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Adverse Effect of Ocean Acidification on Marine Organisms

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Editorial

Evidence over the past 20 years indicates that marine organisms live in a multistressor environment caused by anthropogenic activities since industrialization and agriculture have generated chemical pollution along with several modifications of the ocean temperature and pH [1].

Ocean acidification (OA) is a process induced by a change in the chemistry of carbonate. In normal situations carbon dioxide (CO^2) is produced by either photosynthesis and respiration and in long term scale by geological processes, however the excess of CO^2 generated by fuel burning and industries and released in the atmosphere is up-taken and stored in the oceans [2]. Such dissolved CO^2 into the water surface is progressively creating a pH gradient towards more acidic conditions ultimately resulting in a generalized pH decline. pH of coastal marine waters varies of about 0.5 units in physiological conditions, however different conditions as seasonality, circadian cycles and runoff may strongly influence pH oscillations. At present, scientific community is alarming since it has been predicted that mean global pH will decrease of about 0.5 units within 2,100 generating a diffused OA. Furthermore OA will be accompanied by a generalized global warming [3] and changes of other parameters such as salinity and available oxygen. These multistress conditions may seriously threat marine species that live and reproduce along the coasts inducing pronounced deleterious effects on structure and functions of marine ecosystems.

Acidification impacts physiological cell processes by influencing the acid–base balance or redox affecting in turn cellular homeostasis which is at the basis of several metabolic, osmotic and ionic pathways.

In recent years, many studies have been addressed to evaluate possible impacts of low pH on marine animals [4]. It is known that calcified structures associated with some marine species play a fundamental role in protecting organisms from predators and in improving the access to light and nutrients. Many authors demonstrated a reduced calcification rates in shell/skeletons building of marine organisms from plankton to echinoderms, corals and benthic molluscs submitted to acidified seas conditions. In particular several calcifying species exhibited a reduced calcification and growth rates in laboratory experiments under high-pCO^2 conditions. Other studies, performed in mesocosms and natural waters around volcanic vents areas, did show a clear reduction of calcareous epibionts that in turn impacted the diversity of seagrass species [5]. Conversely, it was observed that sea urchin, corals and mussels are able to survive to a decreased calcification but suffer for a reduced mechanical performance affecting in turn key biotic and abiotic interactions [6]. The structural integrity of components such as shells in bivalve mussels is fundamentals to deter predator's actions as well as is important biomaterials aimed to ensure the attachment of animals to the rocks such as proteinaceous byssal threads that anchor mytilid mussels to hard substrates. These structures have been shown to be weak and less extensible when secreted under elevated pCO2 conditions, thus exerting a reduced mechanical performance. When attachments to the rocks are weakened it is enhanced an hazard for suspended-mussel farms and for intertidal communities anchored by mussel beds [7].

It is known that organisms show different physiological and behavioral responses to environmental stress conditions and that may adapt to abiotic stressors by changing their way to feed grow and reproduce [8]. At present, few studies have been aimed to examine the plasticity of organisms to adapt to negative conditions. Marine invertebrates are key components of all ecosystems and most of them have shown to be able to adapt to environmental changes [9]. Nonetheless these encouraging results, it is difficult to predict if and how these organisms will be able to adapt to ocean pH decrease over long time scale.

Furthermore it is still to be elucidated the potential adverse effects of OA on reproductive processes, as gamete functionality, fertilization, embryo development and larval metamorphosis. The impact of environmental stress on reproductive mechanisms may drastically affect fitness, growth, survival, distributions and abundances of marine organisms in turn posing at risk population dynamics up to the extinctions of species' groups. It is of interest that some organisms are able to live and reproduce in extreme habitats, such as volcanic areas and, depending on the habitat, in presence of multiple stressors. How organisms respond to multiple stressors is critical and is matter of intense investigations [10]. These studies are critical to provide hints on the adaptive shifts that have accompanied the evolutionary capacity of the species. Finally it must be highlighted that basic reproductive mechanisms of marine organisms may also be of help to shed light on the biochemical mechanism of plasticity and the stress tolerance capability occurred during the course of evolution.

Conclusion

It is clear that the threat of OA on marine ecosystems and species represents a priority for future investigations and large-scale investments in green-energy sources [11].

The most important challenge of research is to identify the vulnerability of some physiological processes of key marine species but also rate of tolerance and adaptation capability to the global climate change [12].

In this line we would like to conclude this short editorial quoting a statement that is often attributed to Charles Darwin: It is not the strongest species that survive, nor the most intelligent, but the ones most responsive to change.

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