Monitoring and impact assessment of CO_2 seabed sequestration in China

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Outline

- Potential impact of CO_2 seabed sequestration
- Feasibility of CO_2 seabed sequestration in China
- Case study- impact of CO_2 leakage
- Risk control and management

CCS is regarded as a key technology for the reduction of CO_2 emissions at international level.

项目名称	国家	开始时间	注入量（$t \cdot d^{-1}$）	封存总量（t）	封存地类型
Sleipner	挪威	1996	3000	20000000	咸水层
weybrun	加拿大	2000	3000~5000	20000000	EOR
In Salah	阿尔及利亚	2004	3000~4000	17000000	天然气田
K12B	荷兰	2004	100	8000000	增强气体回收
Frio	美国	2004	177	1600	咸水层
Fenn大山谷	加拿大	1998	50	200	ECBM
Recopol	波兰	2003	1	10	ECBM
Yubari	日本	2004	10	200	ECBM
Gorgon	澳大利亚	2009	10000	-	咸水层
Snøhvit	挪威	2006	2000	-	咸水层
沁水流域	中国	2003	30	150	ECBM
鄂尔多斯	中国	2010	-	100000/年	咸水层

☼ However, little is known about the short-term and long-term impacts of CO_2 storage on marine ecosystems even though CO_2 has been stored sub-seabed in the North Sea (Sleipner) for over 15 years and for 3 years in the Barents Sea (Snhvit).

London Protocol and the OSPAR Commission demand inter alia offshore CCS should be a permanent storage. Risks have to be avoided and substances added to the CO_2 stream should be minimized.

It was clear that the basic risks of offshore CCS to the marine environment are associated with potential leakages. CO_2 as well as substances added to the CO_2 stream and substances mobilized by the CO_2 stream from the surrounding material must be considered.

Impacts of CO_2 leakage on marine ecosystems

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Contents lists available at ScienceDirect

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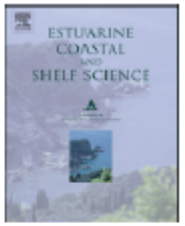
journal homepage: www.elsevier.com/locate/ecss



Assessment of pH variability at a coastal CO_2 vent for ocean acidification studies

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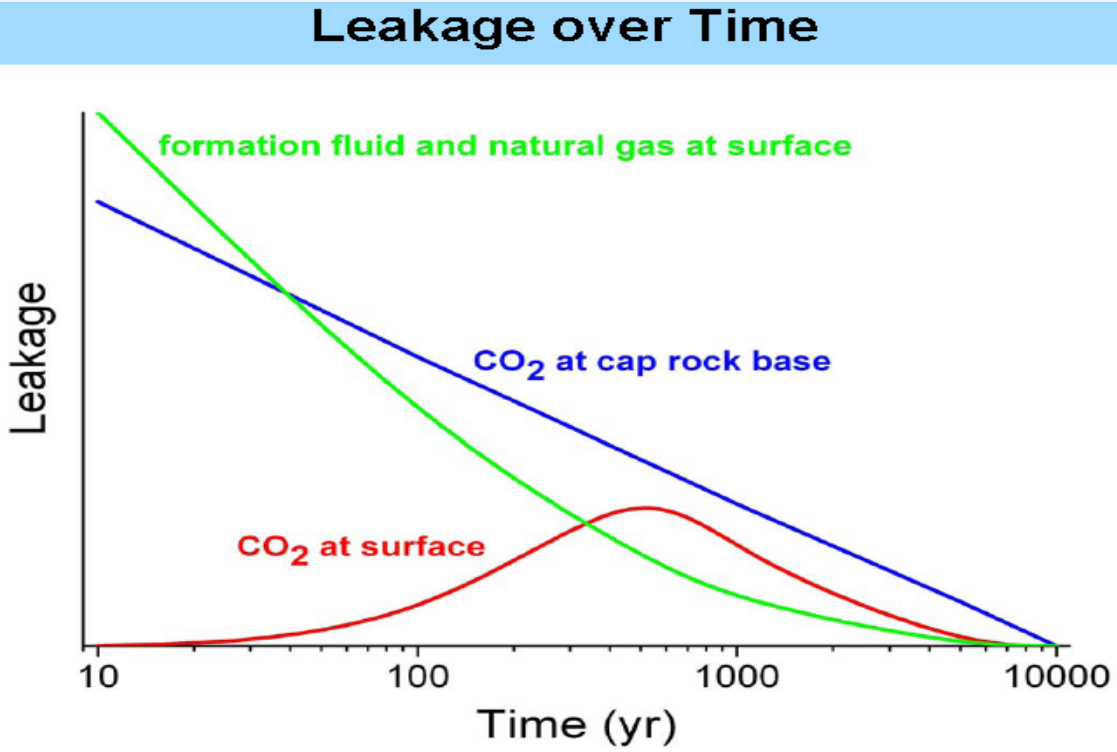
A unique natural laboratory

leakage rate are acceptable ?

