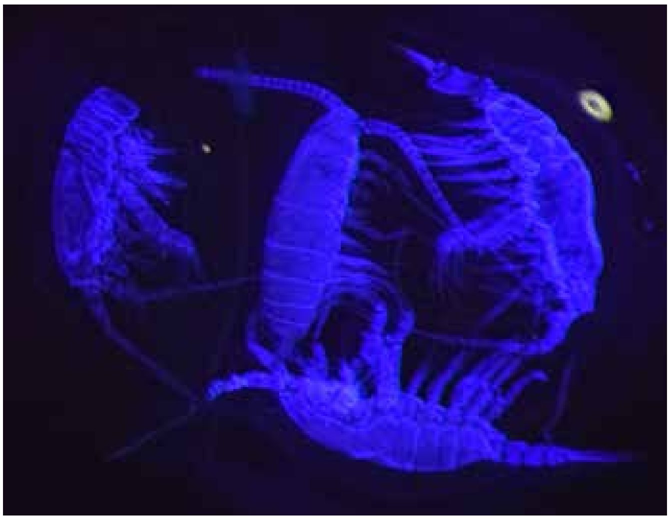
Potential impacts of CO_2 leakage in the ocean

How seawater chemistry might change following a CO_2 leak is now fairly well understood from laboratory and *in situ* experiments and observations at natural seeps. The most common effect is the localised acidification of seawater. Unlike ocean acidification linked to climate change, which is widespread, slowly progressive and long lasting, an accidental CO_2 leak is likely to occur over a shorter timeframe and impact a more limited area.

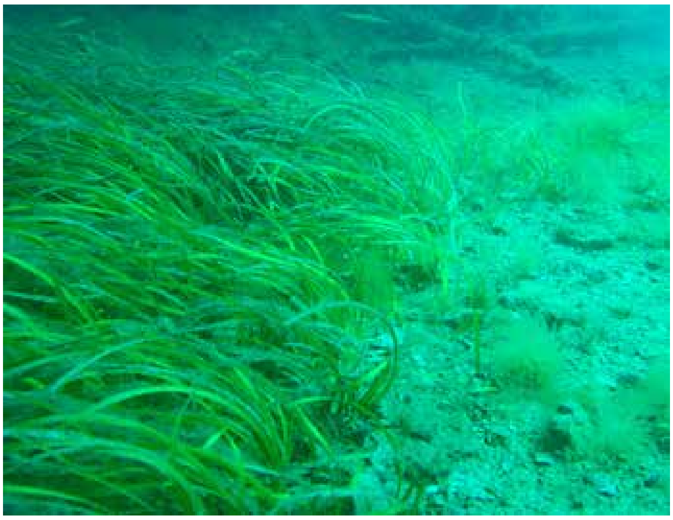
However, leaks may lead to a rapid and more pronounced lowering of pH, which in turn could have more profound implications for the immediate environment: within the sediment through which the CO_2 passes, in the water column above the leak, and along the trajectory of any CO_2 plume that is formed. In short, environmental impacts will be determined by the strength, duration and spread of leaking CO_2 and the habitats that are affected.

Effects will differ

CO_2 is a naturally-occurring gas without which life on Earth could not survive. In high concentrations it can also be a pollutant, putting that same life at risk. Ocean acidification has been demonstrated to have positive effects on some organisms, for example seagrasses, whilst having a detrimental effect on other organisms reliant on calcium carbonate to build shells and skeletons, or those which are sensitive to seawater changes, such as many plankton and their eggs and larvae.



Plankton - such as these copepods - are highly sensitive to changes in seawater chemistry and would be impacted by increased ocean acidity. Image courtesy K.Boot.

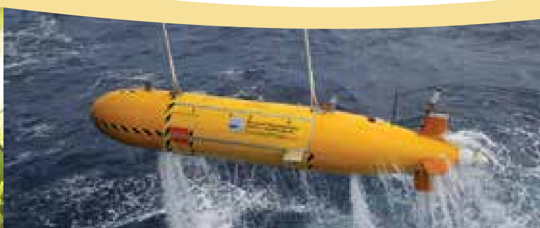


Some organisms, such as seagrasses, might reap positive effects as a result of increased ocean acidity, at least in the short term. Image courtesy Peter Southwood.

Environmental impacts of a leak will be most pronounced in the sediments and seawater in the immediate vicinity, and will decline with distance away from the emission point as the acidic seawater is diluted by normal pH seawater. Where distinct plumes of CO_2 are pulled away from the leak source by currents, effects may also be felt within the 'shadow' of the plumes. Modelling studies can take data from experiments and natural analogues and combine it with knowledge of local seawater chemistry and oceanographic conditions in order to enhance our understanding of how such CO_2 plumes might move and disperse, and what impact they might have on marine organisms.

"Winners and losers"

The idea that some organisms can gain from increased CO_2 while others suffer negatively has led to the concept of winners and losers. Such a concept does not take into account the complexity of marine food webs or the relationships between individuals, populations and communities that are impacted



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Some organisms, such as echinoderms (top), have been shown to be the most sensitive to changes in seawater acidity, whilst other animals such as crustacea (lobsters, middle image, and crabs, bottom) are more tolerant. Images courtesy K. Boot and NOC/JC010.

whenever there is an imbalance. Success of one species versus the dwindling of another alters the natural system that existed previously: the environment is changed.

Certainly some organisms are able to adapt in the short term by 'offsetting' the costs of resilience, for example by taking energy from reproduction and locomotion to invest in shell growth - a short-term strategy but one that may allow survival following a temporary reduction in seawater pH. Benthic (seabed) creatures are likely to be affected first and most by a leak. Amongst these, the echinoderms (starfish, sea urchins and their kin) have been shown to be most sensitive, molluscs less so and crustaceans (crabs, lobsters etc.) and annelids (worms) the least.

Some animals are used to rapid changes in their environment; some can move away from unsatisfactory conditions whilst others are more sedentary and therefore at risk. The ramifications for individuals, populations and communities are not clear: there can be significant differences in tolerance between closely-related species and even within species at different life stages. What is apparent is that if impacts occur they may cascade and have consequences for wider ecosystem functionality such as nutrient cycling, production and waste remediation. Recent work has shown that the benthic microbial community, crucial to ecosystem functioning, can also be affected with genetic diversity being reduced under conditions of increasing CO_2.

Getting back to normal

Experimental and observational evidence shows that any impacts of CO_2 leaks are most likely to occur within a short radius of just a few tens of metres from the leak source, and lessen rapidly with distance. The duration of a leak and its resulting impacts depends on many factors but should not last long. As such, the return to 'normal' should be fairly rapid, fuelled by migration of organisms from adjacent unaffected areas and the ingress of planktonic larvae at the appropriate seasons. However, the nature of the habitat affected will also determine recovery time. Calcareous habitats such as coralline algae and mussel beds that are vulnerable to seawater acidification, or nursery grounds where early life stages of species are especially sensitive to environmental disturbance, may take significantly longer to recover.

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