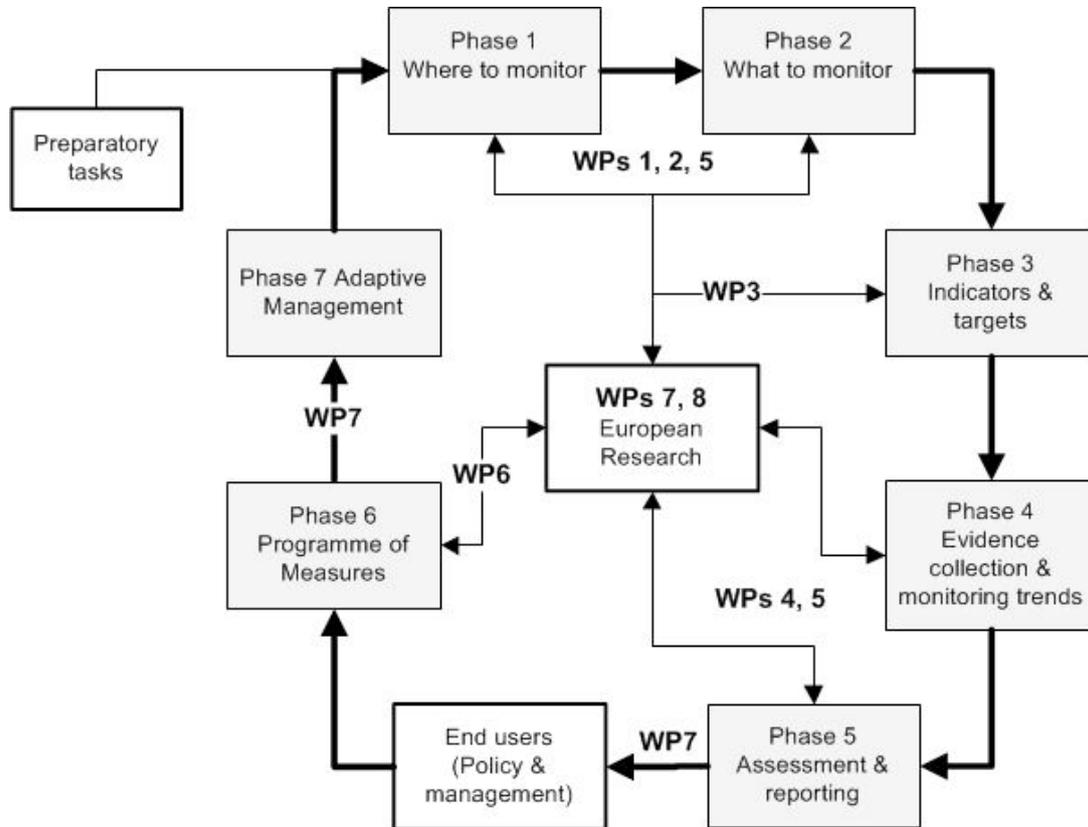


Figure 2. A conceptual model showing interlinks between the phases to be covered when implementing the MSFD and the European research, together with the Work Packages (WP) proposed in DEVOTES (Modified from Descriptor 1 report, Cochrane *et al.*, 2010).

ecosystems, including biological diversity, in order to support the ecosystem based management and fully achieve GES of marine waters. This will be undertaken in a harmonized way for the four regions identified in the MSFD, by testing and validating approved indicators, developing new ones when necessary, using modelling tools for the assessment of biodiversity, developing new monitoring tools and establishing an integrated way of assessing the environmental status of biodiversity and related descriptors (i.e. food-webs and seafloor integrity).

To build the DEVOTES concept and its system of Work Packages (WP) described below, we considered the cyclical phases of a monitoring and adaptive management programme, such as that conceptualised during the development of D1 for Biodiversity (Figure 2). Hence, considering the abovementioned framework the following five key objectives for DEVOTES have been established:

(i) Improve our understanding of the impact of human activities (cumulative, synergistic, antagonistic) and climate change on marine biodiversity, using long-term biodiversity and human pressures data from the 4 EU Regional Seas, both in pelagic and benthic environments (in WP1: ‘Human pressures and climate change’). This will identify the barriers and bottlenecks (socio-economic and legislative) that prevent GES from being achieved (in WP2: ‘Socio-economic implications of GES’) (for links with the MSFD implementation, see Figure 2).

(ii) Test the relevant indicators listed in EC (2010) and currently being compiled by the RSCs, and develop new, innovative ones to assess biodiversity at several ecological scales (species, habitats, ecosystems), including functional diversity, metagenomic and metagenetic analyses and approaches; test the relevant level of integration of the indicators to produce a holistic assessment of biodiversity (in WP3: ‘Indicator testing and development’) (for links with the MSFD implementation, see Figure 2), in a harmonized way throughout the 4 regional seas.

(iii) Develop, test and validate innovative integrative modelling (e.g. statistical, conceptual) and monitoring tools to further improve our understanding of ecosystem and biodiversity changes in space and time, applying both traditional sampling and autonomous data acquisition devices (in WP 4: ‘Innovative modelling tools’ and WP5: ‘Innovative monitoring techniques’). Such tools are required by statutory bodies, Small and Medium Enterprises (SMEs) and marine research institutes to monitor and assess biodiversity. These tools will improve our capacity to provide assessments and where possible predictive advice and strengthen the knowledge base necessary to effect sustainable management of seas and oceans resources. We will propose and demonstrate the pros and cons of innovative monitoring systems capable of efficiently and effectively providing data for many biodiversity parameters (including those used in non-EU countries), to be used as indicators of GES, and, finally, for integration into a unique and holistic assessment (in WP6: ‘Integrative assessment’; for links with the MSFD implementation, see Figure 2). It is important that, as far as possible, the methodologies developed are “platform independent”, i.e. they are sufficiently robust to be applied to data from multiple sources and still produce consistent and comparable results. This will

prevent assessments from neighbouring areas having very different outcomes due mainly to different methods of assessment.

(iv) Implement cost-effective indicators, monitoring and assessment strategies, which should enable uniform applicability across EU Regional Seas (in WP5) (for links with the MSFD implementation, see Figure 2), which will serve as operational tools for managers and policy makers, with a view to reduce pressures through actions.

(v) Propose and disseminate strategies and measures for ecosystems’ adaptive management (related to EA), with consultation of MSs. These strategies will include the active role of industry and relevant stakeholders (including non-EU states) and an economic assessment of the consequences of the management practices proposed by DEVOTES (in WPs 2 and 6, but also in WP7: ‘Outreach, stakeholder engagement and product dissemination’) (for links with the MSFD implementation, see Figure 2). These actions will promote EU-wide harmonisation in the environmental status classification of the marine waters in the four regions for a coherent implementation by all MSs.

This contribution will present the main tasks to be developed within the DEVOTES project.

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