The maximum permissible leakage flux from submarine storage should be defined as less than 10 % of the normal flux rates which generally corresponds to a rate smaller than 10 t of CO_2 per km^2 per year (Prof. Klaus Wallmann).



ECO_2—EU project led by IFM-GEOMAR

4 year €10.5 Mio.

Objective：

The ECO_2 project sets out to assess the risks associated with the storage of CO_2 below the seabed.

3 study sites :

- Sleipner (90 m water depth)
- Snøhvit (330 m water depth)
- the B3 field in the Polish Baltic Sea (80 m water depth)

Focus on :

- whether or not gas is being released at these sites
- how it could be transported through the different strata
- which reactions are involved.

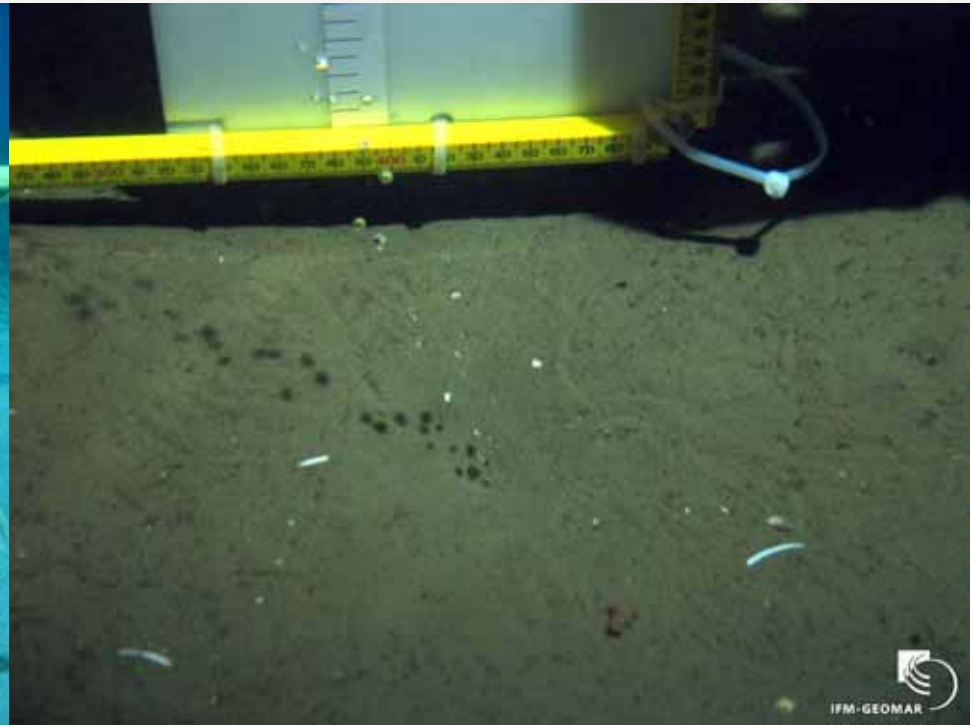
To evaluate

- ✓ the likelihood of leakage,
- ✓ the possible impacts on marine ecosystems,
- ✓ the potential economic and legal consequences of leakage

THE GOAL

To provide not only a comprehensive risk assessment but also guidelines for monitoring and a best environmental practice guide for preparation and management of storage sites.

The first expeditions have already been conducted during spring and summer 2011 to monitor the seafloor and evaluate the safety of the storage sites located in the North Sea and Barents Sea.

