Cellular and Molecular Biology
E-ISSN : 1165-158X / P-ISSN : 0145-5680
www.cellmolbiol.org

Editorial

Biomarkers in marine ecosystems monitoring

Sabrina Oliva

Department of Chemical, Biological, Pharmaceutical and Environmental Sciences, University of Messina, Viale F. Stagno d'Alcontres n. 31, 98166 Messina, Italy

Correspondence to: soliva@unime.it

Received November 29, 2017; **Accepted** November 29, 2017; **Published** December 15, 2017

Doi: http://dx.doi.org/10.14715/cmb/2017.63.12.1

An increasing awareness of the importance of protecting, conserving or enhancing marine ecosystems has risen over the past decades as a consequence of the growing human impacts on marine areas and the possible detrimental effects for the environment and human health.

The European Union Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC) (1) aiming to achieve or maintain 'Good Environmental Status' (GES) in EU waters by 2020 evidences the need to assess the status of marine areas and to develop new monitoring strategies and approaches to quantify impacts of contaminants in marine ecosystems (2-4).

Recent marine environmental monitoring programmes aim to assess the level of contamination in marine areas evaluating the effects of different stressors, including contaminants, on marine organisms, thus linking contaminants with the health of the ecosystem in term of biological effect, and biomarkers, defined as measurable alterations occurring at molecular, cellular, and physiological levels in response to environmental stressors, have been recognized as remarkable tools for the biological effect assessment in marine environmental monitoring. Several biomarkers have been evaluated in various sentinel organisms in response to different contaminants and have also been adopted in the framework of international biomonitoring programs (5-7) to study the quality of the aquatic environment.

Among the sentinel organisms, mussels (*Mytilus* spp.) have long been utilized as a bioindicator for biomonitoring of marine pollution (8-10) and currently the investigations on pollutant responsive biomarkers in mussels count 10% of all reported biomarker studies (11).

Through the years, the studies mainly conducted in strictly controlled laboratory conditions, to assess the impacts of different environmental stressors on the biological response in mussels, have provided suitable sets of biomarkers with a great potential for biomonitoring of marine ecosystems.

Since the advancements in genomics have been applied in marine sciences a boost promoting biomarker discovery has come from our knowledge of the molecular mechanisms underlaying the physiological response of marine organisms to environmental stressors, including chemicals and emerging contaminants, thereby giving new valuable tools for assessing marine health status (12). Moreover, it is becoming increasingly evident that distantly related species share common response pathways to the same environmental stimuli and biomarkers early identified in response to one stressor are actually involved in the response to multiple environmental stressors (12,13).

Transcriptomic approaches contributed to the identification of unknown hypoxia-responsive biomarkers in mussels *Mytilus galloprovincialis* experimentally subjected to air exposure (14) that have effectively applied in ecotoxicological studies of natural marine areas (15) and are likely to be used in future environmental monitoring studies of hypoxic areas that are expected to increase worldwide.

Multi-biomarker approaches have been successfully applied for assessing the impacts of climate change and anthropogenic contaminants on aquatic organisms and demonstrated to be valuable tools not only to reveal the presence of stressor(s) but also to recognize regions of reduced ecosystem health. In particular, the application of a multi-biomarker panel resulted effective for assessing the biological effects of petrochemical contamination on the health status of mussels *Mytilus galloprovincialis* (11,15).

Despite the relationships between exposure to contaminant(s) and biological responses in mussels have been widely addressed, at least for persistent organic pollutants (POPs) and metals (Cu, Hg, Pb, and Zn) pollution, great attention has recently focused on the contaminants of emerging concern including pharmaceuticals and personal care products, microplastics and nanoparticles that are currently recognized as environmental threats in the aquatic environment (16-20). The few investigations on their effects in marine organisms, evidenced several responses at molecular level, physiological performance and organisms health depending on the species under study, and both of kind and concentration of contaminant.

Noteworthy, the rapid development of various omic

methodologies, namely genomics, transcrptomics, metabolomics and proteomics together with the more recent epigenomics, and their successful application in pollution biomonitoring supported the discovery of new biomarkers, thereby providing novel approaches integrating monitoring of chemicals and their biological effects on sentinel species (21).

Future studies should focus on multidisciplinary approach (genomics, proteomics and metabolomics) to understand the synergetic effects of multiple environmental stressors, especially emerging pollutants under field conditions, on marine organisms and to reveal the complexity of anthropogenic impacts on aquatic environment.

Scientific evidences should therefore support the active role of the governments in rising public awareness on environmental concerns and in developing new and efficient strategies to achieve marine ecosystem health.

References

1. European Commission Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Off. J. Eur. Union 2008; L164, 19–40

2. Borja A, Elliott M, Andersen JH, Cardoso AC, Carstensen J, Ferreira JG, Heiskanen AS, Marques JC, Neto JM, Teixeira H, Uusitalo L, Uyarra MC, Zampoukas N. Good Environmental Status of marine ecosystems: what is it and how do we know when we have attained it? Mar Pollut Bull 2013; 76:16-27.

3. Hylland K, Burgeot T, Martínez-Gómez C, Lang T, Robinson CD, Svavarsson J, Thain JE, Vethaak AD, Gubbins MJ. How can we quantify impacts of contaminants in marine ecosystems? The ICON project. Mar Environ Res 2017; 124:2-10.

