Integrated Monitoring Research at Natural CO_2 Vents: Lake Laach (Germany)

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Acknowledgement

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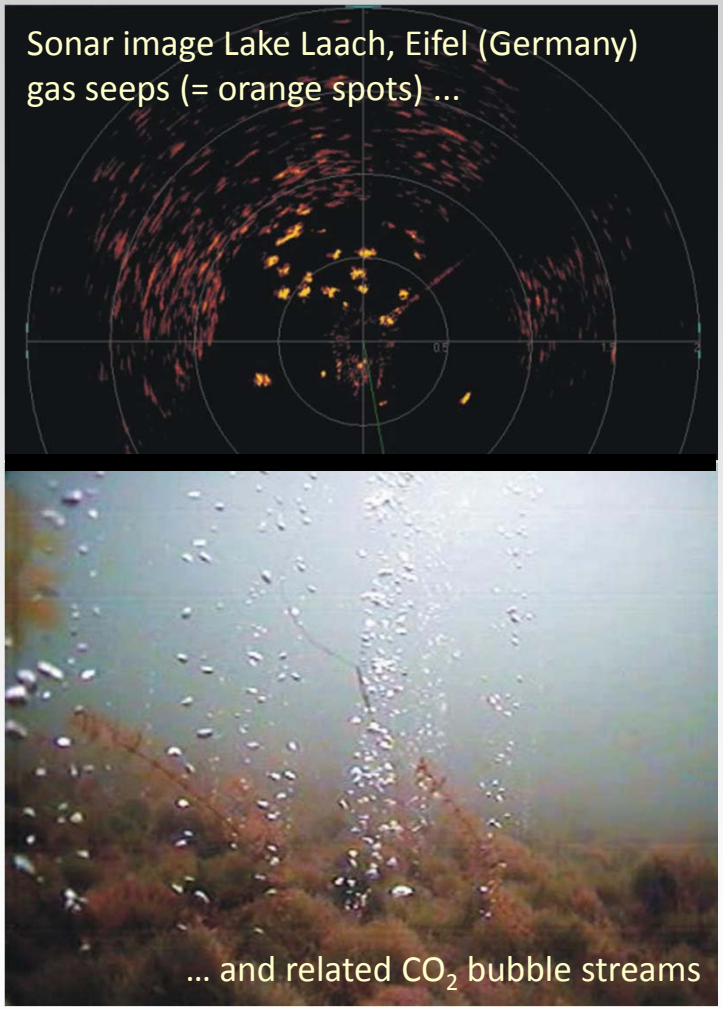
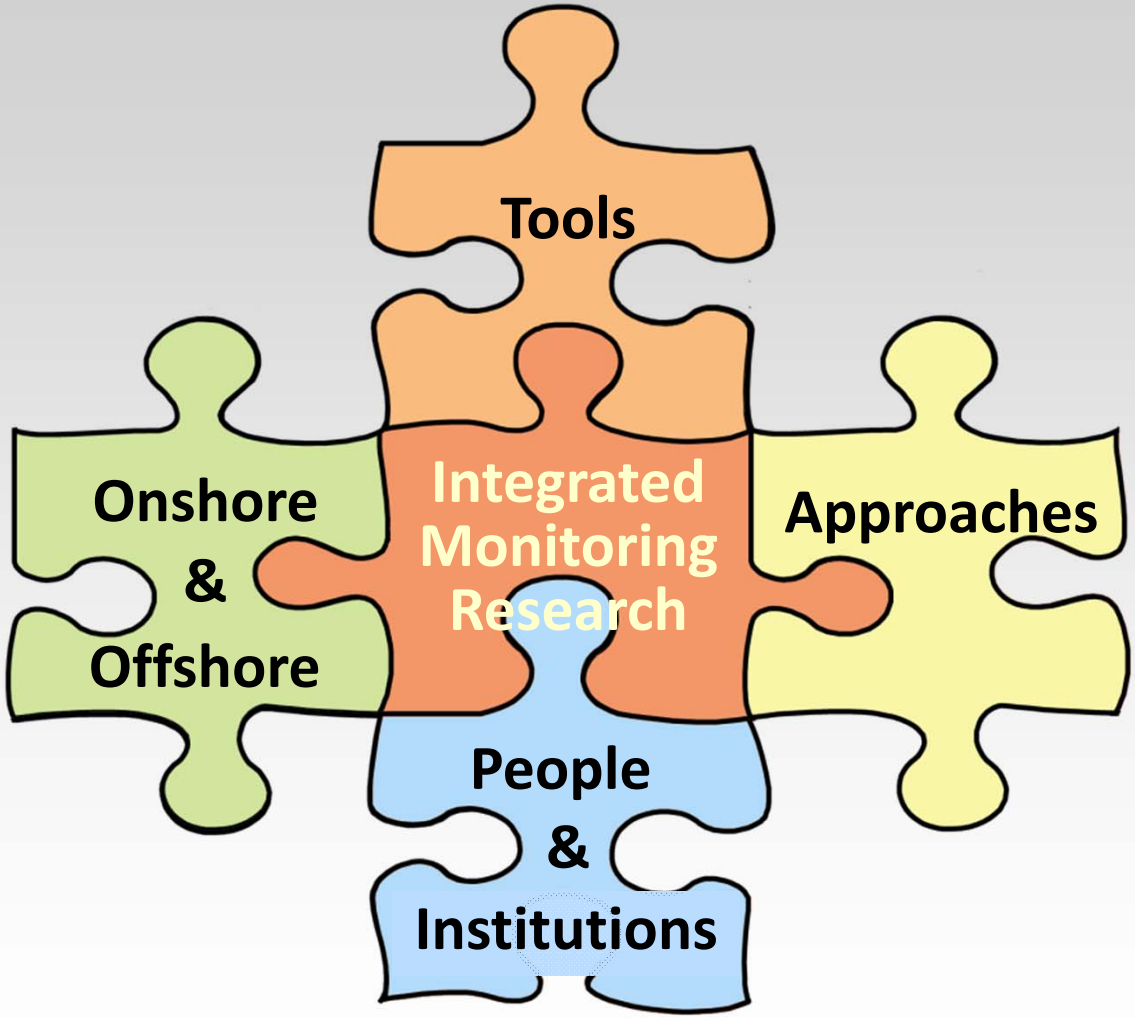


