Journal of Coastal Development

Wang You-Ji, J Coast Dev 2014, 17:1
http://dx.doi.org/10.4172/1410-5217.1000e105

Editorial Open Access

The Future of Marine Invertebrates in Face of Global Climate Change

Wang You-Ji*

College of Fisheries and Life Science, Shanghai Ocean University, Shanghai 201306, China

***Corresponding author: Wang You-Ji**, College of Fisheries and Life Science, Shanghai Ocean University, Shanghai 201306, China, Tel : +021 61900505; E-mail: yj_wang@shou.edu.cn

Received date: April 15, 2014; **Accepted date:** April 18, 2014; **Published date:** April 25, 2014

Global Warming and Sea Temperature Rise

Average sea surface temperature is now 0.6°C warmer than at the start of the industrial revolution [1], and a further increase of 3-6°C is forecasted by the end of this century because of elevated levels of atmospheric carbon dioxide [2,3]. The effects of global warming on marine species include range shifts, population collapses, local extinctions, and phase shifts, which result from individual physiological and behavioural responses to increasing temperature throughout the species' geographic range [3-9]. For ectothermic organisms, habitat temperature is a critically important environmental factor because of the effects of temperature on all biological processes, from molecular to physiological to behavioural [8,10-12]. Local adaptation to thermal gradients can cause populations in different parts of the geographic range to exhibit different responses to temperature variation [11,13-15]. Obviously, forecasting the response of animals to global climate change drivers must encompass more than just physiological sensitivity, e.g., the animal's ability to buffer the effects of climate change through behavior. Consequently, comparing the effects of temperature increases in different populations is essential for generating robust predictions about the impact of global warming on animal community at large spatial scales.

Carbon Dioxide and Ocean Acidification

The ongoing increase of anthropogenic CO_2 in the atmosphere causes an accumulation of CO2 in the oceans and an acidification trend, which develops in parallel with global warming [1,9,12,16-18]. The associated ocean acidification leads to questions about its effect on marine ecosystems in times of ocean warming [12,19]. Our understanding of the biological and ecological consequences of ocean acidification is, however, still in its infancy [20,21]. Reductions in seawater pH have been demonstrated to affect the physiological and developmental processes of a number of marine organisms [19,20,22-24] through reduced internal pH (acidosis) and increased CO2 (hypercapnia) [19,25]. CO_2 has also been shown to cause behavioural alterations in anti-predator behaviour [26-28]. A few studies have provided us with insights into foreseeable effects, or inform us about how predator–prey interactions may be altered in fish [29], given that so far, simultaneous changes of feeding behavior and physiology of invertebrate predators are still incomplete. Determining how ocean acidification might affect the feeding behavior and physiology of benthic organisms is critical to predicting how these impacts might propagate through the food chain. For reliable conclusions concerning the impact of CO_2 on the physiology and fitness of crustaceans in the near future, it is necessary to include realistic CO_2 concentrations in those studies, as postulated for 2100 (710 ppm) or beyond (3000 ppm), and combine them with changing temperatures.

Combined Effects of Temperature and Ocean Acidification

Simultaneous changes in multiple climate variables have the potential to yield surprising biological responses that could not be predicted by responses to single climate variables alone [30]. These stressors are likely to have deleterious interactive effects; increased temperature has a stimulatory effect on physiological processes (until thresholds are reached) while hypercapnia has a suppressive, narcotic effect [12,25]. Shallow-water coastal crustaceans, such as the edible crab Cancer pagurus and the spider crab Hyas araneus, are considered at risk, because of increased sensitivity to the synergistic effects of temperature and hypercapnia [31-33]. Furthermore, sensitivity to CO_2 may be highest where a species experiences extreme temperatures [31] and lives close to the border of its temperature dependent distribution range, e.g. along a latitudinal gradient. Although both warming and acidification represent serious threats to marine life, little information exists on the effect of enhanced CO_2 levels in combination with global warming on the feeding behavior and physiology of crustaceans. Only Walther found that the spider crab Hyas araneus from different latitudes showed different tolerance to the combination of ocean acidification and warming [34]. Most of the studies on the biological action of environmental stressors have concentrated on the action of single factor against organisms, while the combined effects are less well known, in particular whether warming increases the susceptibility to other forms of stress such as ocean acidification. Therefore, establishing principles on how multiple environmental stressors jointly interact from a physio-ecological perspective are needed to provide theoretical support for environmental-specific regulations that are established to protect aquatic ecosystems. In assessing risk to marine biota from climate change it is critical to investigate interactive effects of stressors in multifactorial experiments as this better reflects the real world scenario [19,25].

