Best Management Practices: Sub-Seabed Geologic Carbon Dioxide Transport and Storage on the United States Outer Continental Shelf

BOEM | Office of Environmental Programs

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THE OUTER CONTINENTAL SHELF LANDS ACT

Under the Outer Continental Shelf Lands Act (OCSLA), the Department of the Interior (DOI), Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) have authority to regulate the development of mineral resources and certain energy and marine related uses on the OCS

THE OUTER CONTINENTAL SHELF

The OCS consists of 1.7 billion acres of submerged lands, subsoil, and seabed, lying between the seaward extent of the States' submerged lands and the seaward extent of Federal jurisdiction.

- For most areas, Federal jurisdiction begins 3 nautical miles from the shore baseline. However, for the State of Texas and the Gulf coast of Florida, Federal jurisdiction begins 9 nautical miles from the baseline and for the State of Louisiana Federal jurisdiction begins 3 imperial nautical miles from the baseline.

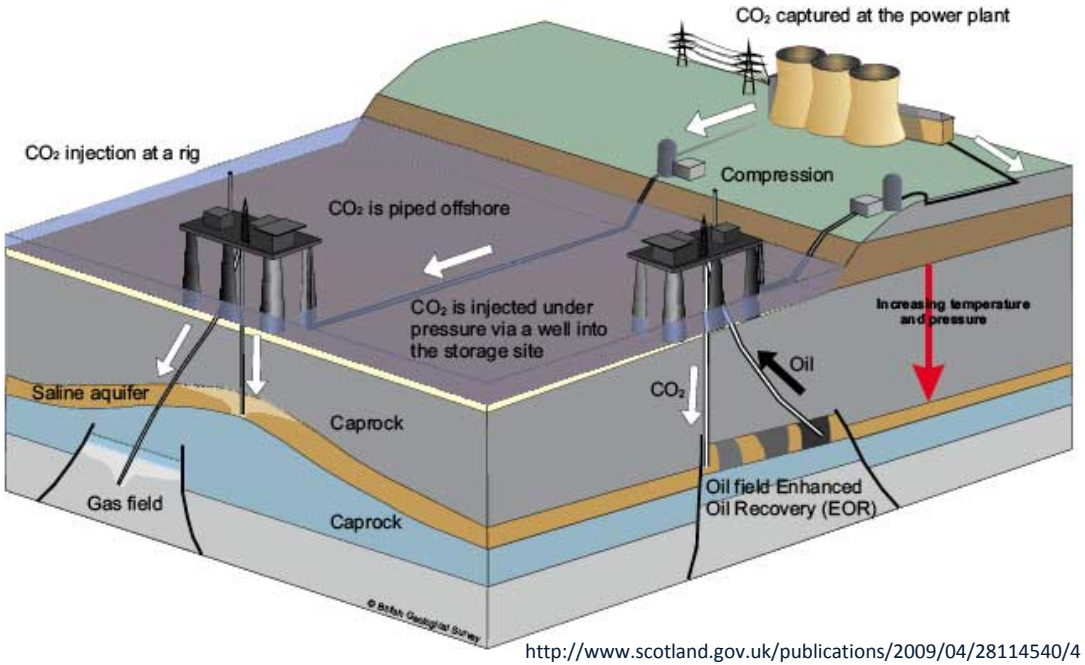
OCS Planning Areas

BOEM
Bureau of Ocean Energy Management

OCSLA AND CO_2

DOI has statutory authority under the OCSLA to permit the use and storage of CO_2 for EOR activities on existing oil and gas leases on the OCS.

