Copepod response to ocean acidification in a low nutrient-low chlorophyll environment in the NW Mediterranean Sea

Soultana Zervoudaki1, Frédéric Gazeau2, Thanassis Moutsopoulos1, Maria Protopapa3, Sophie Marro2, Evangelia Krasakopoulou4.
1. Institute of Oceanography, Hellenic Centre for Marine Research, P.O. Box 712, 19013, Anavyssos, Athens, Greece.
2. CNRS, UMR 7093, LOV, Observatoire océanologique, F-06230, Villefranche-sur-mer, France
3. Zoological Laboratory, University of Athens, Panepistimioupolis, 15771 Athens, Greece.
4. University of the Aegean, Department of Marine Sciences, Aegean, Greece.
tanya@hcmr.gr

Summary
In order to identify how ocean acidification will influence biological interactions and fluxes among planktonic organisms and across trophic levels, a large-scale mesocosm experiment was performed in the oligotrophic Northwestern Mediterranean Sea. Nine mesocosms were deployed in the Bay of Calvi (Corsica, France) in summer 2012. Six mesocosms were subjected to different levels of CO2 partial pressures (550, 650, 750, 850, 1000 and 1250 μatm) covering the range of atmospheric pCO2 anticipated for the end of this century depending on future emission scenarios, and the last three mesocosms were unaltered (ambient pCO2 of ~ 450 μatm). During this 21-day experiment, we monitored copepod egg and nauplius stocks, estimated copepod (Acartia clausi and Centropages typicus) feeding rates and determined the abundance and taxonomic composition of the mesozooplankton community at the start and at the completion of the experiment. Zooplankton community revealed important differences among mesocosms most likely due to natural and experimental variability that cannot be related to CO2 conditions. Eggs and nauplii as well as feeding rates on microplankton showed no significant differences among CO2 levels. The above findings suggest that in low nutrient-low chlorophyll environments, ocean acidification will most likely not have significant effects on planktonic trophic interactions.

Introduction
The Mediterranean Sea is one of the most nutrient-poor regions of the global ocean and characterized by low nutrient and low chlorophyll concentrations with a trophic status ranging from mesotrophic in the Northwest (in winter) to extremely oligotrophic in the East in summer. In this region, studies on the effect of acidification on copepod species are rare (Zervoudaki et al. 2014). Under the framework of the European project MedSea (Mediterranean Sea Acidification in a changing climate; http://medsea-project.eu), a large scale in situ mesocosm experiment was performed in the NW Mediterranean Sea (Bay of Calvi, Corsica, France) in June/July 2012, in order to identify if elevated CO2 levels will influence biological interactions and fluxes among planktonic organisms and across trophic levels. During this mesocosm study, that is the first to investigate the effects of ocean acidification on Mediterranean plankton communities, our specific objective was to study the composition of the mesozooplankton community, to monitor the egg and nauplius stocks and finally to estimate feeding rates of key Mediterranean copepod species at different pCO2 levels. Our working hypothesis was that, under a near future acidification scenario, copepod reproduction and feeding will be negatively altered with consequences on the planktonic food chain.

Materials and methods
A large-scale experimental study (mesocosm experiment) was performed in the Northwestern Mediterranean Sea (Bay of Calvi, Corsica, France) from June 24th (day 0) to July 14th (day 20) 2012. Nine ~50 m3 mesocosms were deployed: six of them were subjected to different levels of pCO2 (P1: 550, P2: 650, P3: 750, P4: 850, P5: 1000 and P6: 1250 μatm) covering the range of atmospheric pCO2:
anticipated for the end of this century and the last three mesocosms were unaltered with an ambient \( pCO_2 \) of \( \sim 450 \) \( \mu \text{atm} \) (C1, C2 and C3). Mesocosms were grouped by 3 in a way that each cluster contains one control, one medium and one high \( CO_2 \) mesocosm (cluster 1: C1, P1 and P4; cluster 2: C2, P2 and P5; cluster 3: C3, P3 and P6). The different \( CO_2 \) levels were achieved by additions of \( CO_2 \) saturated seawater and then evolved as a consequence of biology and exchanges with the atmosphere. Sampling for zooplankton was performed twice during the experiment: (a) in the surrounding waters when all mesocosms were closed (prior to \( CO_2 \) manipulation; day -5) to estimate the initial composition of the zooplankton community and (b) at the end of the experiment both in the field and in all mesocosms. Samples were taken by vertical net tows with a modified WP2 of 45 \( \mu \)m mesh size and preserved in a 4\% buffered-formaldehyde seawater solution. Samples for copepod egg and nauplius standing stocks in the mesocosms were taken every second day. Approximately 5-10 L of water from the mesocosms was filtered onto a 21 \( \mu \)m mesh net and samples were preserved in formalin (4\% final concentration). Four feeding experiments were performed using water sampled in mesocosms of cluster 3 (C3, P3 and P6). Females of the common copepod species \textit{Acartia clausi} and \textit{Centropages typicus} were used for the assessment of the copepod feeding behavior. Copepod clearance rates on diatoms, ciliates, and dinoflagellates were calculated according to Frost (1972), when the difference in prey concentrations between control and experimental bottles was significant.

Results and Discussion

The reproductive efficiency and recruitment process of the enclosed copepod assemblage in this study was examined by monitoring the copepod egg and nauplius stocks over the course of the experiment. Previous studies investigating the direct effect of ocean acidification on the reproduction of different copepod species revealed that egg production and hatching success are significantly inhibited by elevated \( pCO_2 \) levels greatly exceeding what is projected for the coming decades (e.g., Kurihara et al. 2004). In contrast to these studies, our results are in accordance with the few attempts to investigate the effects of projected, near future, \( pCO_2 \) conditions (e.g., Mayor et al. 2012) and suggest no apparent direct effect of ocean acidification on copepod reproduction. Copepod reproduction and growth are functions of the maternal dietary background and the feeding activity of their offspring. Thus, in our experiment, any potential differences in food quality among treatments would have been reflected first of all on egg production rates or even on grazing rates. In this study, zooplankton prey assemblages did not respond significantly to elevated \( pCO_2 \) levels, therefore, no significant differences between the different \( pCO_2 \) levels were found in production and feeding of copepods in this experiment. Zooplankton abundance was quite variable in the mesocosms. This variability could be attributed to the highest patchiness of zooplankton in enclosures compared to open water as well as to the strong food limitation in the mesocosms that might prologue increased zooplankton mortality. However, due to the very large variations in zooplankton abundances found at the end of experiment it is difficult to obtain any conclusion regarding the effect of acidification on zooplankton communities following the methodological approach performed in this study.

References