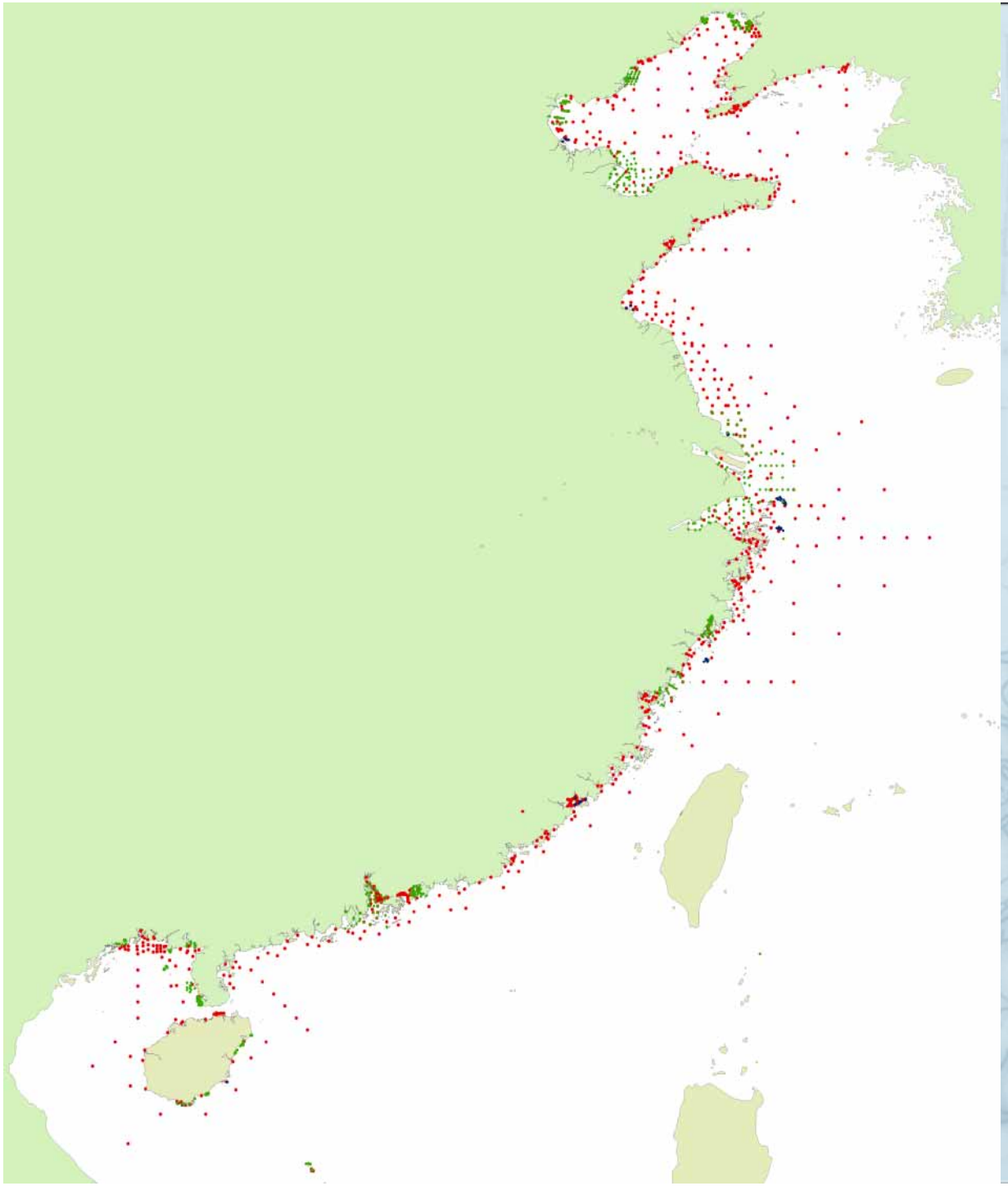


Research projects

Time	Research projects
2006	温室气体地下埋存及提高石油采收率的资源化利用
2007	吉林油田含CO_2天然气开发和CO_2埋存及资源综合利用研究
2007	中欧碳捕获与封存合作行动(COACH)
2008	CO_2的捕集与封存技术
2008	中国CO_2海底封存能力评估与风险控制技术预研究
2010	中澳CO_2地质封存合作项目
2010	广东省CO_2捕集与封存可行性研究

CCS project in Chinese large-scale power plant

企业	启动或投产时间	项目简介
华能北京热电厂	2008年7月投产	国内首座燃煤电厂燃烧后CO_2捕集示范工程，CO_2捕集量3000 $t•a^{-1}$
华能上海石洞口第二电厂	2009年12月投产	目前世界最大的燃烧后CO_2捕集示范工程，捕集和提纯12万$t•a^{-1}$，成本仅为美国同类工程的30%。
华能天津IGCC示范电站	2009年启动	整体煤气化联合循环发电系统（IGCC），是目前世界上最环保的高效发电、低排放燃煤发电技术，首期250 MW将于2011年前建成
中电投重庆双槐电厂	2010年投产	燃烧后捕集装置，自主技术，捕集和提纯1万$t•a^{-1}$。
中国石油吉林油田	2006年启动	CO_2高效捕集、安全埋存和驱油试验，至2009年9月已注入$CO_2$7万t，预测提高采收率14%
中国神华集团	2010年7月启动	我国首个全程CCS示范项目，包括捕集和注入咸水层封存。封存量10万$t•a^{-1}$。将分两步建成年捕集与封存100万t、300万t的项目。



