Best Biomarker and Bioindicator for Marine Environmental Pollution

Elisabetta Tosti* and Alessandra Gallo
Stazione Zoologica, Naples, Italy

In recent decades, large amount of diverse xenobiotics have been released into the marine environment as a consequence of anthropogenic (agricultural/urban/industrial) activities. These substances include heavy metals, herbicides, pesticides, fungicides, plasticizers, polystyrenes, phenols, dioxins and organotins [1]. This environmental pollution represents a serious hazard for marine animals since the impact on their endocrine systems may result in reproductive problems. In fact, it has been shown that xenobiotics may affect the mechanisms of fertilization and early development, leading to disruption of normal reproductive function in adulthood [2]. In this respect xenobiotics are considered as endocrine disruptors (EDs) since they are capable of disrupting the endocrine system of animals, including fish, wildlife, and humans due to an interference with the normal mechanisms of hormone action [3].

Some of the EDs have been prohibited due to their adverse effects on human health and the environment; however they persist in the environment because of their accumulation in sediments, the following release into the aquatic environment, and accumulation in the tissues of organisms. It is now commonly recognized [4] that an irreversible induction of male sex characteristics on females (imposex) marine snails is due to exposure to organotin compounds used as the active agent in antifouling paints for their biocide properties. Heavy metals are also recognized as major pollutants of the marine environment, and there are clear indications of their toxic effects on marine organisms exerting a negative impact on reproductive processes such as gamete functionality, embryogenesis, embryo development, metamorphosis, growth and survival [5]. Eco toxicological studies of the marine environment are addressed to ecological risk assessment.

Provision of ecologically relevant effects might be achieved using biomarkers/bioindicators that are defined as processes/organisms that provide information on the environmental quality through identifiable reactions (biochemical, physiological and morphological). Biomonitoring programs of marine environment are still focused to identify the best biomarker and bioindicator acting as prognostic tool for the marine pollution levels. At the beginning of this decade many molecular biomarkers have been used as diagnostic tools to evidence the presence of pollutants in the environment and their potential endocrine disrupting effects. Among them, they have been identified vitellogenin, zona radiata proteins and oxidases in fish species of commercial interest [6]. Other authors identified estrogen-regulated proteins such as cathepsin D and its gene expression as the result of powerful pollutants impact. In addition, an evident biomarker role was shown to be played by Heath Shock Protein 70 (HSP70) that protects cells against harmful conditions by binding and refolding damaged proteins. HSP70 gene expression was shown to be significantly increased by exposure to pollutants in marine teleosts [7].

Among biomarkers, the followings have also received special attention: cytochrome P4501A induction, DNA integrity, acetylcholinesterase activity (AchE) and metallothionein induction. Each of them may be successfully used as a potential biomarker of exposure to specific pollutants [8]. In a recent survey, some of these latter biomarkers were shown to indicate neurotoxicity; in particular AchE activity proved to be the most responsive biomarker at sites influenced by agricultural, urban and industrial activities [9].

Of interest is also the role played by enzymes that are responsible for metabolizing xenobiotics. Their use is increasing by means of different experimental approaches. Although contrasting data are reported in the literature [10], the induction of cytochrome P4501A enzymes that are involved in chemical carcinogenesis, play a central role in transforming pesticides in aquatic organisms [11].

On the contrary, the use of metallothioneins (MTs) seems to be recognized as the most valid method to indicate metal exposure. Infact MTs are induced by metals residues and measurements of their levels are at present used in both vertebrates and invertebrates [8]. More recently, classical bio monitoring strategies are going to be modified initiating to consider the organisms and some of their peculiar processes to represent alternative biomarkers. There is an increasing evidence for a significant role of marine invertebrates in assessing impacts of environmental pollutants. Hence, in last years big efforts have been aimed to identify the most relevant model organism to test toxicity looking first at characteristics such as a abundance in nature, the ecological and commercial importance and the position in marine food chains especially for what concern the transfer of energy. Although many authors have tried to point on vertebrates [3, 12,13], various species of sentinel marine organisms such as polychaetes, copepods, mussels, clams, oysters, snails, fishes, etc. [8,14-16] have been recognized to be reliable candidates for routine ecotoxicity testing. Mussels have been indicated as the target of pharmacological reactions to pollutants, in particular for the organotin-induced imposex that ultimately may result in a sterilization of females [17]. Since reproductive mechanisms of marine invertebrates appear to be very sensitive to pollutants, this kind of studies have focused on the importance of the reproductive systems and process as the target of environmental contamination. In this respect, a recent paper evidenced as metals are able to interfere with the molecular mechanisms at the basis of reproductive process in the ascidian Ciona intestinalis [5] confirming previous observations [18] on the role of Tunicates as model organism for testing coastal pollution toxicity. The fact that Ciona matches all the requisites to be a bio indicator and shows the closest evolutionary relationships with the vertebrates [19], makes it and its reproductive process good candidates to detect ecological risk at the level of populations and communities.

*Corresponding author: Elisabetta Tosti, Animal Physiology and Evolution laboratory, Stazione Zoologica Anton Dohrn, Napoli, Italy, Tel: 39-081-5833288; Fax: 39-081-7641355; E-mail: tosti@szn.it

Received March 13, 2012; Accepted March 15, 2012; Published March 17, 2012.