Introduction: Terms & Outline



Monitoring

- Near surface monitoring in the CCS context
- Leakage detection
- Longterm leakage surveillance

Integration

- … putting objects, tools and methods of the working environment in the right place and connect them meaningful …

Introduction: Lake Laach

Introduction: Lake Laach

- The lake fills a volcanic caldera formed by an eruption about 12,900 yrs ago
- Surface level at 275.3 m asl, area of about 3.31 km^2, max. depth presently at 52.34 m
- No natural run-off, but tunnel constructions in the 12th and 19th century
  → lowered the lake level by 10+5m
- CO_2-degassing related to upper mantle anomalies (intrusion to lower crustal levels)
- Accompanying He and C isotopes point to a mantle signature
- Estimated CO_2-flux into the lake is at about 5000 t CO_2 per yr
  (Aeschbach-Hertig et al. 1996)

Integrating People & Institutions

Field work, *i.a.* within CO_2GeoNet

- BGR
- BGS
- BRGM
- OGS
- URS

- Centre for Innovation in CCS, Nottingham
- Inst. for Biogeochemistry & marine Chem., Univ. Hamburg
- Inst. of Geology, Univ. Mainz
- Atlas Electronics, Bremen
- Northern Inst. of Advanced Hydrographics, Hamburg
- LUWG, Mainz etc.