Estuarine and coastal marine systems are among the most ecologically and economically important habitats in the world. In many cases, benthic invertebrates including molluscs are the most important components of the coastal ecosystems. Molluscs are also major commercial fisheries worldwide [35]. Given the importance of coastal habitats, research aiming to predict changes in the coastal systems in face of climate change is urgently needed. The effects of acidification on marine invertebrates have not been well studied, and recent studies are most related to the calcification response of corals and coccolithophores [36,37]. There is now a critical need to test the consequences of ocean acidification on ecologically and commercially important benthic invertebrates at climate-relevant CO_2 levels under warming conditions.

Citation: Wang YJ (2014) The Future of Marine Invertebrates in Face of Global Climate Change. J Coast Dev 17: e105. doi: 10.4172/1410-5217.1000e105

References

1. Griggs DJ, Noguer M (2001) IPCC Climate Change 2001: The scientific basis. In Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.
2. Meehl GA, Stocker TF, Collins WD (2007) Climate Change 2007: The Physical Science Basis. Cambridge University Press Cambridge 686–688.
3. Lough JM (2008) Shifting climate zones for Australia's tropical marine ecosystems. Geophysical Research Letters 35.
4. Walther GR, Post E, Convey P, Menzel A, Parmesan C, et al. (2002) Ecological responses to recent climate change. Nature 416: 389-395.
5. Root TL, Price JT, Hall KR, Schneider SH, Rosenzweig C, et al. (2003) Fingerprints of global warming on wild animals and plants. Nature 421: 57-60.
6. Perry AL, Low PJ, Ellis JR, Reynolds JD (2005) Climate change and distribution shifts in marine fishes. Science 308: 1912-1915.
7. Grebmeier JM, Overland JE, Moore SE, Farley EV, Carmack EC, et al. (2006) A major ecosystem shift in the northern Bering Sea. Science 311: 1461-1464.
8. Pörtner HO, Knust R (2007) Climate change affects marine fishes through the oxygen limitation of thermal tolerance. Science 315: 95-97.
9. Brierley AS, Kingsford MJ (2009) Impacts of climate change on marine organisms and ecosystems. Curr Biol 19: R602-614.
10. Stillman JH, Somero GN (2000) A comparative analysis of the upper thermal tolerance limits of eastern Pacific porcelain crabs Genus Petrolisthes: Influences of latitude, vertical zonation, acclimation and phylogeny. Physiological and Biochemical Zoology 73: 200–208.
11. Pörtner HO (2001) Climate change and temperature-dependent biogeography: oxygen limitation of thermal tolerance in animals. Naturwissenschaften 88: 137-146.
12. Pörtner HO (2008) Ecosystem effects of ocean acidification in times of ocean warming: a physiologist's view. Marine Ecology Progress Series 373: 203–217.
13. Farrell AP, Hinch SG, Cooke SJ, Patterson DA, Crossin GT, et al. (2008) Pacific salmon in hot water: applying aerobic scope models and biotelemetry to predict the success of spawning migrations. Physiol Biochem Zool 81: 697-708.
14. Schroer M, Wittmann AC, Gruner N, Steeger HU, Bock C, et al. (2009) Oxygen limited thermal tolerance and performance in the lugworm Arenicola marina: A latitudinal comparison. Journal of Experimental Marine Biology and Ecology 372: 22–30.
15. Munch SB, Salinas S (2009) Latitudinal variation in lifespan within species is explained by the metabolic theory of ecology. Proc Natl Acad Sci U S A 106: 13860-13864.
16. IPCC (2007) Climate change : The physical science basis. In Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change 996.
17. Harley CD, Randall Hughes A, Hultgren KM, Miner BG, Sorte CJ, et al. (2006) The impacts of climate change in coastal marine systems. Ecol Lett 9: 228-241.