marine environment monitoring in China

Monitoring stations

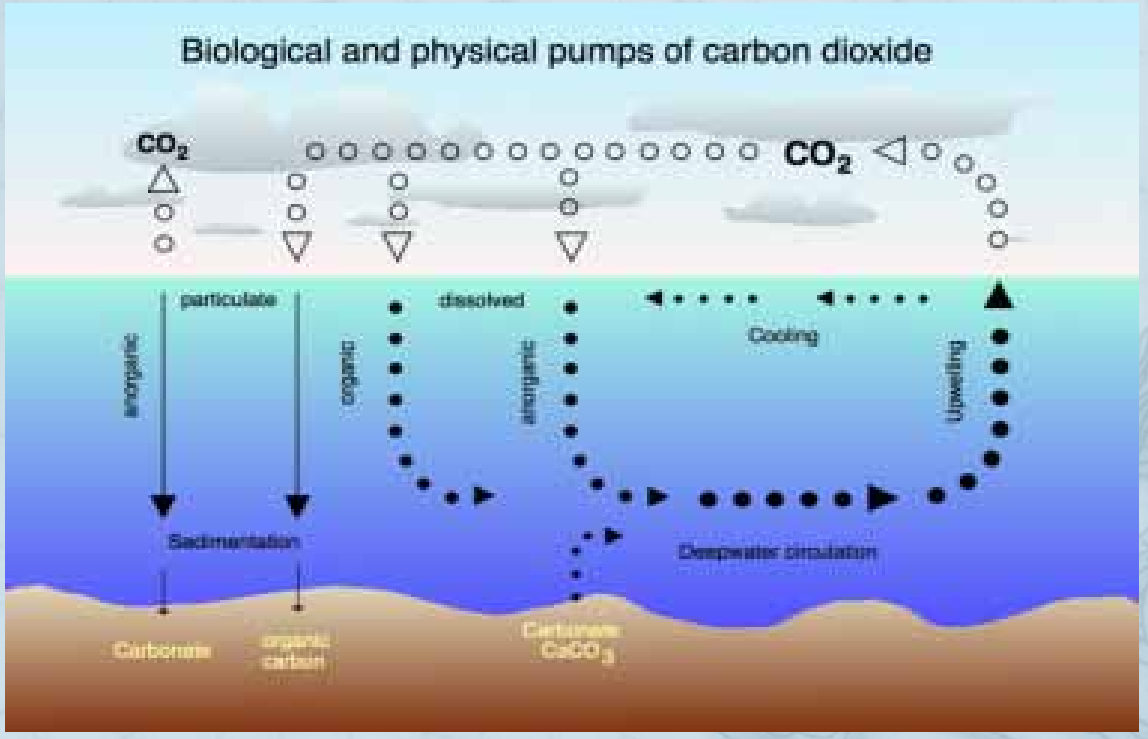
Environmental elements

Ecological elements

Methods and instruments is more and more mature and advanced.

CO_2 concentrations in the atmosphere and ocean are essential for monitoring changes in carbon sinks and climate.

- Monitoring of CO_2 switching throughput is in full operation in 2009.



A three dimensional, real-time air-sea carbon dioxide monitoring system has preliminarily formed.

- About 20 shipborne underway monitoring sections have been deployed, and 5 shore-based stations and 5 buoy stations are being under construction.

6 monitoring sections in the Bohai Sea;

5 monitoring sections in the west of the North Yellow Sea

5 monitoring sections in the East China Sea

4 monitoring sections in the South China Sea

Improving of marine environment monitoring technology and means

satellite, plane, ship, buoy; Remote sensing, On-line monitoring

Assessment of CO_2 sequestration capacity of seabed in China and pre-study of risk control technology

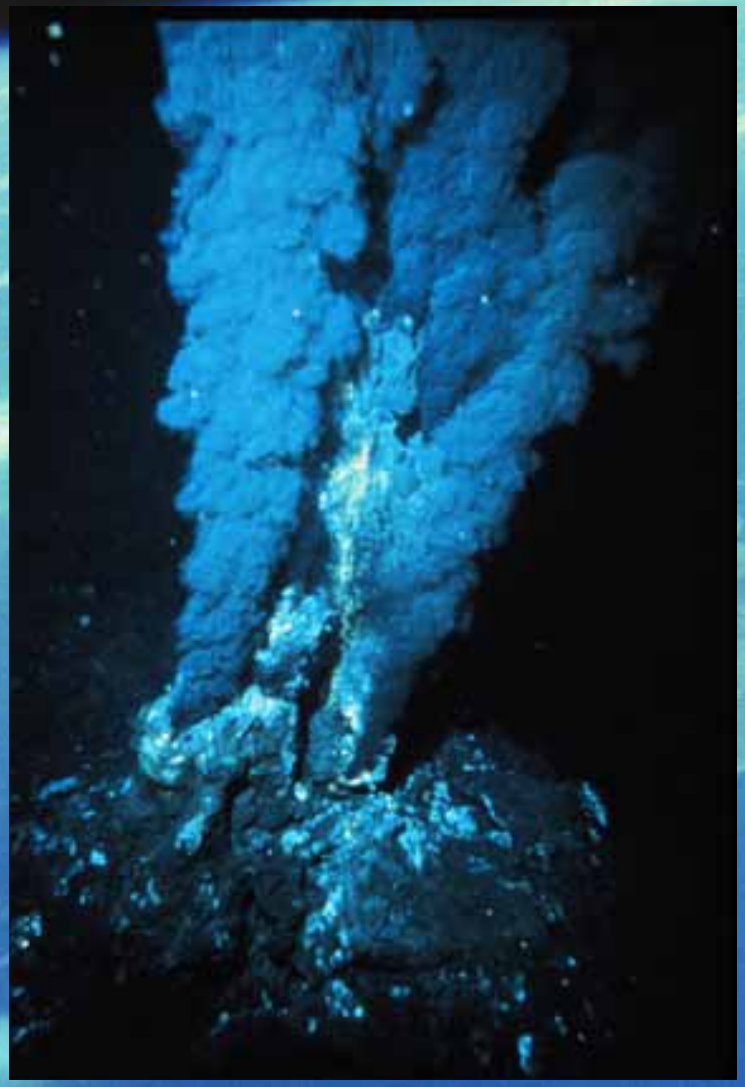
✓**Focus on the potential capacity of geological storage of CO_2 in the Bohai Sea and South China Sea especially.**