Integrating People & Institutions

Networking, *e.g.*

Workshop on Natural Releases of CO_2: Building Knowledge for CO_2 Storage Environmental Impact Assessments; Nov. 2010

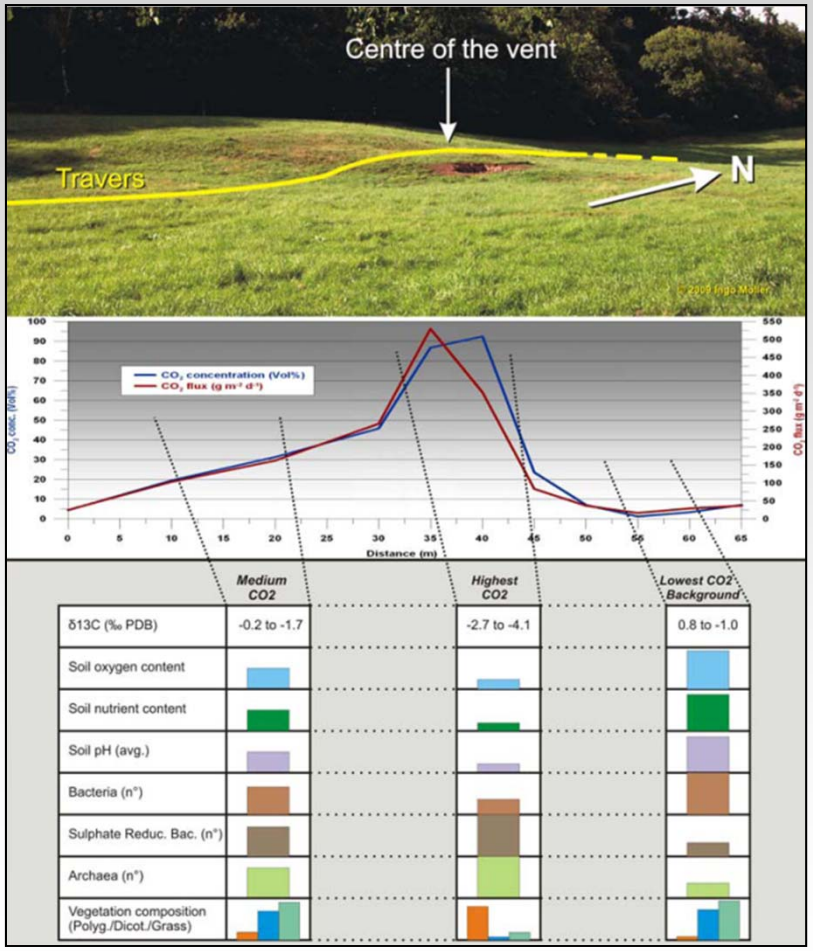
- organised by IEAGHG in co-operation with CO_2GeoNet and BGR
- sponsorship: IEAGHG & IPAC-CO_2 Research
- ~ 50 participants from all over the world

Field activities: Onshore

e.g. Joint Geoecological Research of Natural CO_2 Sources in the East Eifel, Germany within CO_2GeoNet's activities on monitoring near surface leakage and its impacts 2007-2009

- BGR, BGS, BRGM, URS
- Near surface gas surveys
- Impact studies:
  - Botany
  - Invertebrates
  - Microbiology
- Survey of water physics and chemistry
- Initial underwater gas survey
- later also OGS, airborne remote sensing

Lake Laach, Western Shore:



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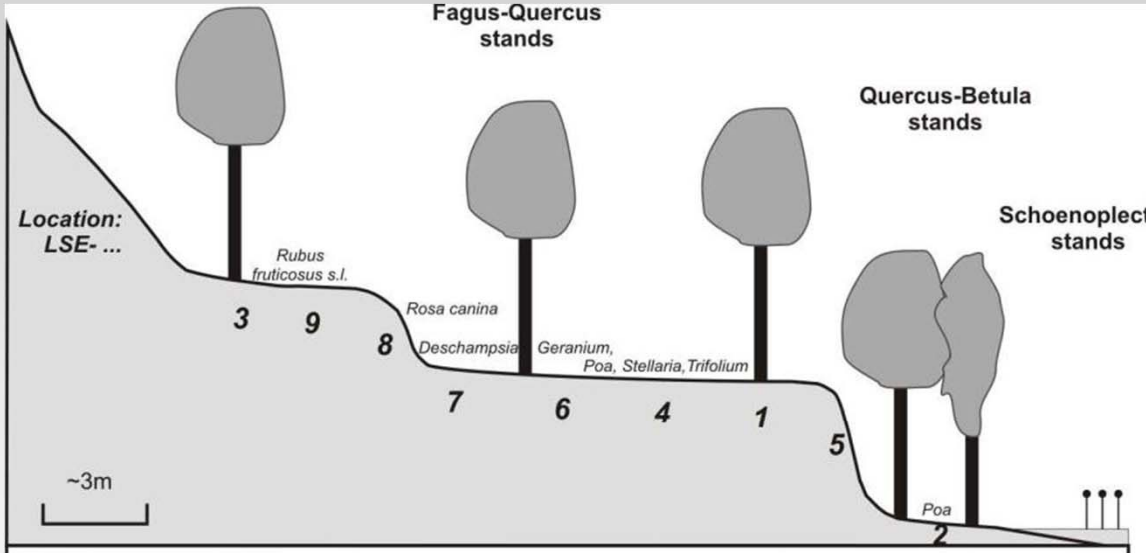
Lake Laach, Eastern Shore:

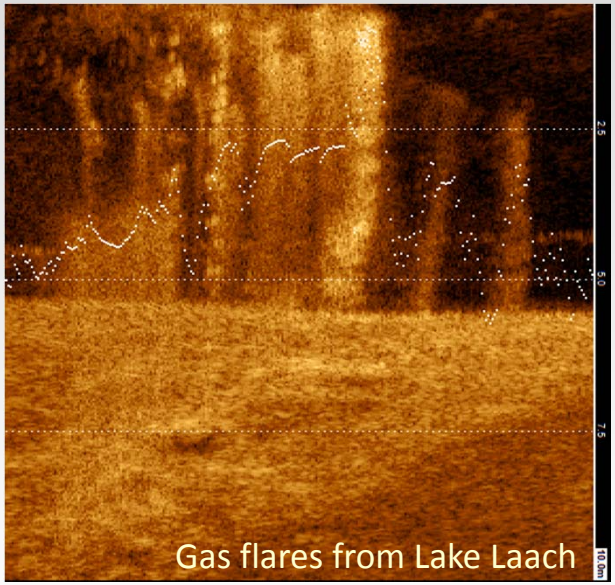


pH ($CaCl_2$):	4,5-5,1	---	---	---	---	---	3,6-4,0	---	4,1-6,6
Soil moisture:	dry	dry	fresh	fresh	dry	dry	dry	fresh	humid-wet
Soil org. matter:	low	low	low	medium	medium	low	low	medium	high
CO_2 conc. (Vol%, 40cm):	0,0*	3,0	4,5	7	14	14	24	48	36,0
CO_2 conc. (Vol%, 1m):	1,6	---	---	---	---	---	56,0	---	90,0
CO_2 flow ($g/m^2/d$):	0,0*	0,0*	0,0*	293	317	447	6823	2240	934
$d^{13}C_{CO2}$ (PDB):	-9,8	---	---	---	---	---	-2,6	---	-2,4

Field activities: Offshore

A Multi-Level Concept as Systematic Underwater (Gas) Monitoring Approach

1. Level: Detection



Periodic surveys by means of ship-mounted hydro-acoustic methods covering large areas

2.+3. Level (in case of anomalies): Verification and Characterization

Inspection of anomalies using ROV-based techniques; *i.a.* video capturing, gas sampling & gas flux quantification