18. Fabry VJ, Seibel BA, Feely RA, Orr JC (2008) Impacts of ocean acidification on marine fauna and ecosystem processes. ICES Journal of Marine Science 65: 414–432.
19. Pörtner HO, Langenbuch M, Michaelidis B (2005) Synergistic effects of temperature extremes hypoxia and increases in CO2 on marine animals: from Earth history to global change. Journal of Geophysical Research 110.
20. Raven J, Caldeira K, Elderfield H, Hoegh-Guldberg O, Liss P, et al. (2005) Ocean acidification due to increasing atmospheric carbon dioxide. The Royal Society policy document. Clyvedon Press Cardiff, UK.
21. Gattuso JP, Bijma J, Gehlen M, Riebesell U, Turley C (2011) Ocean acidification: knowns unknowns and perspectives. Ocean acidification 291–311.
22. Portner HO, ReipschlAGerY A, n (1998) Acid-base regulation, metabolism and energetics in sipunculus nudus as a function of ambient carbon dioxide level J Exp Biol 201 : 43-55.
23. Pörtner HO, Langenbuch M, Reipschläger A (2004) Biological impact of elevated ocean CO2 concentrations: lessons from animal physiology and earth history. Journal of Oceanography 60: 705–718.
24. Parker LM, Ross PM, O'Connor WA, Borysko L, Raftos DA, et al. (2012) Adult exposure influences offspring response to ocean acidification in oysters. Global Change Biology 18: 82–92.
25. Widdicombe S, Spicer JI (2008) Predicting the impact of ocean acidification on benthic biodiversity: What can animal physiology tell us? Journal of Experimental Marine Biology and Ecology 366: 187-197.
26. Dixson DL, Munday PL, Jones GP (2010) Ocean acidification disrupts the innate ability of fish to detect predator olfactory cues. Ecol Lett 13: 68-75.
27. Munday PL, Dixson DL, McCormick MI, Meekan M, Ferrari MC, et al. (2010) Replenishment of fish populations is threatened by ocean acidification. Proc Natl Acad Sci U S A 107: 12930-12934.
28. Ferrari MCO, Dixson DL, Munday PL, McCormick MI, Meekan MG, et al. (2011) Intrageneric variation in antipredator responses of coral reef fishes affected by ocean acidification: implications for climate change projections on marine communities. Global Change Biology 17: 2980–2986.
29. Ferrari MC, McCormick MI, Munday PL, Meekan MG, Dixson DL, et al. (2011) Putting prey and predator into the CO2 equation--qualitative and quantitative effects of ocean acidification on predator-prey interactions. Ecol Lett 14: 1143-1148.
30. Pörtner HO (2010) Oxygen- and capacity-limitation of thermal tolerance: a matrix for integrating climate-related stressor effects in marine ecosystems. J Exp Biol 213: 881-893.
31. Pörtner HO, Farrell AP (2008) Ecology. Physiology and climate change. Science 322: 690-692.
32. Metzger R, Sartoris FJ, Langenbuch M, Pörtner HO (2007) Influence of elevated CO2 concentrations on thermal tolerance of the edible crab Cancer pagurus. Journal of Thermal Biology 32: 144–151.
33. Walther K, Sartoris FJ, Bock C, Pörtner HO (2009) Impact of anthropogenic ocean acidification of the thermal tolerance of the spider crab Hyas araneus. Biogeoscience 6: 2837–2861.
34. Walther K, Anger K, Pörtner HO (2010) Effects of ocean acidification and warming on the larval development of the spider crab Hyas araneus from different latitudes (54° vs. 79°N). Marine Ecology Progress Series 417: 159–170.
35. Gutiérrez JL, Jones CG, Strayer DL, Iribarne OO (2003) Mollusks as ecosystem engineers: the role of shell production in aquatic habitats. Oikos 101: 79–90.
36. Orr JC, Fabry VJ, Aumont O, Bopp L, Doney SC, et al. (2005) Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437: 681-686.
37. Harley CD, Randall Hughes A, Hultgren KM, Miner BG, Sorte CJ, et al. (2006) The impacts of climate change in coastal marine systems. Ecol Lett 9: 228-241.