✓**Assessment of the ecological sensitivity / vulnerability**

Ecologically Sensitive Areas to CO_2seabed sequestration

- Spawning, nursery and feeding grounds;
- Marine protected areas ;
- Special marine protected areas ;
- Fishery areas such as marine fish, shrimp, shellfish and algae farms;

Sensitive species to CO_2 leakage



- Possible ecological impacts could be categorized into acute and chronic.

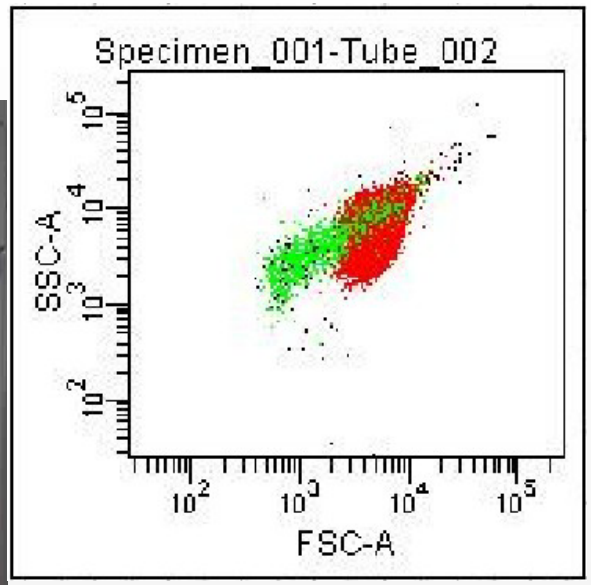
- Acute impact such as mortality of marine organisms could be determined by lab and field experiments and assessed by simulation models.

- Chronic impacts, such as sub-lethal effects (metabolic suppression, reduced protein synthesis, respiratory stress) would be difficult to verify by the same approach as for acute impacts.

Calcified algae

foraminifer


人工气候培养箱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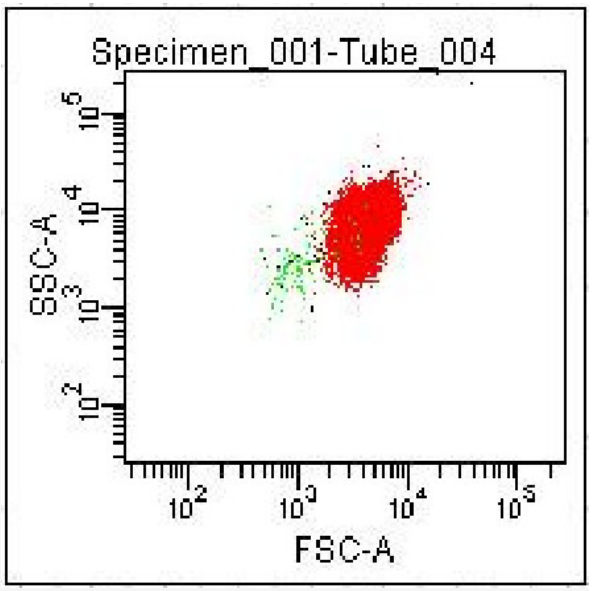
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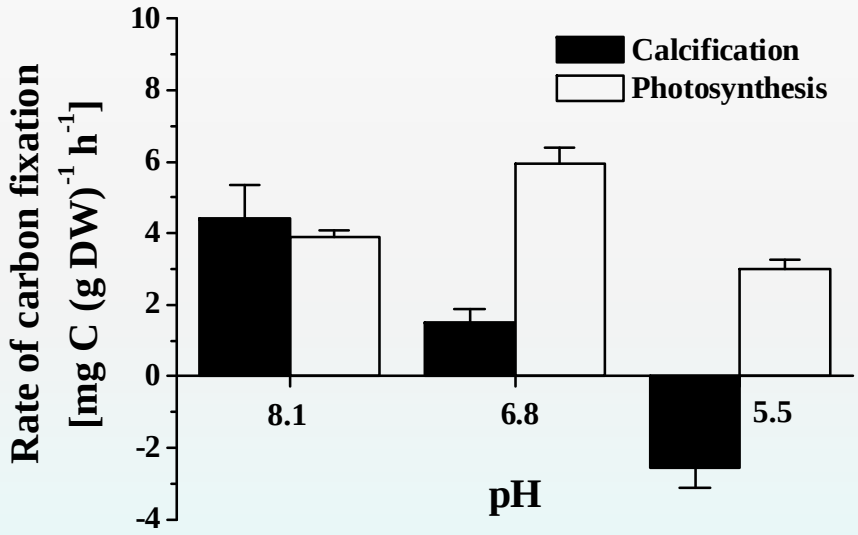
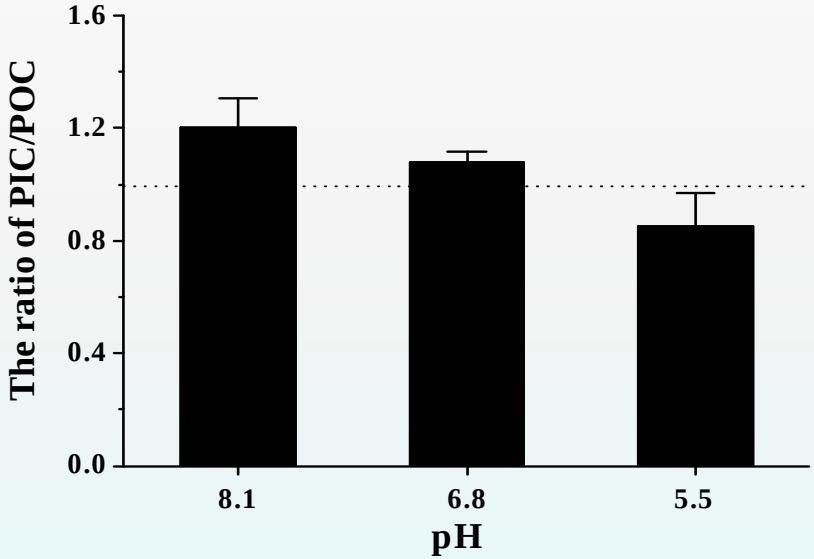
讲究质量
讲究