Citation: Tosti E, Gallo A (2012) Best Biomarker and Bioindicator for Marine Environmental Pollution. J Marine Sci Res Development 2:e101. doi:10.4172/2155-9910.1000e101

Copyright: © 2012 Tosti E, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
Conclusions

The search to identify biomarkers in marine pollution monitoring is clear since from last two decades. International meetings and experts (2nd Iberian Congress of Environmental Contamination and Toxicology; the Wingspread work session; OECD Test Guidelines Programme; US Environmental Protection Agency) have brought this need to the attention of scientific community.

Data reported here shows contrasting results in the selection of appropriate molecules, systems and animal models that make difficult to indicate the more reliable and relevant test system.

However, because invertebrates are key components of all marine ecosystems [20] and their health and survival are seriously threaten by marine pollution, it appear that, close to a combination of the selected biomarkers, most toxicity assessments may rely on a marine invertebrate model and its reproductive process for the more efficient assessment of the impact of marine contaminants.

References

1. Wurz O, Obbaid J (2004) A review of pollutants in the sea-surface microlayer (SML): a unique habitat for marine organisms. Mar Pollut Bull 48: 1016-1030.
2. Danzo B (1997) Environmental xenobiotics may disrupt normal endocrine function by interfering with the binding of physiological ligands to steroid receptors and binding proteins. Environ Health Perspect 105: 294-301.
3. Hotchkiss AK, Rider CV, Blackstone CR, Wilson VS, Hartig PC, et al. (2008) Fifteen years after “Wingspread”–environmental endocrine disrupters and human and wildlife health: where we are today and where we need to go. Toxicol Sci 105: 239-259.
4. Tiley-O’Neal CP, Munkittrick KR, Macdonald BA (2011) The effects of organotin on female gastropods. J Environ Monit 13: 2360-2388.
5. Gallo A, Silvestre F, Cuomo A, Papoff F, Tosti E (2011) The impact of metals on the reproductive mechanisms of the ascidian Ciona intestinalis. Marine Ecology 32: 222-231.
6. Fossi MC, Casini S, Marsili L, Nerl G, Mori G, et al. (2002) Biomarkers for endocrine disrupters in three species of Mediterranean large pelagic fish. Mar Environ Res 54: 667-671.
7. Carnevali O, Maradonna F (2003) Exposure to xenobiotic compounds: looking for new biomarkers. Gen Comp Endocrinol 131: 203-208.
8. Sarkar A, Ray D, Shrivastava AN, Sarker S (2006) Molecular Biomarkers; their significance and application in marine pollution monitoring. Ecotoxicology 15: 333-340.
9. Tsangaris C, Kormay K, Strogyloou E, Hatzianestis I, Neofitiou C, et al. (2010) Multiple biomarkers of pollution effects in caged mussels on the Greek coastline. Comp Biochem Physiol C Toxicol Pharmacol 151: 369-378.
10. Cajaraville MP, Bebbiano MJ, Bisancio J, Porte C, Sarasquete C, et al. (2000) The use of biomarkers to assess the impact of pollution in coastal environments of the Iberian Peninsula: a practical approach. Sci Total Environ 247: 295-311.
11. Katagi T (2010) Bioconcentration, bioaccumulation, and metabolism of pesticides in aquatic organisms. Rev Environ Contam Toxicol 204: 1-132.
12. Ankley GT, Johnson RD (2004) Small fish models for identifying and assessing the effects of endocrine-disrupting chemicals. ILAR J 45: 469-483.
13. Scholz S, Mayer I (2008) Molecular biomarkers of endocrine disruption in small model fish. Mol Cell Endocrinol 293: 57-70.
14. Hutchinson TH, Jha AN, Dixon DR (1995) The polychaete Platynereis dumerillii (Audouin and Milne-Edwards): a new species for assessing the hazardous potential of chemicals in the marine environment. Ecotoxicol Environ Saf 31: 271-281.
15. Raisuddin S, Kwok KW, Leung KM, Schlenk D, Lee JS (2007) The copepod Tigriopus: a promising marine model organism for ecotoxicology and environmental genomics. Aquat Toxicol 83: 161-173.
16. Lee KW, Raisuddin S, Hwang DS, Park HG, Lee JS (2007) Acute toxicities of trace metals and common xenobiotics to the marine copepod Tigriopus japonicus: Evaluation of its use as a benchmark species for routine ecotoxicity tests in Western Pacific coastal regions. Environ Toxicol 22: 532-538.
17. Horiguchi T (2006) Masculinization of female gastropod mollusks induced by organotin compounds, focusing on mechanism of actions of tributyltin and triphenyltin for development of imposex. Environ Sci 13: 77-87.
18. Zega G, Pennati R, Candidi S, Pestarino M, De Bernardi F (2009) Solitary ascidians embryos (Chordata, Tunicata) as model organisms for testing coastal pollutant toxicity. ISJ 6: S29-S34.
19. Delius F, Brinkmann H, Chourrout D, Philippe H (2006) Tunicates and not cephalochordates are the closest living relatives of vertebrates. Nature 439: 969-969.
20. Ramirez Llodra E (2002) Fecundity and life-history strategies in marine invertebrates. Adv Mar Biol 43: 87-170.
21. Gray LE, Jr, Wilson V, Noriega N, Lambright C, Furr J, et al. (2004) Use of the laboratory rat as a model in endocrine disruptor screening and testing. ILAR J 45: 425-437.