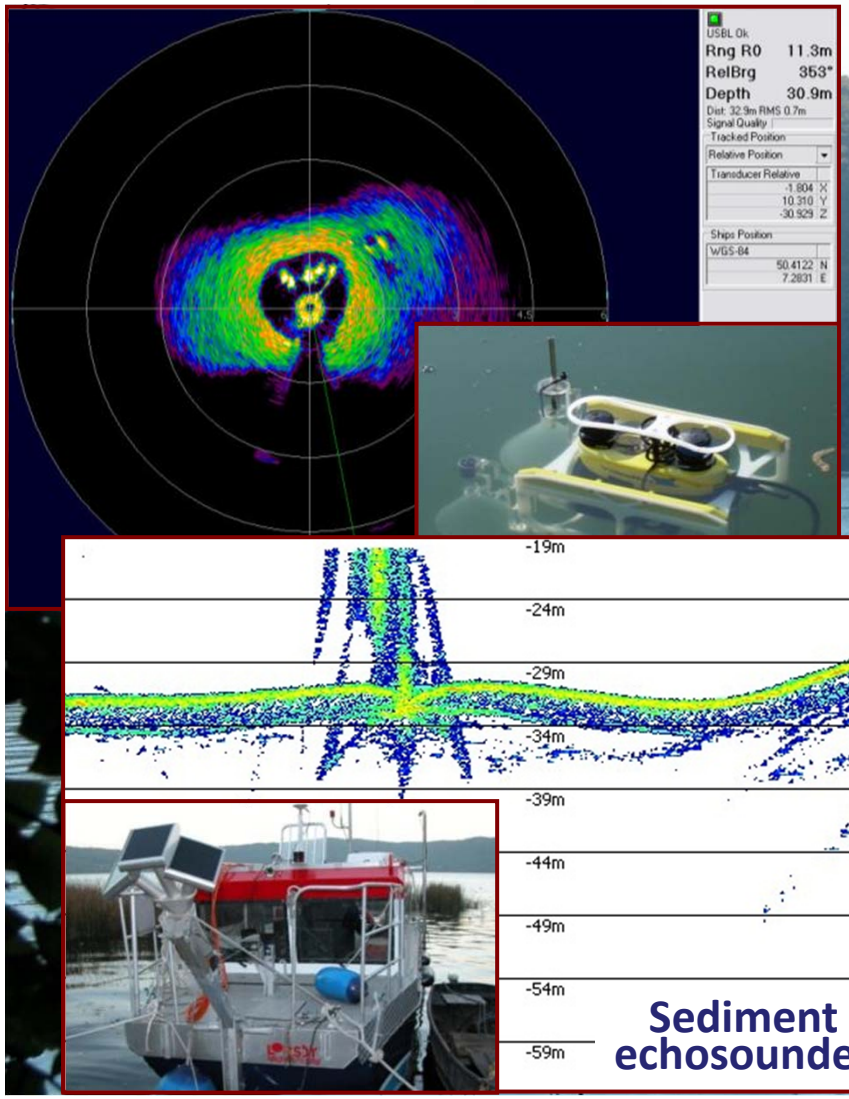
4. Level (in case of leakage): Long-term Monitoring

Installation of stationary monitoring devices for the long-term survey of identified seepages