DOI has the statutory authority to permit the storage of CO_2 for certain types of projects.



http://www.scotland.gov.uk/publications/2009/04/28114540/4

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior · March 3, 1849

OCSLA AND CO_2

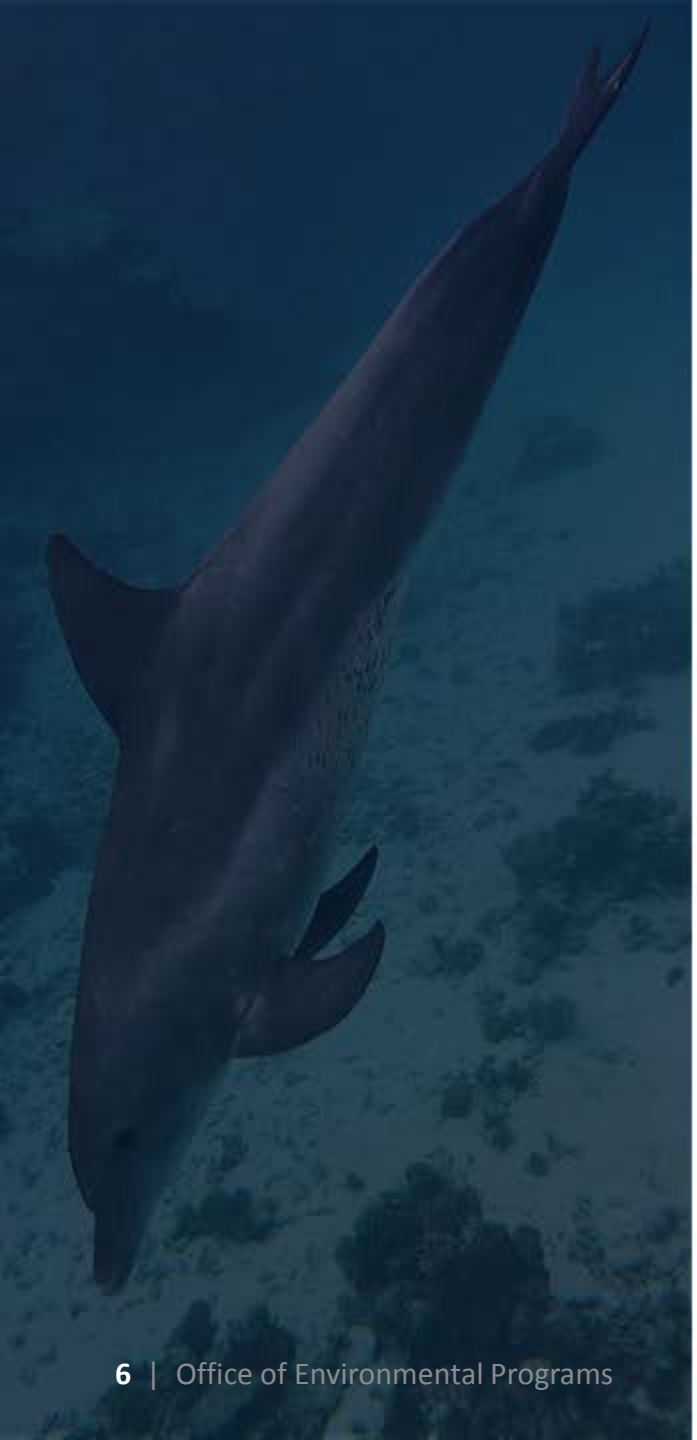
Under Section 8(p)(1)(C) of the OCSLA (43 U.S.C. 1337)(p)(1)(C)), BOEM may issue leases, easements, and rights-of-way for activities that:

> "**produce or support production, transportation, or transmission of energy from sources other than oil and gas"**

In certain circumstances, Section 8(p)(1)(C) allows BOEM to issue leases for sub-seabed CO_2 storage…

- Such as for the purpose of sub-seabed storage of CO_2 generated as a by-product of electricity production from an onshore coal-fired power plant.

Under Section 8(p)(1)(C), BOEM may not be able to issue OCS leases for the purpose of sequestering CO_2 emitted from refineries, natural gas power plants, and non-energy industries (e.g., steel or cement).



