Marine Strategy Framework Directive: Current Gaps in Microbiological Issues

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Editorial

One important objective for the preservation of natural equilibria of aquatic ecosystems has been reached with the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) by the European Parliament and the Council of the European Union, adopted on June 17, 2008 [1]. This Directive answers to the needs underlined by the European Community (EC) to reduce impacts on marine waters, since there is an increased awareness that marine environments are important resources which need protection, preservation and restoration and that it is required to maintain their biodiversity and keep them clean, healthy and productive [2]. Therefore, the MSFD integrates the concepts of protection and sustainable use of the marine environment; it indicates as its main objective the achievement and/or maintenance of Good Environmental Status (GES) by the year 2020. In order to meet this objective, each Member State is required to find and adopt any measure needed to protect GES. Moreover, MSFD states that different and specific solutions are required by various marine regions or sub-regions in the Community, due to the occurrence of diverse conditions, problems and needs.

The achievement of GES is assessed in terms of 11 descriptors (D), which are expressively defined by the Directive: D1, Biological Diversity; D2, Non indigenous species; D3, Fishery stocks; D4, Trophic webs; D5, Eutrophication; D6, Sea floor integrity; D7, Alterations of hydrological conditions; D8, Contaminants; D9, Contaminants in fish and other seafood for human consumption; D10, Marine Litter; D11, Underwater noise.

Associated to each descriptor there are several criteria and indicators; these are indicated in the Decision of the European Commission (2010/477/EU) on criteria and methodological standards on GES of marine waters, which came into force in Italy with the Legislative Decree n. 190 of October 13, 2010 [3].

Every six years, implementation and up-to-date of the Directive is taken into consideration, to fill some gaps and to make MSFD more adequate to answer to the needs of environmental assessment and preservation.

In its current version, microbial community and related parameters are neglected by the MSFD and Decision 2010/477/EU. In the MSFD, the sole reference to bacteria is in terms of microbial pathogens, whose introduction is responsible for biological disturbance in the marine environment. However, comparing the monitoring parameters reported in the MSFD Annex III and their relevant MSFD indicators reported in the 2010/477/EU, the parameter 'Introduction of microbial pathogens', although specifically indicated in the MSFD, is not reflected in the Decision of European Commission on GES criteria [4]. Therefore the Element 'Microbial pathogens' does not have a specific GES descriptor in the MSFD Annex I.

The lack of this component- which represents the lower level of the trophic web- is still a matter of scientific debate. Indeed, Prokaryotes (bacteria and archaea) are now recognized as the most abundant living component of the biosphere with approximately 12×10^{28} cells/ litre found in the oceanic water column and about 10^8-10^9 cells/litre in the Mediterranean waters. Moreover, these biological components are major players in regulating nutrient and energy fluxes within aquatic ecosystems [5-8].

Microbes are relevant to several MSFD Descriptors, notably Descriptor 1 (D1, Biological Diversity); Descriptor 4 (D4, Food webs), Descriptor 5 (D5, Eutrophication), Descriptor 8 (Contaminants).

Within the deadline of April, 30, 2013, all Member States have reported to the EC on the state of their marine waters, focusing on their essential features and characteristics, and on their predominant pressures and impacts. They have also reported on what they consider as a GES and on the objectives and targets they have set to reach GES by 2020 (articles 8, 9 and 10 of the MSFD). The Reporting on the initial assessment (Art. 8 of MSFD) has been carried out by each State at the level of 'assessment areas' (AAs). For each AA an analysis of pressures, impacts and activities was carried out, according to the DPSIR procedure [9]. About the current state of art of MSFD in Italy, an agreement was signed in 2012 between Italian National Research Council (CNR) and Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), and some Working Groups cooperated for each Descriptor to indicate criteria, indicators and thresholds for GES achievement.

What actions have been performed in Italy under MSFD in terms of microbial components? Concerning the Reporting sheets for Microbial pathogens submitted to the EC, these were filled using data collected under other EU Directives and National laws (Water Framework Directive, Bathing water Directive 2006/7/EC). Data on faecal contamination indicators (i.e. intestinal enterococci and *Escherichia coli*) were gathered and analyzed for their spatial and temporal variations to describe the level of pressure related to sewage pollution in the different AA. Conversely, the impact analysis of Microbial pathogens on the marine environment has not been completed, since data on mortality of biota, shifts in community structure are not yet available.

