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Utilization of small Remotely Operated Vehicles (ROV) for underwater CO2 leakage monitoring

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Until recently, Remotely Operated Vehicles (ROVs) were big, heavy and very expensive systems with the necessity for a large operator team and complex infrastructure such as big working vessels with specialized crews. Therefore, their utilization was limited mainly to the offshore oil and construction industry. During the last few years, remotely operated camera systems, originally designed as recreational 'toys', have evolved into full-fledged Micro-ROVs, providing a very interesting option for scientific underwater surveys. These Micro-ROVs are small, reliable, inexpensive and easy to handle, and can operate from a small boat or the lakeshore. This opens new opportunities for a wide variety of scientific applications in the geosciences, biology and archeology, for example.
A recent challenge for researchers is to find efficient and safe systems to reduce the atmospheric concentration of carbon dioxide of anthropogenic origin in order to reduce global warming. Carbon Capture and Storage (CCS) techniques are under study and one such storage solution could be the sub-seabed geological sequestration of CO2. One of the concerns related to the storage of carbon dioxide below the sea bottom is the possibility of leaks from the reservoir and subsequently how this leakage could affect the marine environment. For this reason, we are working on the development of leakage detection and monitoring systems, focusing on long-term monitoring. As an analogue to leaking storage sites, natural gas releases were used in our studies to verify the impact of local and strong increase of carbon dioxide on the aquatic environment.
The study methods regard the modification of water chemistry due to the presence of carbon dioxide both as dissolved and free gas, the impact on the biological communities and the effect on the sediment cover of the strongest flow. Since it is mandatory to collect data underwater for these studies, the way to achieve this is through the use of specialized scientific divers and, where it is not possible to dive or where is more appropriate, by using Micro-ROVs. The Micro-ROV requires less logistics and people (two well-skilled people are sufficient) than the option of using divers, and can operate faster and longer, thus covering larger areas.
The Micro-ROVs used by BGR and URS are two different VideoRay models. The first model, tested by URS, was the VideoRAY Scout, a pure survey ROV with a submersible weight of less than four kilograms. This basic model was successfully used to conduct video-transects on the bottom of Laacher See, a volcanic lake in the Eiffel region of Germany that hosts carbon dioxide gas vents on the bottom. With the ROV, it was possible to verify the existence of these gas vents in the deepest part of the lake for the first time, and also to collect video footage of the rising bubbles.
After the good results obtained with this basic model, BGR purchased a more complex model (VideoRay Pro 3) with a higher depth rating, stronger propulsion and the capability to carry different sensor systems. It is equipped with two cameras, scanning sonar, positioning system and manipulator, but still offers the same advantages in size etc. of the basic model. Currently, the use of the sonar system for bubble detection over a larger area is being tested, and an ROV-mountable in-situ gas sampler and several flux meters are under development. It is also planned to add sensors for temperature, salinity etc. to the ROV. The development of sediment sampling equipment (e.g. push corer) is somewhat limited by the low mass of the ROV, but would be very interesting for microbiology.
The ROV will be the basis of a detection system for carbon dioxide leaks that may eventually happen from sub-seabed storage site placed in near-shore areas or in shallow offshore areas such as the Sleipner field that is currently a test site for sub-seabed CO2 injection in shallow water (less than 100 m). The experiences with our Micro-ROV systems can easily be transferred to working class ROVs for later use in deeper waters or high-current settings.