OCS LEGAL REQUIREMENTS

- Outer Continental Shelf Lands Act (OSCLA) of 1953 with amendments in 2005
- National Environmental Policy Act (NEPA) of 1969
- Marine Mammal Protection Act (MMPA) of 1972
- Endangered Species Act (ESA) of 1973
- Clean Air Act (CAA) of 1970, as amended 2012
- Clean Water Act (CWA) of 1972, as amended in 1990
- Oil Pollution Act (OPA) of 1990
- Resource Conservation and Recovery Act (RCRA) of 1976, as amended in 1996
- Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987
- Magnuson Fishery Conservation and Management Act (MFCMA) of 1976
- National Historic Preservation Act (NHPA) of 1966
- Coastal Zone Management Act (CZMA) of 1972, as amended in 1996
- Executive Order 11990 (1977), Protection of Wetland
- Executive Order 12898 (1998), Environmental Justice
- Code of Federal Regulations (CFR), 30 CFR Chapter II (BSEE) and Chapter V (BOEM)
- Department of the Interior Manual, Part 516

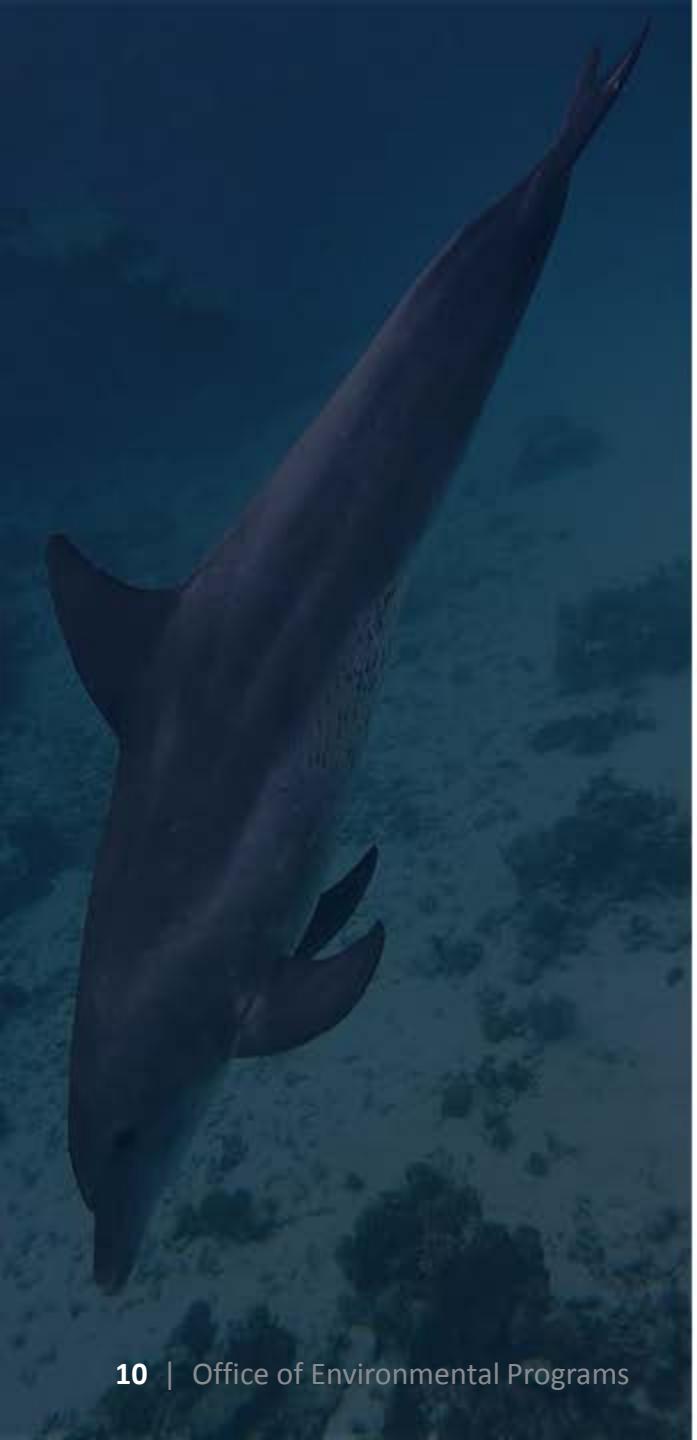
OEM Office of Environmental Programs

ENVIRONMENTAL PROGRAMS MISSION

To study and prevent/minimize environmental harm from energy development and minerals extraction on the Outer Continental Shelf

