

Carbon Capture and Storage

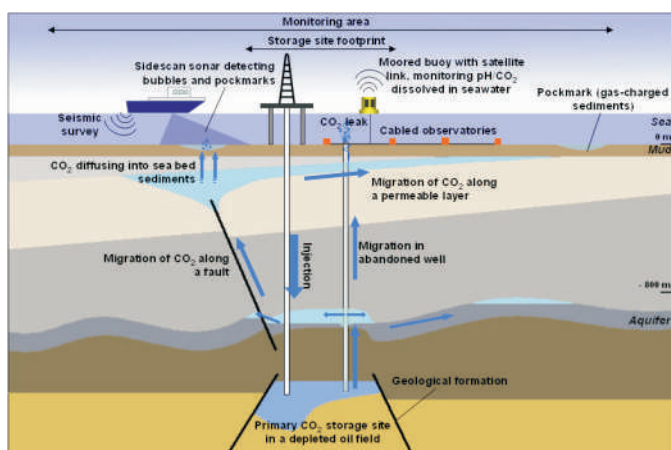
Carbon dioxide (CO₂) capture and storage (CCS) means separation of CO₂ from industrial and energy related sources, transport to a storage location, and long-term isolation from the atmosphere in secure spaces such as geological formations, including old oil and gas fields and aquifers under the seabed.

CCS is considered by the Intergovernmental Panel on Climate Change (IPCC) as an option in a portfolio of climate change mitigation actions (IPCC 2005). Indeed, where very long-term storage is achievable, CCS may complement measures to reduce greenhouse-gas emissions at source. However, CCS is only part of a package of measures needed to reduce CO₂ emissions that should include conservation of energy (demand restraint), renewables and improved energy efficiency.

OSPAR has adopted a decision 'to ensure environmentally safe storage of carbon dioxide streams in geological formations': a new amendment in 2007 states that CO₂ streams from capture processes can be stored provided that:

- the CO₂ is injected into a sub-soil geological formation;
- the streams consist overwhelmingly of carbon dioxide;
- no wastes are added for the purpose of disposal;
- the CO₂ is intended to be retained permanently and will not lead to significant adverse consequences for the marine environment.

Ongoing research at Plymouth Marine Laboratory (PML) provides comprehensive expertise in terms of environmental risk assessment of CCS, through an integrated and multidisciplinary approach, combining know-how on biogeochemical impacts, ecosystem responses, modelling, risk assessment and monitoring.



Carbon Capture and Storage Monitoring

Research areas

Predict the effects of increased CO₂ on our oceans

Leakage of CO₂ from a geological formation under the seabed would lead to the acidification of the surrounding water and impact the marine ecosystem. PML is using experiments in mesocosms to investigate the response of chemical processes and various marine species to acidified seawater. Scientists have identified significant variability in the pH sensitivity of a number of different benthic faunal organisms, for example echinoderms, which show far less tolerance to pH change than molluscs. Such variability in sensitivity will have considerable implications for the maintenance of biodiversity in marine sediments, as we could potentially lose the more sensitive species, which would result in a subsequent loss of ecosystem function and value.

30 years of core research into biodiversity and sustainable ecosystems

Rapid rates of biodiversity alteration and loss in our seas could compromise both the maintenance of global ecosystem processes and the sustainable use of exploitable resources. PML's biodiversity research aims to provide concepts and tools for management and appropriate conservation: we are developing indices and methodologies that can tell us about how biodiversity is changing at different spatial (regional to global) and temporal scales. We could therefore transfer this knowledge to monitoring CCS and define indicators and methodologies to assess the environmental impacts of CCS on the surrounding marine communities.

Modelling environmental impacts of CCS

Modelling provides our key methodology for assessing the scale and impact of any given leak event. Using our shelf-seas biogeochemical and ecological modelling capability, we have examined a number of rudimentary leakage scenarios. Results to date suggest that larger leaks are capable of producing significant chemical perturbations within the locality of the leak. However the strong tidally driven mixing of the North Sea disperses the signal away from the leak site. We have hypothesised that the rapid diffusion and mixing in the water column would minimise effects to pelagic systems but that the immobile and slower growing benthic infaunal organisms would be exposed sufficiently to be considered at risk. Research is ongoing in tandem with the experimentalists to provide better descriptions of processes that may be vulnerable to high CCS leaks.

Technology development and facilities

Measuring pCO₂ in seawater

PML has been involved in the development of underway pCO₂ systems for over 20 years and has contributed to many international studies. The latest PML/Dartcom pCO₂ systems measure the partial pressure of CO₂ in the ocean compared to that in the atmosphere. They are designed for autonomous, ship-borne, underway operation at sea and have the capability to produce data continuously in real-time via Iridium satellite communications or live internet feeds. A built-in GPS enables live tracking of measurements and diagnostic system sensors allow remote checking of system performance.

Marinising pH meters for monitoring CO₂ leakage

PML has been at the forefront of instrument development for precise measurement of pH in seawater and has recently installed a precision instrument on the RV Quest for routine measurements as part of the Western Channel Observatory (www.westernchannelobservatory.org.uk). Funding is currently being sought to enable development of autonomous pH instruments that could be mounted on sea bed moorings as part of a networked instrument array for the detection of CO₂ leakages.

Mesocosms

The PML seawater acidification system is housed within a spacious temperature controlled (5°C to 20°C) mesocosm facility which gives us the flexibility to carry out a wide range of experimental work under highly controlled conditions.



The ocean acidification experimental system comprises a number of large (450L) cylindrical reservoir tanks in which seawater can be acidified by bubbling with carbon dioxide.

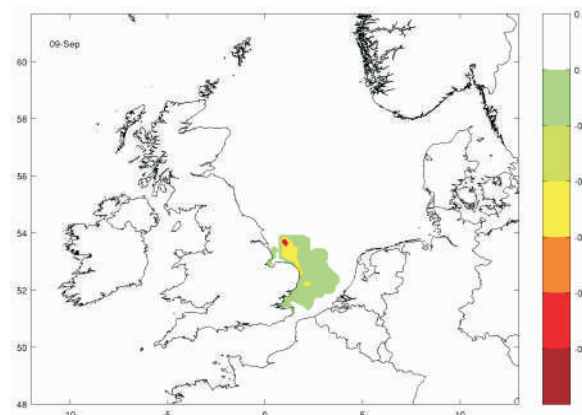
The bubbling rate of CO₂ is computer-controlled to achieve stable seawater pH levels. Seawater at controlled pH is then pumped through the experimental tanks to study the effects of increased ocean acidity on a variety of marine organisms e.g. crabs, sea urchins etc. The mesocosm facility also includes a separate culture room with independent temperature control for running small scale experiments and an adjacent dry laboratory containing instruments for monitoring seawater carbonate chemistry.

Computer cluster

A new 320 node Bull compute cluster allows us to process and evaluate significant numbers of leakage scenarios and their impacts efficiently.

The future

PML has the capability and experience to assess the potential risk from leakage or seepage of CO₂ from geological reservoirs into the marine environment, by collaborating with geologists and engineers on the particular attributes of given storage areas. We are also able to evaluate the impacts of leakage through the use of genetics, experimental mesocosms, predictive modelling techniques and design of appropriate environmental monitoring programmes. These same technologies and tools will also allow us to assess the recovery of marine ecosystems following experimental injections of CO₂ plus contaminants and/or cessation of leakage.



The plume of acidified seawater arising from an extreme and long term leak scenario. The colour indicates the predicted environmental impact, green: little impact, amber: warning, red: harmful