Acute impacts-copepod

species	time/h	LC_{50} pH	95% confidence interval
Calanus sinicus	24	6.15	6.23-6.06
	48	6.40	6.48-6.32
Acartia pacifica	24	6.43	6.55-6.31
Steuer	48	6.62	6.75-6.49
Tigriopus	24	5.85	5.98-5.73
japonicus	48	5.93	6.05-5.80

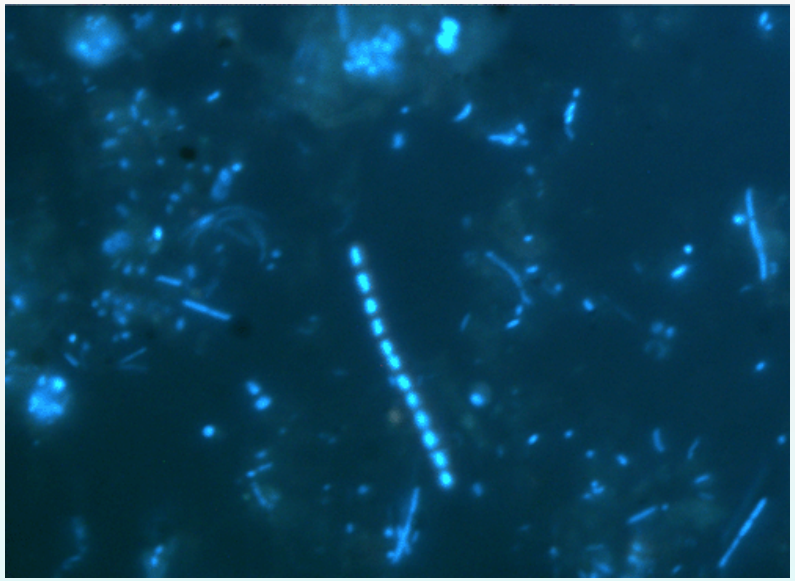
Chronic impacts - *Corallina pilulifera*