WHO WE ARE

- Biologists
- Chemical Oceanographers
- Physical Oceanographers
- Biological Oceanographers
- Meteorologists
- Air Quality Experts
- Geologists
- Archaeologists
- Economists
- Sociologists
- Wildlife Managers
- Law and Policy Experts
- Technical Editors
- Budget Analysts
- Administrative Specialists



WHAT WE STUDY AND PROTECT

physical, chemical, biological and human environments

- avian biology
- marine mammals
- sea turtles
- fish
- invertebrates
- corals
- benthic ecology
- chemical and physical oceanography
- marine and coastal ecology
- marine acoustics
- marine archaeology
- meteorology and air quality
- economics
- sociology and anthropology
- literature syntheses
- data management

ENVIRONMENTAL STUDIES PROGRAM PRINCIPLES

Be **use-inspired** to apply results towards management decisions

Adhere to the utmost levels of **scientific integrity** and credibility

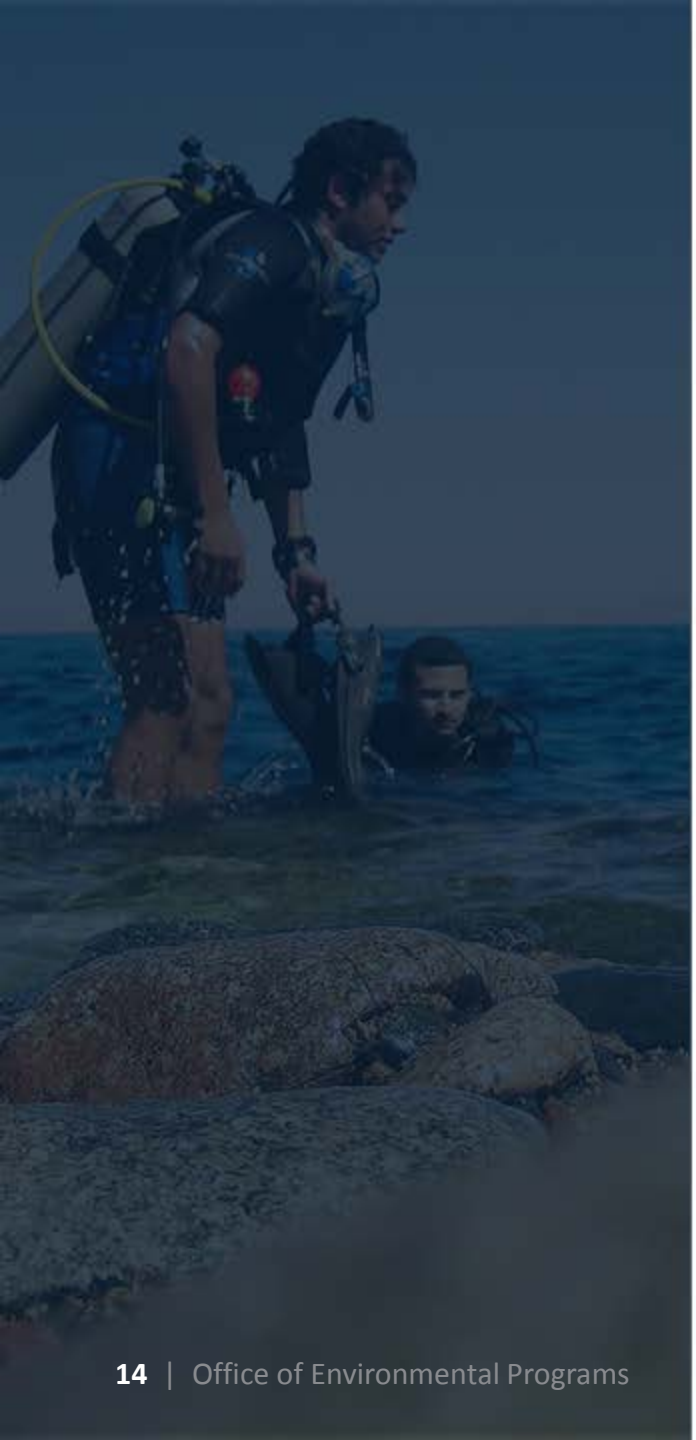
Seek partnerships to leverage funds and maximize utility of results

