Theme session Report

Taking stock on ocean acidification research for provision of future efforts

Conveners: Silvana Birchenough (United Kingdom), Tsuneo Ono (Japan), Pablo León Díaz (United Kingdom)

Content

OA and climate change share a common cause, increasing CO_2 concentrations in the atmosphere. However, OA must be distinguished from climate change as it is not a climatic process but rather an alteration to the chemistry of seawater. The ocean is the largest natural reservoir of dissolved carbon and holds an immense buffering capacity for changes in atmospheric CO_2 concentrations. Due to the rapid increase of atmospheric CO_2 since the industrial revolution, oceans and seas are absorbing increasingly greater amounts of CO_2. This process disturbs the pre-existing chemical equilibrium of the sea's carbonate chemistry, resulting in seas becoming more acidic. The impacts of OA may have serious consequences for ecosystems and the services they provide over this century. The expectation is that OA may trigger impacts through the marine food web that will affect ecological, biogeochemical, and socio-economic values globally. OA research has indicated that while some species will be negatively affected, others will benefit from the changes that are the result of more acidic conditions. Although it is certain that the pH in the world's oceans is decreasing at a high rate, research into the long-term effects of acidification on ecosystems and the influence on the ocean's buffering capacity is still evolving. To date, there are areas where further research is needed to understand combined impacts and how these will affect societies and end-users. Further research is also needed to develop adaptation to these changes.

This theme session was aimed to discuss the latest developments in Ocean Acidification (OA) science and its interactions with other marine environmental co-stressors (i.e. warming and de-oxygenation), as well as management initiatives to mitigate OA impacts on associated ecosystem services. The session called for presentations on topics related to OA covering multiple-aspects including chemistry, biology, policy, economy and social science:

a) Current understanding of marine carbonate chemistry dynamics, biological, ecological, and socio-economic impacts of OA.

b) New sensor technologies and developments of potential biological indicators for OA monitoring.

c) Understanding from OA monitoring programmes and/or time-series interactions.

c) Developments of OA modelling effort.

d) Management and potential policy recommendations to mitigate OA effects.

Originally, in 2020, ten communications were submitted to the session covering a wide range of topics related to OA, including aspects such as monitoring, methodological, experimental, modelling and socio-ecological analyses. Considering the impossibility to fit all the communications in the time allocated for the session (1 hour), five papers were selected for oral presentation was done, and the rest were

selected for poster presentations. Unfortunately, after ICES ASC 2020 being postponed, only one communication was submitted to the session in 2021.

The session included the participation of the 3 co-conveners, one speaker and about 38 attendants aprox., and it was structured as follows:

- Presentation by the co-conveners describing the stock of current scientific advances on OA as well as showcasing science and policy interactions across the NE Atlantic. Several points for discussion with the speaker and the attendants were proposed.

- Pre-recorded presentation by B. Townhill entitled "Exposure of commercial shellfish to changing pH levels: how do we scale-up experimental evidence to regional impacts". This communication highlighted some of the challenges in experimental designs and the integration of that research with modelling and the need to adequate experimental scenarios to more realistic present and projected conditions in the field.

- Q&A session. Several questions were made by attendants to the session raising very interesting points including a wide range of aspects related to OA research, including the need to carry out more realistic experiments in accordance with present conditions experienced by organisms. The need of more co-stressors studies was also pointed out as the organisms are subjected to several stressors and not only OA. In this context, the benefit of multidisciplinary projects was remarked. The need to integrate the huge amount of evidence available was mentioned several times during the discussion, as well as to "translate" the evidence to make it more approachable for stakeholders and policy-makers (e.g. OSPAR QSR 2023, ICES ecosystem and fisheries overviews and dedicated advisory requests, etc.). In this aspect, the lack of communication and coordination between scientists across disciplines (e.g. chemistry, biology and social aspects and policy) was also pointed out as one of the more urgent needs, as there is still a single stand- alone sense across studies and disciplines.

Conclusions (to be completed)

A diverse range of topics were covered throughout the presentations and the discussion sessions. OA research is recognised to be a complex phenomenon with some areas there is growing evidence. In some cases, species and life stages will be able to adapt to predicted CO_2 concentrations, as these species have been exposed to different level of environmental variability. It was encouraging that research was moving forward considering the combined approach of experimental results with modelling, adaptation, and consideration of the natural variability to which the species are being subjected, considering the natural systems rather than solely under controlled laboratory incubations. However, there is a real need to undertake combined continuous high frequency long term monitoring, of both chemical and biological parameters, on a decadal scale to differentiate diel, seasonal and inter-annual variations, and the wider implications of multiple stressors on species and ecosystems. The session closed with a recommendation to ICES/PICES that multi-disciplinary working group should be consider for working across different areas (e.g. conservation, government and academia) to ensure that the research and recommendation are targeted and applied, ensuring that some of the gaps are tested and the newly generated scientific evidence is fit for purpose.

Feedback (to be completed)

A good discussion between co-chairs and online participants (total of 28 online participants). Positive feedback received from collaborators working in this area.