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Ship-board experiments to determine calcification rates of Mediterranean cold-water corals under variable pCO$_{2}$ conditions

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Global environmental change and the rise of CO_2 have been identified as a major threat to scleractinian corals and corals reefs. General predictions are that ocean acidification will be detrimental to reef growth and that 40 to > 80 % of present-day reefs will decline during the next 50 years. Cold-water corals are thought to be even more affected by changes in ocean acidification due to the fact, that their distribution is confined to deep and/or cold waters where they are affected even sooner by the shallowing of the aragonite saturation horizon. While the impact of global change on reef-building, tropical corals has been intensely studied, not much is known on the response of cold-water corals. The Mediterranean Sea is an enclosed system and can be regarded as a miniature ocean that is expected to react faster to global change than the open ocean, which renders it a perfect study site. At three geographically distant sites, we therefore studied calcification rates of three species of Mediterranean cold-water scleractinian corals directly on board research vessels and immediately after collection. Corals were incubated directly onboard in vials using ambient seawater under ambient, reduced or enriched pCO_2 and calcification rates were determined by the TA anomaly technique. Calcification rates ranged from 0.008 % d^{-1} for Desmophyllum sp. and 0.116 % d^{-1} for *Madrepora oculata.* Lowest calcification rates were found for corals collected at a site south off Malta, in the Strait of Sicily, while corals collected at the canyon Lacaze Duthiers and the Gulf of Cassidaigne in the western Mediterraanean were not significantly different in calcification rates. Calcification rates of corals under variable pCO_2 levels were on average 0.055 % d^{-1} and were similar for ambient and elevated pCO_2 (404-867 μatm), while calcification rates were on average 0.1 % d^{-1} for corals under reduced pCO_2. However, this difference was not statistically significant. Our results indicate that cold-water corals may be able to cope, at least for a short while, with elevated pCO_2 levels and maintain a normal calcification rate. We also proved evidence that on-board incubations are superior to study effects of climate change on cold-water coral calcification than long-term aquarium experiments. Cold-water corals appear to recover extremely fast from sampling stress if sampled carefully by ROV. Conducting experiments with freshly collected cold-water corals has the advantage that their response is close to in situ conditions and is not influenced by artificial aquarium conditions that may not reflect the natural environment with respect to feeding, current regimes, sedimentation and other potential factors influencing coral behavior. A systematic comparison of calcification rates from cold-water corals sampled over a large gradient with respect to geography, depth and seawater carbonate chemistry is more likely to provide reliable information on the potential response of cold-water corals to future changes in pCO_2 and aragonite saturation state than experiments conducted with corals maintained under artificial aquarium conditions.