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Effects of sub-seabed CO_2 leakage: Short- and medium-term responses of benthic macrofaunal assemblages

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ABSTRACT

The continued rise in atmospheric carbon dioxide (CO_2) levels is driving climate change and temperature shifts at a global scale. CO_2 Capture and Storage (CCS) technologies have been suggested as a feasible option for reducing CO_2 emissions and mitigating their effects. However, before CCS can be employed at an industrial scale, any environmental risks associated with this activity should be identified and quantified. Significant leakage of CO_2 from CCS reservoirs and pipelines is considered to be unlikely, however direct and/or indirect effects of CO_2 leakage on marine life and ecosystem functioning must be assessed, with particular consideration given to spatial (e.g. distance from the source) and temporal (e.g. duration) scales at which leakage impacts could occur. In the current mesocosm experiment we tested the potential effects of CO_2 leakage on macrobenthic assemblages by exposing infaunal sediment communities to different levels of CO_2 concentration (400, 1000, 2000, 10,000 and 20,000 ppm CO_2), simulating a gradient of distance from a hypothetic leakage, over short-term (a few weeks) and medium-term (several months). A significant impact on community structure, abundance and species richness of macrofauna was observed in the short-term exposure. Individual taxa showed idiosyncratic responses to acidification. We conclude that the main impact of CO_2 leakage on macrofaunal assemblages occurs almost exclusively at the higher CO_2 concentration and over short time periods, tending to fade and disappear at increasing distance and exposure time. Although under the cautious perspective required by the possible context-dependency of the present findings, this study contributes to the cost-benefit analysis (environmental risk versus the achievement of the intended objectives) of CCS strategies.

1. Introduction

The accelerating rise in atmospheric carbon dioxide (CO_2) levels (IPCC, 2013) is causing ocean warming and acidification at unprecedented rates, posing critical threats to single species, habitats, oceanic regions and overall global ecosystem functioning (Caldeira and Wickett, 2003; Feely et al., 2004; Hale et al., 2011; Mora et al., 2013, Cerrano et al., 2013; Meadows et al., 2015; Gattuso et al., 2015). As a direct consequence, it is urgently needed to identify suitable options for reducing/mitigating CO_2 emissions (McCormack et al., 2016). One particularly promising technology involves capturing CO_2 from point source effluents (mostly, energy generation plants), then transporting it as a supercritical liquid to be stored in deep porous geological rock formations, such as saline aquifers or existing hydrocarbon reservoirs (Gibbins et al. 2006; Holloway 2007). This process is defined as CO_2 Capture and Storage (CCS). In Europe and North America the technical feasibility of CCS approaches has been already demonstrated. For example, at the Sleipner West gas field in the Norwegian sector of the North Sea, CCS has been operational since 2000 with approximately 1 million tons of CO_2 pumped into the storage reservoir every year (Paulley et al., 2012, Jones et al., 2015). However, as with almost any other human activity, this technology is not risk-free in terms of posing potential environmental hazards (reviewed by Damen et al. 2006). Before industrial scale CCS activities become widely accepted and implemented these risks need to be identified and quantified. Perhaps the greatest environmental risk associated with CCS is that of CO_2 leaking into the marine environment either during transport, sequestration or from the geological storage reservoir itself. Whilst current evidence

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