Impact of Ocean Acidification on the Metabolism of Calcifying Planktonic Organisms

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ABSTRACT

Atmospheric pCO_2 is predicted to double by the end of the century, and this increase is expected to lead to both global warming and ocean acidification, both being enhanced in polar oceans. Because of the freshening and increased carbon uptake in response to sea ice retreat, pH should decrease by more than 50% by 2050 in the Arctic. Marine calcifying organisms are particularly important in high latitudes as a food source for different species and for carbon fluxes, and will likely be directly affected as shells and other structures of calcium carbonates dissolve with lower pH. It is unclear though how those organisms will react, adapt and survive within this carbonate undersaturation scenario. Marine calcifying organisms include strictly planktonic as well as meroplanktonic organisms. Meroplankton spend only part of their life in a planktonic stage and include benthic larvae. In order to understand the effect of decreasing pH on the metabolism of calcifying organisms, perturbation experiments were performed on two meroplanktonic organisms: benthic gastropods and clams larvae, and one strictly planktonic organism: pteropods. During these experiments, oxygen was monitored every 6-9 hours in order to measure the organisms' respiration at regular sea water pH (8.1) and at the lower pH predicted for the next 100 years (7.7). The increase of respiration at lower pH reflects a change in the organisms' metabolism probably due to stress. By affecting calcifying organism metabolism, ocean acidification is likely to lead to changes in food web structure, carbon fluxes and benthic communities.

Background and Research question

Anthropogenic increasing of atmospheric carbon dioxide is making the ocean more acid thereby reducing their degree of saturation with respect to the calcium carbonate. The pH should decrease by more than 50% by 2050 in the Arctic.
Respiration has been traditionally used as an indicator of overall metabolism, and can, in particular, reflect stress.

Will changes in sea water chemistry (lower pH) affect the overall metabolism of calcifying organisms ?

Sampling location indicated by a red star

Study area

Arctic fjord, Isfjorden in the Spitsbergen archipelago (see map on the left), October 2009.
Water depth: 250 m with a mixed layer in the first 20 meters.
Animals were collected in the first 20 meters with a VP2 net, equipped with a 90 µm mesh.

Plankton wheel

Methods

Changes of water pH

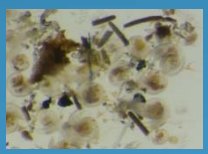
In order to simulate a ocean acidification scenario, incubation were performed at both, the regular seawater pH of 8.1 and at a lower pH of 7.7. The lower pH was adjusted by addition of HCl (125 µl) and NaHCO buffer (250 µl) to 1,5 L of 0.2 µm filtered sea water. The addition of both, HCl and NaHCO as buffer, allows keeping the carbonate equilibrium as it would be in a natural increase of atmospheric CO_2.

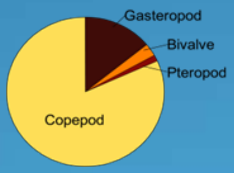
Respiration

Animals were transferred in 4 and 20 ml vials. Vials were placed in a plankton wheel (see upper photo), rotating at 1 rpm to keep organisms in suspension.
Oxygen was monitored every 6-9 hours during 72 hours, using a oxygen microsensor (UNISENSE, see photo on the right).

O_2 measurement

Importance of meroplankton and calcifying organisms





Meroplankton: organisms planktonic for only a part of their life cycles (larval stage).

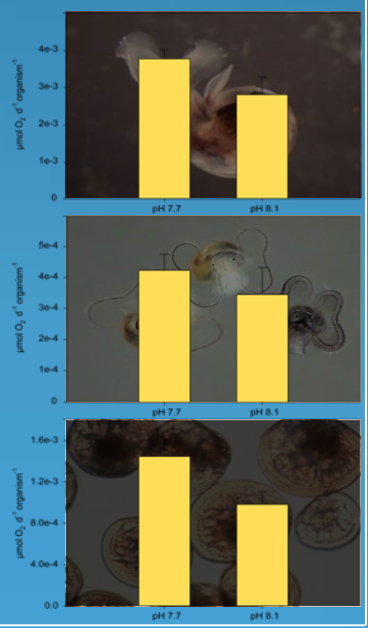
No well studied, although can dominate zooplankton at some period .

In October, zooplankton was dominated by copepods (81%), the rest being calcifying organisms.

3 major organisms calcifying groups were present: benthic gasteropod larvae, benthic bivalve larvae and planktonic pteropod (76%, 16% and 8% of the total of calcifying organisms respectively).

More attention to meroplankton in future studies.

Respiration of dominant calcifying organisms



At lower pH (7.7, predicted for the next 100 years), respiration increased for all 3 shell-building organisms.

Shell-building organisms are stressed by lower pH.

Negative impact of ocean acidification on shell-building organisms in particular larval stage of benthos.

Future work: Synergic impact of decrease pH and increase in temperature?

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