Analogues of an Arctic in Rapid Transition, WGAnalogueART

Introduction and reference:

Rising levels of CO_2 in the atmosphere are causing worldwide modification of surface seawater carbonate chemistry, with gradual reductions in pH and carbonate ion (CO_3^{2-}) availability, in a process known as ocean acidification (OA). As water masses in the northern Norwegian Sea and the polar ocean have relatively low water temperature (causing a high solubility of CO_2) and low pH these regions have a naturally low calcium carbonate ($CaCO_3$) saturation state (Chierici and Fransson, 2009; Chierici et al. 2016). It is one of the first areas already being affected by shifting boundaries of carbonate with rapid expansion of areas where organisms may experience limitations in calcification within the next few years if the rate of CO_2 emissions to the atmosphere are not reduced (Olafsson et al. 2009, AMAP 2013). The polar ocean is experiencing one of the most rapid shifts in biogeographic boundaries on the planet due to polar and tundra ice melt coupled with rapid warming and acidification – these all affect the ecology of marine organisms. Whilst rapid adaptation and shifts in benthic flora are expected (Brodie et al. 2014), long-lived benthic animals in the region often show limited metabolic plasticity which may reduce their chances of adapting/acclimatising to changing environments (e.g. Rastrick & Whiteley 2011, 2013).

Ocean acidification is expected to have direct consequences for many commercially important calcifying species in northern waters, such as crabs, lobsters, shrimp and scallops (Paralithodes camtschaticus, Homarus gammarus, Pandalus borealis, Pecten maximus, Chlamys islandica) (Agnalt et al. 2013, Andersen et al. 2013, Dupont et al. 2014, Hall-Spencer & Allen 2015).

Acidified seawater will severely impact the extensive biogenic habitats around northern Norway created by coralline algae (Brodie et al. 2014) and cold-water corals (Jackson et al. 2014), this is expected to impact nursery and brood stock areas for commercially important molluscs and fish (Branch et al. 2013, Sunday et al. in press). Although a number studies have shown adult fish to be relatively resistant to elevated pCO_2, they many suffer neurological impairment (Milazzo et al. 2016) and a recent study showed increased mortality in Atlantic cod larvae resulting in reduced recruitment to the stock (Stiasny et al. 2016). Our current understanding of key processes driving the response of commercially important species and ecosystems to climate change is, however, limited since the majority of studies conducted so far have been in vitro, short-term, rapid perturbation experiments on isolated elements of the ecosystem (Agnalt et al. 2013, Andersen et al. 2013). It is difficult to extrapolate from such studies to larger scales, as these are generally too short-term to reveal how organisms may adapt/acclimatise, have often set steady pCO_2 levels (which are unrealistic) and use organisms that are separated from their natural suite of competitors, predators, parasites and facilitators.

One approach to study the ecosystem effects of predicted future chronic elevations in mean pCO2 as well as associated increases in acute fluctuations in carbonate chemistry due to freshwater run off is to use natural analogies. Such analogues for future predicted OA have included volcanic CO2 vent sites (e.g. Hall-Spencer et al. 2008), up-welling of deep CO2 rich water (Manzello et al. 2014) and temperate systems which present a mosaic of alkalinity and pH conditions (Thomsen et al. 2010). These natural analogies provide an opportunity to simultaneously investigate changes in naturally assembled community structure (e.g. Hall-Spencer et al. 2008, Kroeker et al. 2013) and the capacity for physiological adaptation/acclimatisation of key species in responses to elevated pCO2 and low carbonate ion concentration (e.g. Calosi et al. 2013, Harvey et al. 2016). In addition, broader evolutionary responses to past and future pCO2 changes can be addressed (Garilli et al. 2015). They have also been used to investigate the importance of natural variability in carbonate chemistry on the mechanisms that set the distribution of species (e.g. Small et al. 2015) and to investigate the effect of multiple stressors in naturally fluctuating environments (e.g. Thomsen et al. 2010, Kroeker et al. 2016). Recent studies have identified how shifting boundaries of water and ice in subarctic and arctic systems create mosaics of alkalinity and pH conditions (Fransson et al. 2015; 2016) which could be used as natural analogues to investigate the effects of climate change and OA on the physiology, ecology and distribution of flora and fauna in northern ecosystems. However, to date, despite the potential for natural OA analogues at higher latitudes such studies are limited to the Baltic in cold-water ecosystems.

Consequently, this working group will act as a platform to develop methodologies and accelerate the establishment of natural analogues to investigate the effects of climate change and OA in subarctic and arctic ecosystems. To do this the working group will achieve the following:

Terms of Reference (ToRs):

1. Identify the advantages of using natural analogues to assess the posable effects of climate change and OA.

2. Identify the disadvantages and difficulties of using natural analogue approaches and develop new methodologies and codes of best practise to move forward.

3. Identify suitable natural analogues for future research into climate change and OA in the subarctic and arctic waters.

4. Form a strong cross disciplinary group of experienced researchers to support future applications for funding work into this topic.

Implementation plan:

2017- Establish the working group from the workshop “Using natural analogues to investigate the effects of climate change and ocean acidification on northern ecosystems” held at the ESASS open science meeting in Tromsø, Norway.

2017- prepare a manuscript “Using natural analogues to investigate the effects of climate change and ocean acidification on northern ecosystems”

2018- Synthesis available water chemistry data and select posable natural analogue sites for further investigation.

2018- Organise a workshop at the ESASS annual meeting, identified and develop further funding opportunities and develop a peer group to support and review funding applications prior to submission.

2018- Submit funding applications.

2019- Organise a workshop at the ESASS annual meeting.

2019- Synthesis data from selected natural analogue sites and select the most appropriate for further biological investigation (dependent on the success of 2018 funding applications).

2020- Organise a workshop at the ESASS annual meeting.

2020- Publish a review of suitable natural analogues for future research into climate change and OA in the subarctic and arctic waters.

Deliverables:

2017-2018- Publication “Using natural analogues to investigate the effects of climate change and ocean acidification on northern ecosystems”.

2018-2019- A strong cross disciplinary of experienced researchers to support and review funding applications prior to submission.

2018-2019- Submitted funding applications.

2019-2020- Publish a review of suitable natural analogues for future research into climate change and OA in the subarctic and arctic waters.

Members:

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