Arctic Ocean turning corrosive

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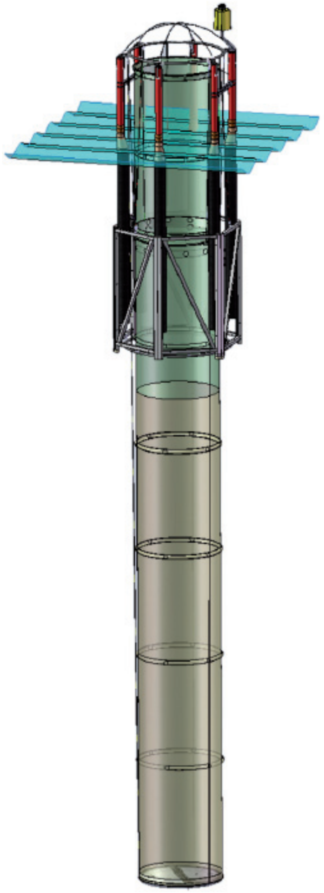
The cold waters of the polar seas are naturally low in carbonate saturation. As uptake of anthropogenic CO_2 continues to acidify the oceans worldwide, the Arctic Ocean will be the first to pass the chemical threshold where surface seawater becomes undersaturated, i.e. corrosive for unprotected shells and skeletons of calcifying organisms. While the overall impacts of ocean acidification on the Arctic ecosystems are still unknown, the predicted changes in seawater chemistry are expected to make it increasingly difficult for calcareous organisms to inhabit these regions.

If atmospheric CO_2 levels continue to rise at current rates, in less than 10 years from now about 10% of the Arctic Ocean is projected to have crossed the saturation threshold for aragonite, one of the major forms of calcium carbonate. By the time atmospheric CO_2 exceeds 490 parts per million (2040 to 2050, depending on the scenario considered), more than half of the Arctic Ocean is projected to be corrosive to this mineral. In case of unabated CO_2 emissions, the entire Arctic Ocean will turn corrosive before the end of this century. The projected changes in ocean acidity go beyond anything organisms have experienced in the last 20 million years of their evolutionary history. Arctic waters are home to a wide range of calcifying organisms, both in benthic and pelagic habitats, including shell fish, seas urchins, coralline algae, and calcareous plankton. Many of these are key species providing crucial links in the Arctic food web, such as the sea butterflies (pteropods), which serve as food for fishes, seabirds and whales.

To study the impacts of ocean acidification on plankton communities, a group of 35 researchers of the EU-funded European Project on OCean Acidification (EPOCA) conducted the first major CO_2 perturbation experiment in the Arctic Ocean. Led by the Leibniz Institute of Marine Sciences (IFM-GEOMAR) nine mesocosms were set out in the Kongsfjord off the north-western coast of Svalbard. Each of the giant, 17 m long 'test tubes' held about 50 cubic metres of seawater. The enclosed plankton community was exposed to a range of different CO_2 and pH levels, representative for glacial to projected mid-next-century levels (Fig. 1) and was closely monitored over a 5-week period. The EPOCA scientists, who stayed at the Ny Ålesund research station, sampled the mesocosms daily from zodiacs with plankton nets, water samplers and pumps, and conducted measurements with profiling sensors and in situ probes.

EPOCA's 2010 mesocosm campaign, which involved molecular and cell biologists, marine ecologists and biogeochemists, ocean and atmospheric chemists, addressed a range of urgent questions concerning the impacts of ocean acidification on Arctic ecosystems. How will ocean acidification affect the production



Above: Esperanza with mesocosms on deck. Photo: U. Riebesell. Right: Schematic diagram of a mesocosm system.

of food at the base of the Arctic food web and its transfer to consumers at higher levels? How will ocean acidification influence competition and trophic interactions at various levels of the pelagic ecosystem? Will there be winners and losers of ocean acidification? Another set of questions concerns the possible consequences for the cycling of key elements. Will ocean acidification affect the sequestration of carbon in the