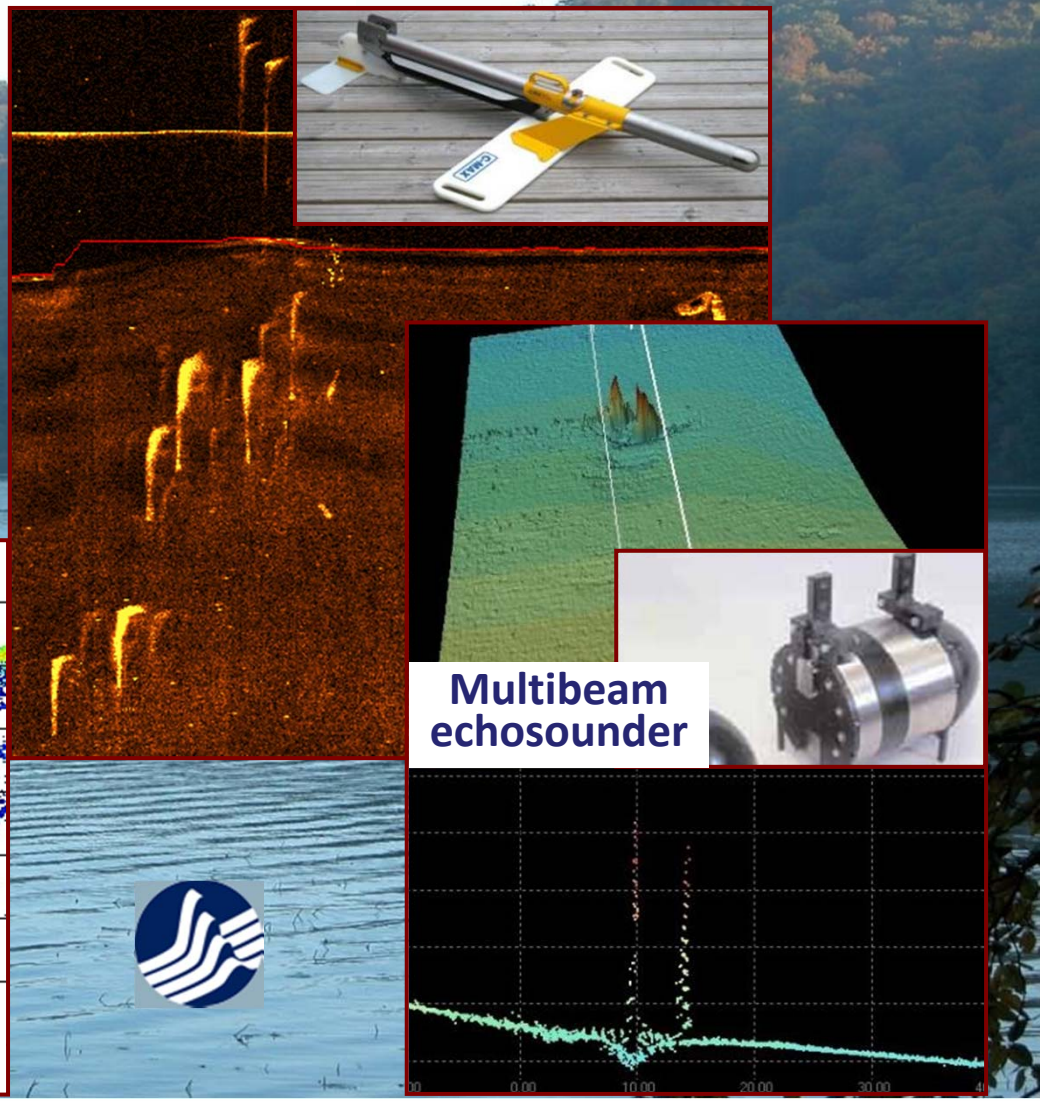
CO2 GeoNet · CCS Europe · CO2 REMOVE research monitoring verification · BGR

Field activities: Offshore leakage detection

Horizontal scan sonar



Side scan sonar



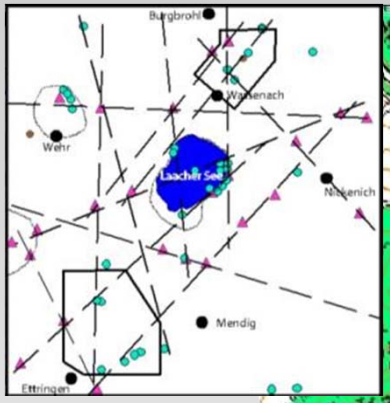
GeoNet · CCS Europe · CO2 REMOVE research monitoring verification · BGR

Field activities: Offshore leakage detection

Systems Evaluation, preliminary

Sonar system	Multibeam echosounder 	Sidescan sonar, towed 	Sediment echosounder 
Position accuracy	+ [cm range]	- [~5 m ±2.5]	+ [cm range]
Spatial coverage	+ [readily acquirable]	+ [readily acquirable]	- [small beam width of 1.8°]
Detection certainty	- [notably false positives]	+/- [limits for small releases]	+ [exact identification]
…	…	…	…
Time requirements	+/- [fast to time-consuming]	+ [more or less fast]	- [complex processing]
Σ:	reliable for strong gas plumes	rapid surveying with uncertainties	very good detection along traverses

Field activities: Regional interpretation



slightly modified after:
Mundhenk (2009).