Engage regularly with stakeholders and public educational outreach for quality assurance, peer-review planning, and data dissemination

OCS CO2 Transportation and Sub-Seabed Storage BMPs

BOEM OCS CO_2 TRANSPORTATION AND SUB-SEABED STORAGE BMPS

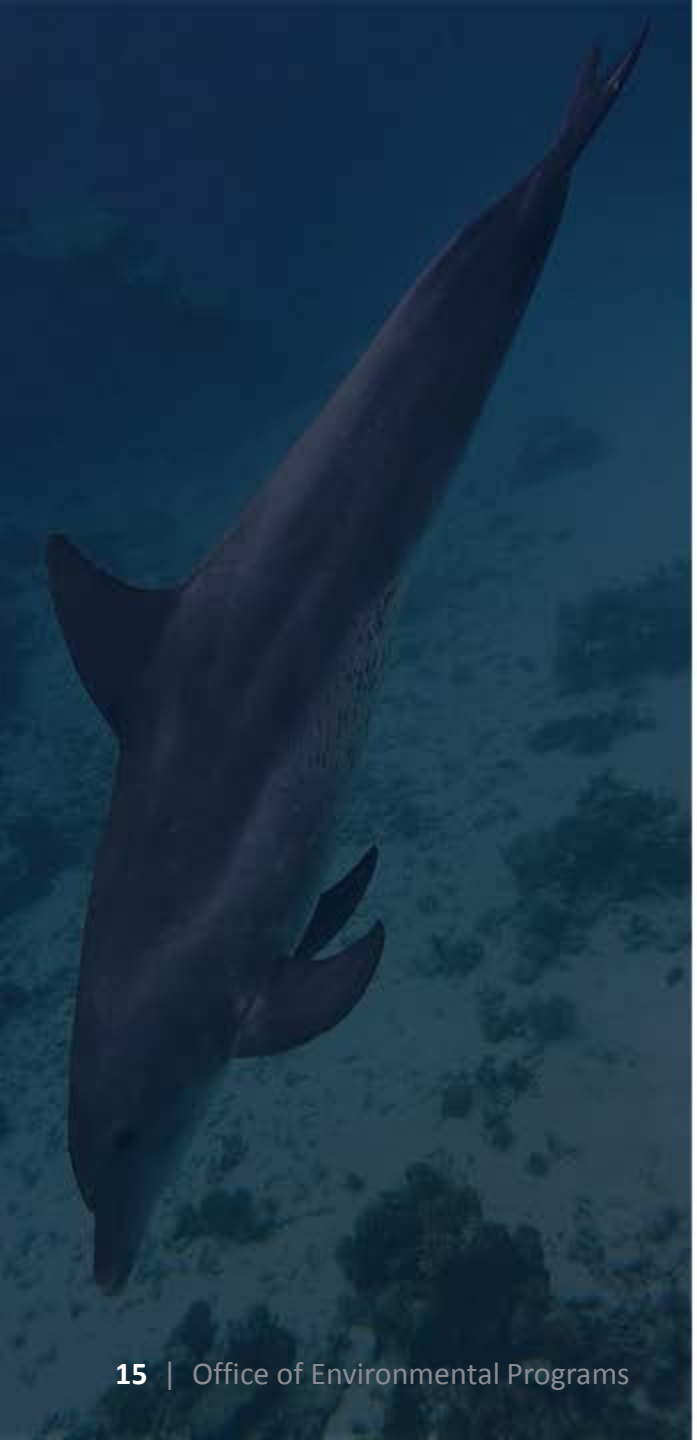
- BOEM is finalizing research for Best Management Practices (BMPs) for CO_2 offshore transportation and sub-seabed storage on the OCS
- The BMPs address the project lifecycle from site characterization through site closure