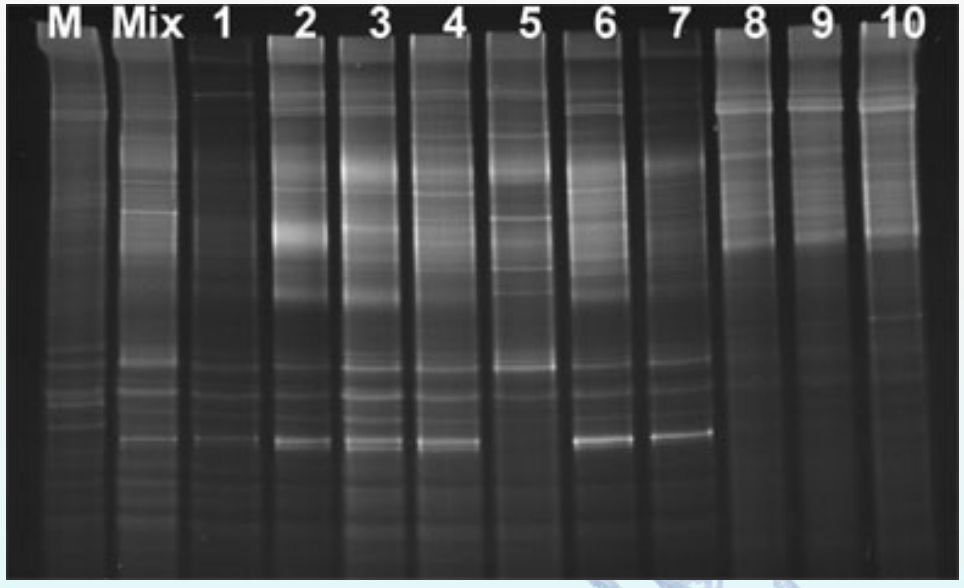




microorganism

In deep-sea layers, bacteria are dominant organisms and play significant roles in oceanic carbon cycling.





DGGE

The microbial population dynamics could be monitored by DGGE technique.

Suggested monitoring indicators

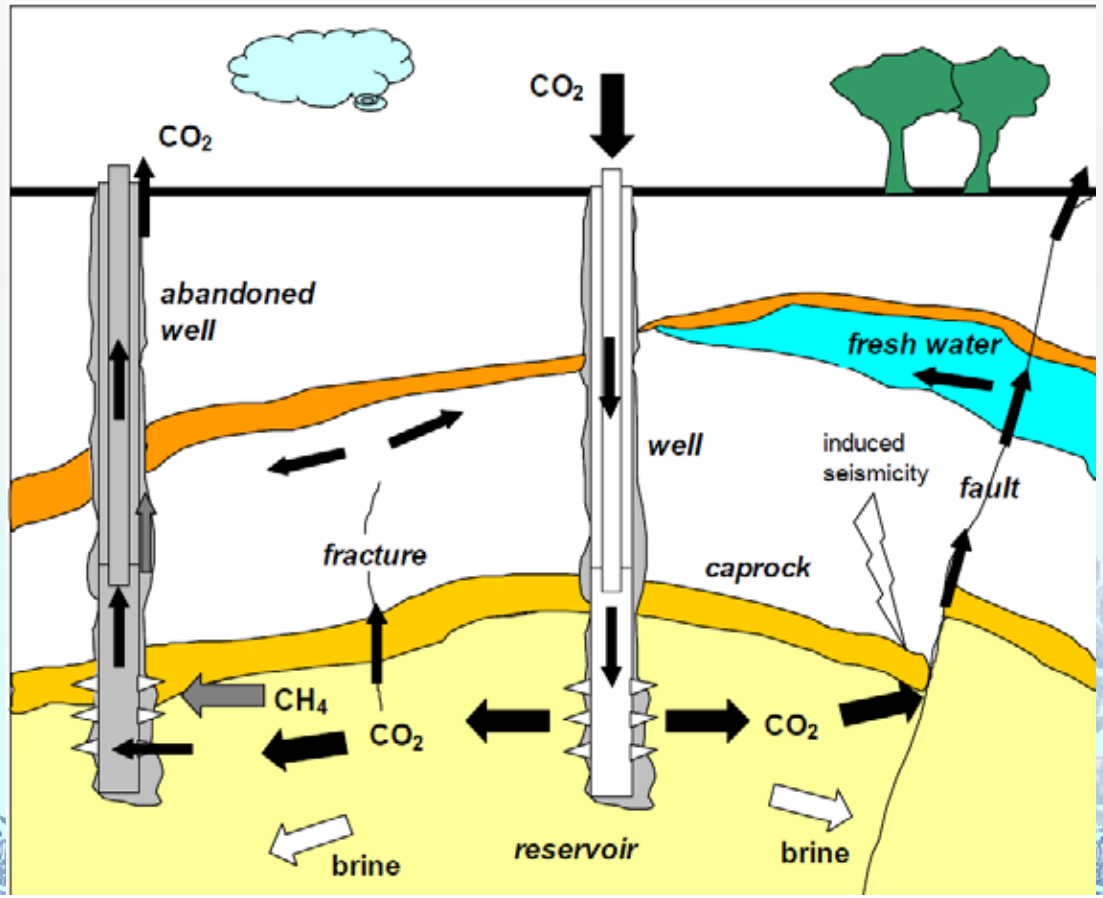
- pH
- pCO_2
- saturation ratio of aragonite
- Trace metal
- Sensitive species:

  carbonate skeleton molluscs、 foraminifer

  calcified algae、 microorganism population…

Risk control and risk management

The main research topic in risks associated with underground CO_2 sequestration is leakage.



☼ Insight in the risks associated with underground CO_2 sequestration is a key factor affecting public acceptance.