Concerning the Descriptor 9 "Contaminants in fish and other seafood for human consumption", to date only chemical contaminants are considered, but the Working Group coordinated by dr. G. Marino (ISPRA, Rome) stressed the importance of considering also microbial contaminants for a better assessment of the safety of fishery products. For marine areas designed for shellfishculture, the bacteriological quality of Western Mediterranean, Adriatic, Ionian and Central Mediterranean waters was analyzed. Monitoring of microbial pathogens in shellfish waters was performed under the Shellfish Water

Directive 2006/113/EC (National Decree 152/2006), and the Shellfish Hygiene Regulations (Reg. 854/2004/EC, Reg. 853/2004/EC, Reg. 2073/2005/EC, Reg. 1021/2008/EC). The first gives provision on the concentration of faecal coliforms in shellfish waters, the others on *Escherichia coli* and *Salmonella* spp.

Some debates and workshops of the scientific community interested in environmental safeguard and protection have focused on the need to revise the use of the planktonic community as a possible indicator for the assessment of ecological quality status of marine ecosystems; many studies have underlined the gaps in its current version, offering new insights for its implementation. As one example, a Workshop has been organized on December 13, 2013 at the National Research Council in Rome to discuss on "The Plankton in the Marine Strategy Framework Directive: proposals of monitoring for environmental status assessment". It gathered members of Italian government (Ministry of Environment), researchers, local Regional Agencies for Environmental Protection (ARPA) and other stakeholders working with or in relation to the European marine environment. At European level, the STAGES (Science and Technology Advancing Governance on Good Environmental Status) project- which is an EU FP7 Coordination and Support Action Project- is designed to directly address the knowledge deficit which may hinder full implementation of the MSFD and the achievement of GES in European waters. Within this project, coordinated by Centro Tecnológico del Mar (CETMAR, Spain), a survey was sent to European marine stakeholders working at a European, Regional and National levels (http://www.stagesproject.eu/) to collect information about the ecological status from many aquatic environments.

Starting from July 2014, monitoring plans will be performed under MSFD considering only two components of the planktonic community - phytoplankton and zooplankton - for which specific criteria and indicators have been detailed in the 2010/477/EU Decision. For the bacterioplankton, some proposals have been drawn and put forward to implement Monitoring Plans. As the current version of the MSFD does not consider the ecological significance of microbially-mediated processes in water biogeochemistry, efforts have been made to underline that, due to the role of bacteria in ecosystem functioning - both as decomposizers and producers - and their ability to modulate their metabolism in response to environmental changes, microbial community should be taken into account in biodiversity and ecological quality monitoring programmes, as previously stated in multidisciplinary research approaches [10-14].

Considering the future of MSFD, more efforts are urgently needed if the EU wants to reach its goal. Specific challenges for future implementation of the Directive are: the definition of coordinated monitoring plans for the ongoing assessment of the environmental status of their marine waters; the inter-calibration of protocols and procedures for in situ monitoring; the choice of reference sites. Substantial work is still needed to clearly define the use of planktonic communities as indicators for the assessment of GES, due to the lack of data with adequate spatial and temporal coverage and lack of established methods at the regional and/or subregional level [9]. Future implementation of MSFD should consider also microorganisms such as *Vibrio* spp., enteric viruses as well as protozoa, which are recognised as emerging pathogens, besides commonly used indicators (enterococci, *Escherichia coli* and *Salmonella* spp.). Specific reference methods for their detection, which are still lacking, should be reported. Moreover, algal biotoxins (e.g. PSP, ASP, DSP, YTX, AZA) regulated by the EU Regulation 853/2004 and Reg. 854/2004, should be also mentioned among health issues in shellfish waters as potential source of severe intoxication in consumers and cause of the closures of numerous shellfish production areas. There is an urgent need to investigate issues related to the microbial role in ecosystem functioning across a range of ecological zones, the potential influence of climate-induced warming on microbial function in marine ecosystems and the relationships between pressures and microbial function, particularly for sea-floor impacts, such as physical disturbance and organic loading. All these aspects constitute a serious knowledge gap of the MSFD which has been recognized by the scientific community working in the field of microbiology and biotechnologies [9-11,15]. They need to be addressed in the future MSFD implementation. Particularly, the inclusion of the microbial community within the MSFS could give useful contributions whether environmental quality assessment is considered under a holistic point of view [16,17].

Acknowledgments

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