Detection of CO_2 bubbles in shallow sea using side-scan sonar (SSS)

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An important issue for geological storage of carbon dioxide (CO_2) is how to detect leakagea marine environmental impact assessment for offshore storage into deep aquifers. In the case of the sub-seabed storage of CO_2, not only the geological structures around the deep reservoir but also the sea areas above it should be monitored to verify that the CO_2 is retained in the reservoir, or that there is no signs of CO_2 leakage. The monitoring would help gain public acceptance, as well as it is required by a law, Act on Prevention of Marine Pollution and Maritime Disaster, in Japan. Since CO_2 is in its gaseous phase at temperature and pressure of the bottom of shallow sea, gaseous CO_2 or CO_2 bubbles would be likely to leak out into the water column should CO_2 leakage occur in shallow sea. Thus, a promising way to detect CO_2 leakage in the marine environment is to find CO_2 bubbles in the water column. It is well known that some kinds of sonar can be used to detect bubbles in the water column. Among those kinds of sonar is side-scan sonar (SSS), which is suitable for a sweeping search. Although CO_2 bubbles are easy to dissolve into seawater, and consequently to diminish quickly, we have confirmed that SSS can detect CO_2 bubbles in the previous year. Detailed ability of SSS for detecting CO_2 bubbles, however, remains to be studied.

To specify feasible conditions for detecting CO_2 bubbles with SSS, we conducted comprehensive experiments at the innermost part of Suruga Bay, where it is about 32 meters deep. In the experiments, we released CO_2 bubbles at the seabed and observed them with SSS towed in the water column by a fishing vessel. The release rate was set between 500 ml/min and 5,000 ml/min, the initial diameter of the bubbles was set to be about 5 mm orand 7 mm, the speed of the vessel was set between 3 knots and 6 knots, the depth of towed SSS were was set from 10 m above the seabed to near the sea surface, and the horizontal distance between SSS and the release point were was set from 0 to 50 m.

Through the experiments, the following were revealed. First, SSS can detect CO_2 bubbles only within the circle whose center is SSS and whose radius is the altitude of SSS (the distance between SSS and the seabed beneath it). Second, the detectability improves as the release rates increases and the vessel speed decreases. Third, the detectability does not greatly depend on the initial size of the bubbles. In conclusion, when the vessel towing SSS cruises at a speed of 5 knots or smaller than it, CO_2 leakage whose leakage rate is equal to or larger than 500 −1000 ml/min could be detected with SSS. We would like to emphasize that this leakage rate, corresponding to about 2 - 4 tonnesCO_2/year (depending on water temperature and pressure), is tiny compared with the injection rate at demonstration scale storage, not mention to commercial scale storage.

Keywords: offshore CO2 storage, side-scan sonar, leakage