Field activities: Verification & Characterisation

ROV-based surveying

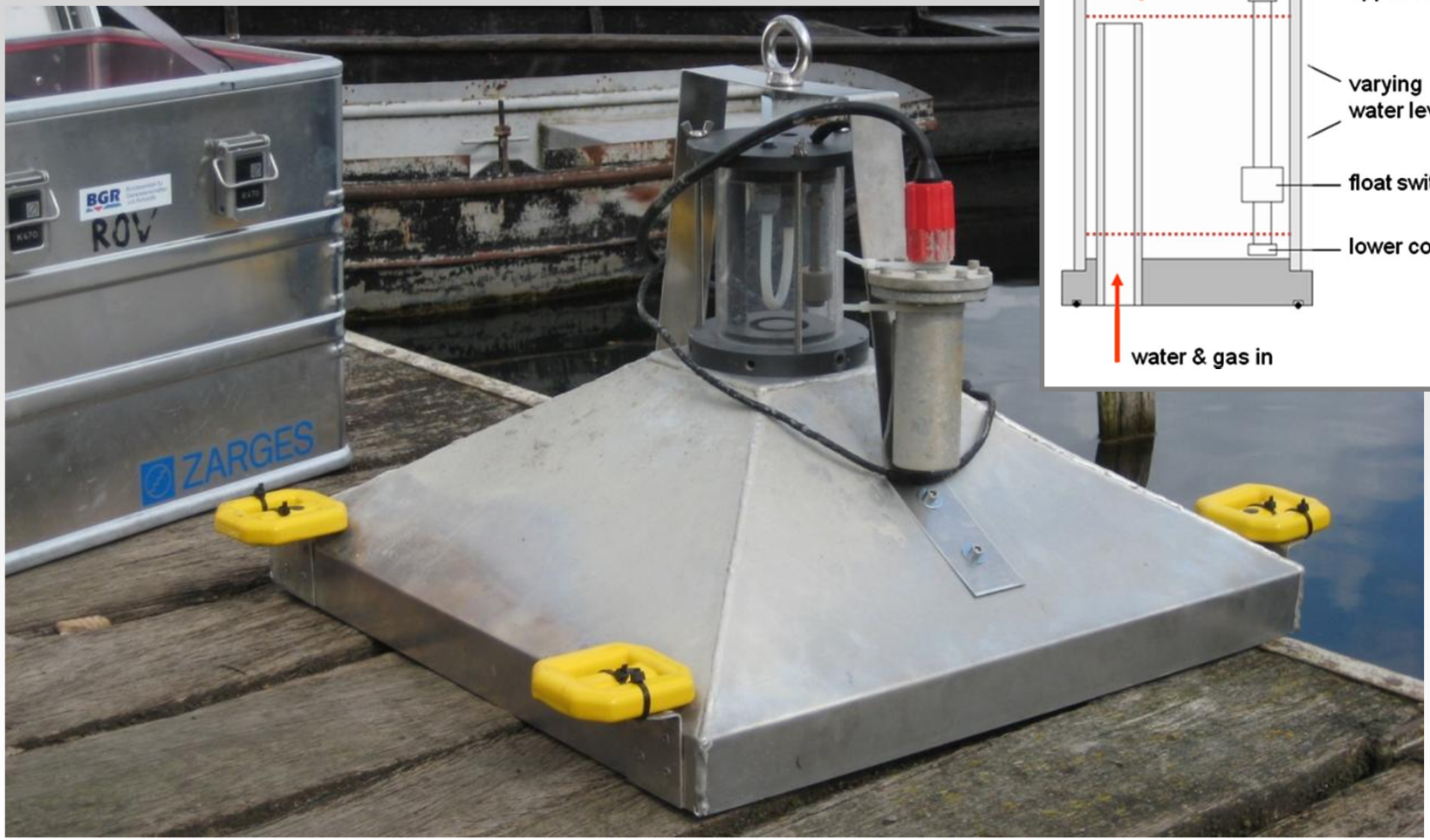
Development focused on:

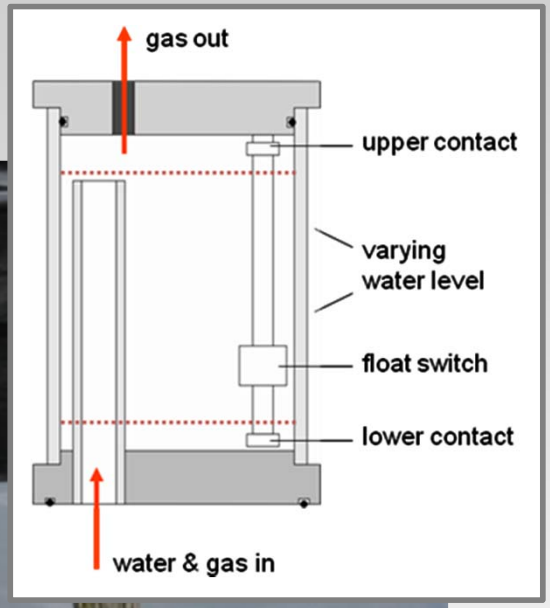
- High Mobility
- Fast Interventions
- Systems Integration
- Robustness
- Least costs

- Sonar navigation & logging
- USBL positioning & logging
- Video documentation
- Gas flow recording
- Gas sampling
- Water sampling
- Sensors for dissolved gases (CO_2 and CH_4) mountable
- Temperature and pressure recording

Field activities: Long-term monitoring

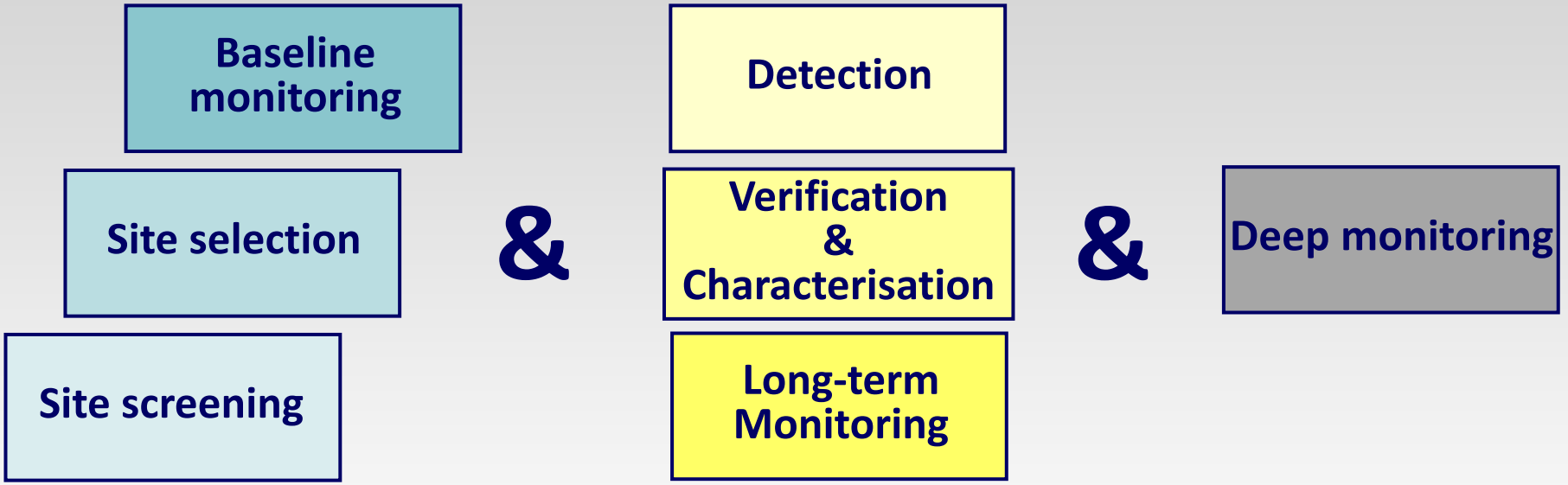
Collector based long-term monitoring





Conclusion

A realistic underwater gas monitoring of CO_2 storage complexes requires a multi-level concept



$\Sigma \rightarrow$ **Integrated monitoring system as primary design requirement of (offshore) CCS operations**