4. Vethaak AD, Davies IM, Thain JE, Gubbins MJ, Martínez-Gomez C, Robinson CD, Moffat CF, Burgeot T, Maes T, Wosniok W, Giltrap M, Lang T, Strand J, Hylland K. Integrated indicator framework and methodology for monitoring and assessment of hazardous substances and their effects in the marine environment. Mar Environ Res 2017; 124:11-20.

5. ICES Report of the Study Group on Integrated Monitoring of Contaminants and Biological Effects (SGIMC), 14–18 March 2011, Copenhagen, Denmark. ICES CM 2011/ACOM. 30 (265 pp.)

6. OSPAR Background Document and Technical Annexes for Biological Effects Monitoring, Update 2013, ISBN 978-1-909159-22-8, p. 238. Monitoring and Assessment Series 589/2013

7. OSPAR Technical Annex on Supporting Parameters for Biological Effects Measurements in Fish and Mussels. Background Document and Technical Annexes for Biological Effects Monitoring, Update 2013, ISBN 978-1-909159-22-8, pp. 211-219. Monitoring and Assessment Series 589/2013

8. Viarengo A, Lowe D, Bolognesi C, Fabbri E, Koelher A. The use of biomarkers in biomonitoring: a 2-tier approach assessing the level of pollutant induced stress syndrome in sentinel organisms. Comp Biochem Physiol C Toxicol Pharmacol 2007; 146:281-300.

9. Fasulo S, Guerriero G, Cappello S, Colasanti M, Schettino T, Leonzio C, Mancini G, Gornati R. The ‘‘SYSTEMS BIOLOGY’’ in the study of xenobiotic effects on marine organisms for evaluation of the environmental health status: biotechnological applications for potential recovery strategies. Rev Environ Sci Biotechnol 2015; 14:339–345.

10. Martínez-Gómez C, Robinson CD, Burgeot T, Gubbins M, Halldorsson HP, Albentosa M, Bignell JP, Hylland K, Vethaak AD. Biomarkers of general stress in mussels as common indicators for marine biomonitoring programmes in Europe: The ICON experience. Mar Environ Res 2017; 124:70-80.

11. Beyer J, Green NW, Brooks S, Allan IJ, Ruus A, Gomes T, Bråte ILN, Schøyen M. Blue mussels (Mytilus edulis spp.) as sentinel organisms in coastal pollution monitoring: a review. Mar Environ Res 2017; 130:338-365.

12. Bourlat SJ, Borja A, Gilbert J, Taylor MI, Davies N, Weisberg SB, Griffith JF, Lettieri T, Field D, Benzie J, Glöckner FO, Rodríguez-Ezpeleta N, Faith DP, Bean TP, Obst M. Genomics in marine monitoring: new opportunities for assessing marine health status. Mar Pollut Bull 2013; 74:19-31.

13. Giannetto A, Fernandes JMO, Nagasawa K, Mauceri A, Maisano M, De Domenico E, Cappello T, Oliva S, Fasulo S. Influence of continuous light treatment on expression of stress biomarkers in Atlantic cod. Dev Comp Immunol 2014; 44:30-34.

14. Giannetto A, Maisano M, Cappello T, Oliva S, Parrino V, Natalotto A, De Marco G, Barberi C, Romeo O, Mauceri A, Fasulo S. Hypoxia-Inducible Factor α and Hif-prolyl Hydroxylase characterization and gene expression in short-time air-exposed Mytilus galloprovincialis. Mar Biotechnol 2015; 17:768-781.

15. Maisano M, Cappello T, Natalotto A, Vitale V, Parrino V, Giannetto A, Oliva S, Mancini G, Cappello S, Mauceri A, Fasulo S. Effects of petrochemical contamination on caged marine mussels using a multi-biomarker approach: histological changes, neurotoxicity and hypoxic stress. Mar Environ Res 2017; 128:114-123.

16. Gomes T, Pinheiro JP, Cancio I, Pereira CG, Cardoso C, Bebianno MJ. Effects of copper nanoparticles exposure in the mussel Mytilus galloprovincialis. Environ Sci Technol 2011; 45:9356-62.

17. Schmidt W, Rainville LC, McEneff G, Sheehan D, Quinn B. A proteomic evaluation of the effects of the pharmaceuticals diclofenac and gemfibrozil on marine mussels (Mytilus spp.): evidence for chronic sublethal effects on stress-response proteins. Drug Test Anal 2014; 6:210-219.

18. Renault T. Immunotoxicological effects of environmental contaminants on marine bivalves. Fish Shellfish Immunol 2015; 46:88-93.

19. Avio CG, Gorbi S, Regoli F. Plastics and microplastics in the oceans: from emerging pollutants to emerged threat. Mar Environ Res 2017; 128:2-11.

20. Cappello T, Vitale V, Oliva S, Villari V, Mauceri A, Fasulo S, Maisano M. Alteration of neurotransmission and skeletogenesis in sea urchin Arbacia lixula embryos exposed to copper oxide nanoparticles. Comp Biochem Physiol C Toxicol Pharmacol 2017; 199:20-27.

21. Holland N. Future of environmental research in the age of epigenomics and exposomics. Rev Environ Health 2017; 32:45-54.