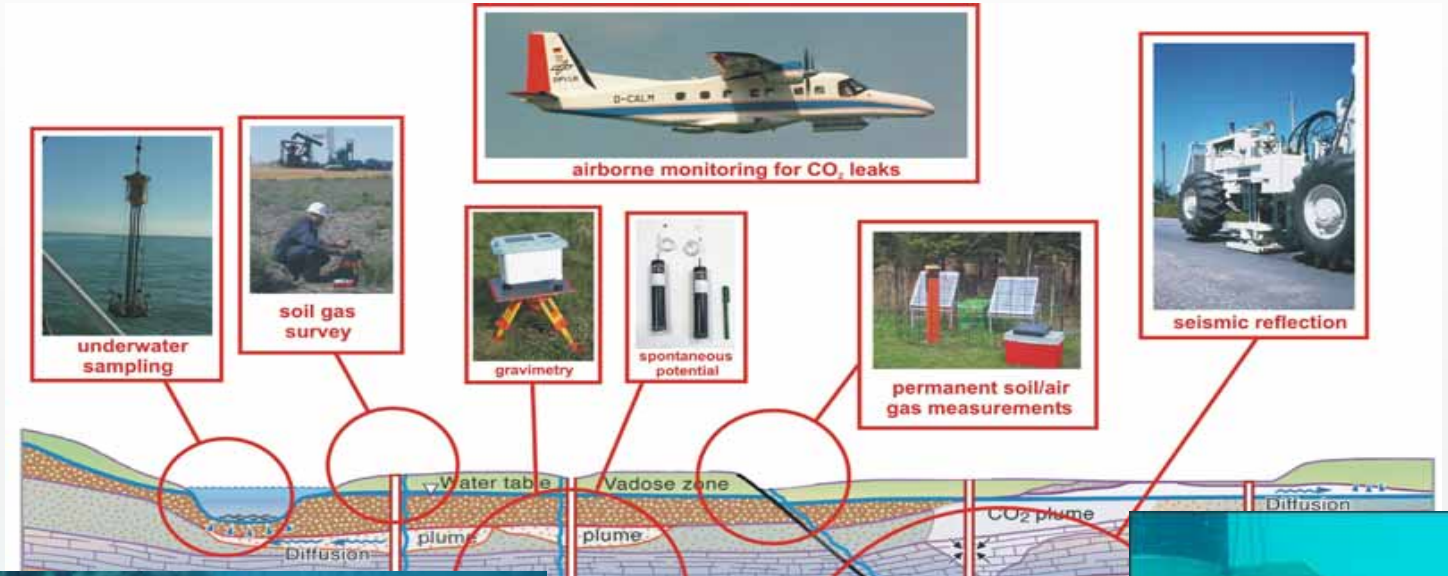
☼ Understanding those risks is indispensable to facilitate the formulation of standards and a regulatory framework required of large-scale application of CCS.

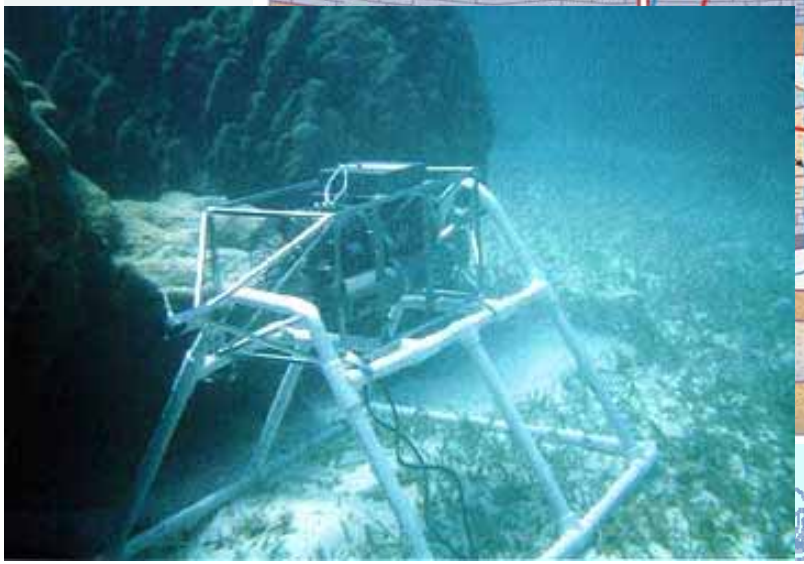
- Before sequestration, careful and sufficient investigation must be conducted for ecological and environmental assessments.
- Evaluation of the direct impact of the increased CO_2 and decreased pH on marine material cycling, individual organisms and ecosystems
- Accumulating base-line information through a field survey of biomass, biodiversity and the trophic structure in order to evaluate induced ecosystem alterations.

Monitoring of CO_2 seabed sequestration

- Therefore practical implementation of CO_2 seabed sequestration must, as a precautionary measure, employ monitoring programs for its ecological impacts.
- The monitoring programs should be designed **for both acute and chronic impacts**. Those for the acute impacts will be restricted to areas near CO_2-injection site and need to be conducted at frequent intervals, whereas those for chronic impacts will be extended over much larger areas

Monitoring of CO_2 seabed sequestration





Thank You !