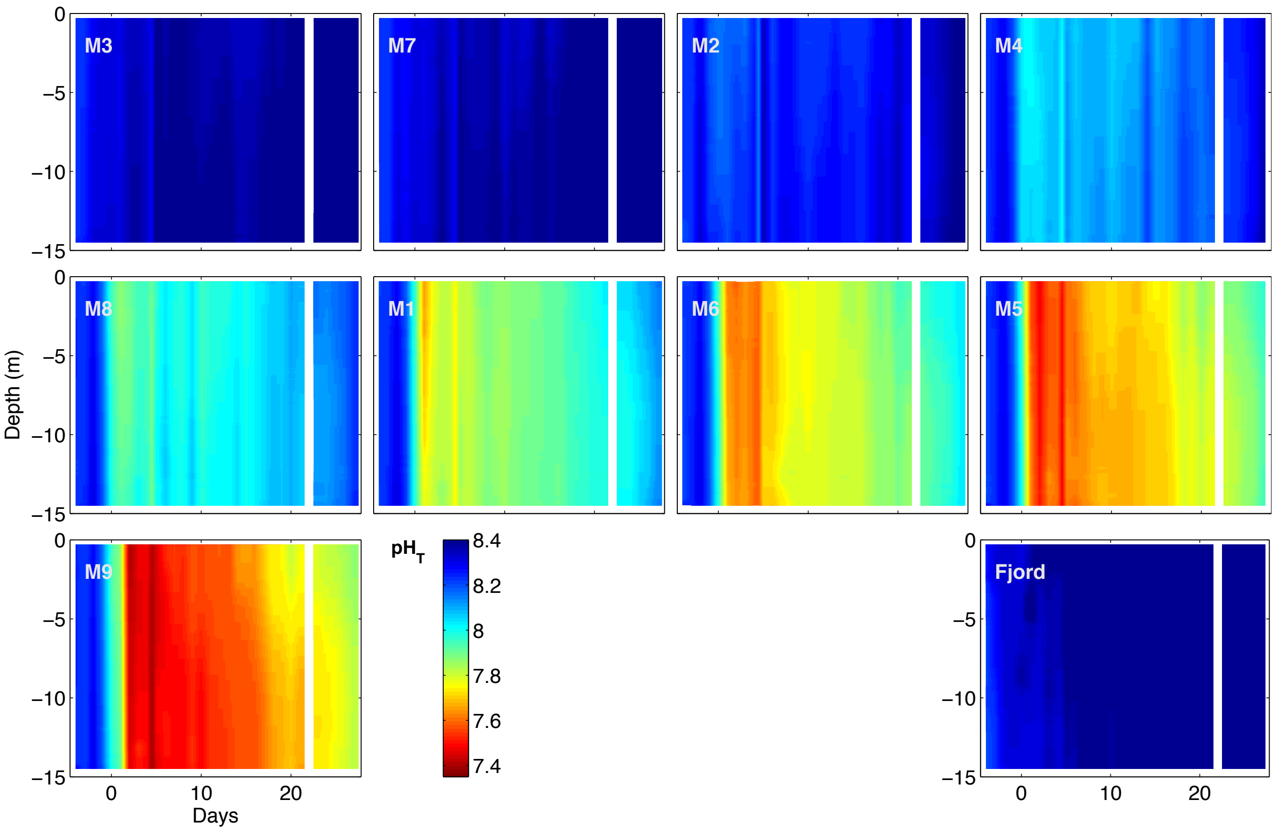
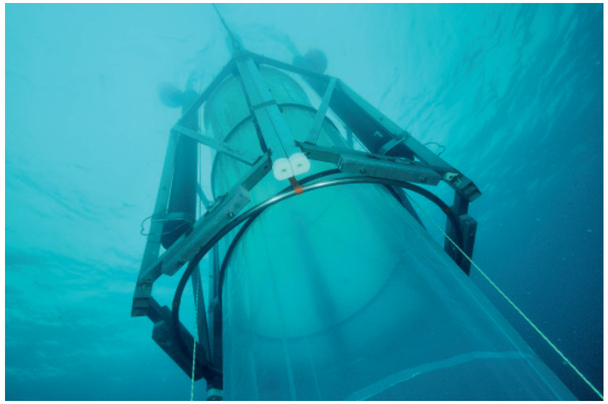


Figure 1: Temporal development of seawater pH in the nine mesocosms and the adjacent fjord. From days 0 to 4, CO_2 enriched seawater was added to the mescosms in different amounts to achieve a gradient representative for glacial to projected mid-next-century pCO_2 levels of 180 to about 1050 µatm, respectively.

Arctic ocean? Will it change the turn-over and balance between the primary building blocks of life such as carbon, nitrogen and phosphorus? A third set of questions concerns the exchange of climate relevant gases between ocean and atmosphere. Will ocean acidification affect the production of these gases and if so, will it amplify or dampen global climate change?

The scientists participating in this unusual campaign, the first of its kind in polar waters, were prepared to face a range of technical and logistical challenges. In addition to the nine mesocosms, each weighing nearly two tonnes, they had to transport over 150 boxes of scientific equipment to the high Arctic. IFM-GEOMAR, as the coordinating institute, received support from the Greenpeace vessel ESPERANZA, which transported the mesocosms and other heavy equipment from Kiel to Ny Ålesund and back as part of its 2010 Arctic Campaign. Another challenge, the risk of damage to the mesocosms by drifting sea ice and icebergs calving off the three glaciers extending into the Kongsfjord, could be avoided by 24-hour ice watches and pushing icebergs off their track with small boats before they could hit the moored mesocosms. Considering the many unknowns involved in this endeavour, the experiment went surprisingly smooth and according to plan. The scientists collected nearly 15,000 samples and acquired data for over 45 parameters characterizing the responses of the Arctic ecosystem to ocean acidification. The results of this study, which will be presented at various international conferences this year, are expected to provide the first comprehensive insight into the sensitivities of an Arctic ecosystem to a rapidly acidifying ocean.



Underwater photo of extended mesocosm enclosure. Photo: Y. Gladu.