Put to the test: carbon capture and storage

For the first time scientists have run an experiment to measure the effects of a leak from a carbon capture and storage facility. Sue Nelson asked Jerry Blackford and Steve Widdicombe from Plymouth Marine Laboratory (PML) how their results will help us assess the potential of CCS for mitigating climate change.

Sue Nelson: I've come to Plymouth to learn about the QICS project – quantifying and monitoring potential ecosystem impacts of geological carbon storage. QICS aimed to understand the potential impact of a leak from a carbon capture and storage (CCS) system. Jerry, what exactly did you do?

Jerry Blackford: In fact we carried out the experiment in Oban, Scotland. PML's scientific diving facility is there – and we needed a lot of divers – but in fact the environment near Oban was perfect: relatively unpolluted and quite sheltered with good access to the shoreline.

We don't expect a leak to happen. But our aim was to find out what might happen if it did, so we wanted to replicate a leak as closely as possible – to see how CO_2 would move through the sediment and into the water column, how we can best monitor it (which is a regulatory need) and also what environmental impact it would have. So we drilled a hole from the shore 350m out underneath the bay, then pumped CO_2 out through a diffuser about 11m below the seabed for 37 days.

Sue Nelson: How did you measure whether carbon dioxide was leaking through the sea floor?

Jerry Blackford: The obvious thing is that you see bubbles coming from the sea floor, like a carbonated drink. But we used sophisticated seismic imagery to see how far the gas was spreading, whether it was focusing in chimney-like areas or diffusing through the sediments. We had chemical sensors in the water column to look for changes in acidity and we used cameras as well as taking sediment samples to analyse in the lab.

Sue Nelson: What percentage of the carbon dioxide was leaking?

Jerry Blackford: One of the big surprises for us was that only about 15 per cent of the injected CO_2 made it across the sea floor and into the water column. We must stress that we weren't testing storage – we were trying to make the CO_2 leak. But we were very surprised that the shallow sediments could hold on to so much CO_2.

Sue Nelson: How did it affect the alkalinity of the water?

Jerry Blackford: It had a really interesting effect on the alkalinity of the sediments. The CO_2 dissolves into the pore water – the little spaces between the sand and mud particles – where it causes all the remnants of seashells to dissolve. This creates a buffer that greatly reduces the chemical effect in the sediment. It may be a relatively


Divers sampling around lander.

Both images: Henrik Stahl, SAMS

short-term effect but that is really why so much of the CO_2 stayed around in the sediments and didn't come up into the water column.

We did see a change in acidity in the water column itself; we know CO_2 makes seawater more acidic and that effect was quite clear.

Sue Nelson: In terms of marine life, Steve, did you see positive or negative effects?

Steve Widdicombe: Though the chemical effects were perhaps less than we expected, there was a clear detrimental impact on the organisms living in the sediment itself. In the area most affected by the leak we saw quite significant changes to the health and behaviour of creatures like crabs and worms that burrow deep within the sediment.

But it's important to understand these animal communities also change naturally, for example in response to varying food supply and temperature through the seasons. So we also looked at reference sites to understand what natural changes were going on, so we could then see what changes were actually being caused by CO_2 leakage.

Sue Nelson: Often an environmental change creates winners and losers; did you see that here?

Steve Widdicombe: Some organisms, particularly very small ones like nematodes, did seem to increase in abundance in some areas. But this isn't because they like CO_2 – it's because some of the more CO_2-sensitive creatures that usually eat them or compete with them for food are being removed from the system. On the face of it it's a good thing for the worms but, again, we're not sure how sustainable that would be in the long term.

Sue Nelson: Jerry, are the results of your project good news for future CCS schemes?

Jerry Blackford: Yes, I think it is a relatively positive message for CCS. It is the first time this has ever been done in the world and we've attracted a lot of interest from people wanting to see our results and join in with our work. Whilst we saw an impact on the ecosystem where we released the CO_2, one of the most striking things was how quickly it recovered. When we stopped injecting CO_2 the chemical changes disappeared within a couple of days and the biological systems recovered within about three weeks. So I think that does show that a small leak from a CCS system almost certainly wouldn't be an environmental catastrophe.

Sue Nelson: In reality would the CO_2 be injected and stored at a much deeper level?

Jerry Blackford: Absolutely. Most storage would be in rock between one and two kilometres below the sea floor, so there is an awful lot of rock for the CO_2 to move through. The natural gas we extract from the North Sea has been there for millennia and it stays there, it doesn't come up. So there are many reasons to think that if CCS is done properly, with all the appropriate monitoring in place and the appropriate choice of storage sites, the CO_2 should stay there.

Sue Nelson: Where do you go from here?

Steve Widdicombe: QICS has been successful but it's only been done once and we know the biological and environmental responses are incredibly dependent on things like the time of year, which habitats you experiment in, how much CO_2 you're going to release and how long for. So to generalise from this one experiment would be unwise at the moment; this is a great story but we need to be generating this kind of information over a much broader suite of habitats, communities and situations.

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