BOEM OCS CO_2 BMPS STUDY

- **The BMPs address the lifecycle of offshore CO_2 transport and storage, including:**

1. Site Selection and Characterization (data collection, capacity/injectivity assessments, and modeling)
2. Risk Analysis
3. Project Planning and Execution (design, construction, operation, and maintenance)
4. Monitoring
5. Mitigation
6. Inspection and Performance Auditing
7. Reporting Requirements
8. Emergency Response and Contingency
9. Decommissioning and Site Closure



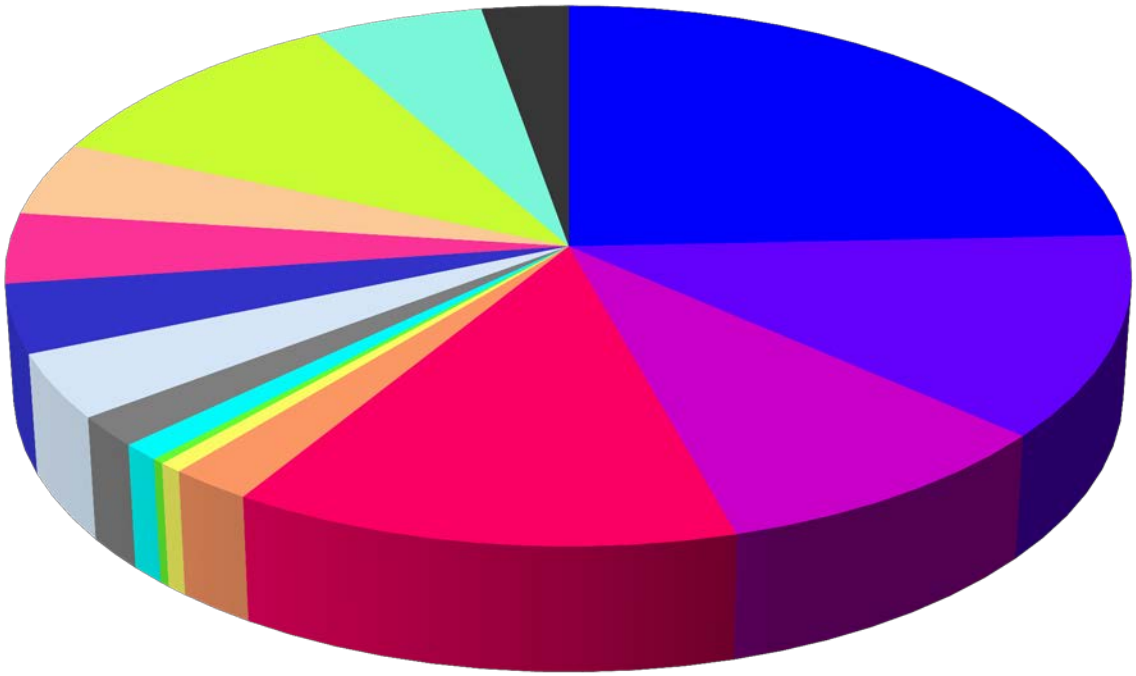
DELIVERABLES

1. **Worldwide Annotated Literature Database:**
   - Online database containing literature and other materials complied with annotations

2. **BMPs with Data Gaps Analysis**
   - BMPs, where possible
   - Identify data gaps in the information and practices.

ANNOTATED BIBLIOGRAPHY DATABASE

Number of Literature Sources by Subtopic



- Site Selection & Characterization (237)
- Risk Analysis (118)
- Project Planning and Execution (90)
- Monitoring (128)
- Mitigation (21)
- Inspection & Performance Auditing (6)
- Reporting Requirements (3)
- Emergency Response & Contingency (10)
- Decomissioning & Site Closure (18)
- General CCS (38)
- EOR-GS (40)
- International Policy &Regulations (41)
- U.S. Policy & Regulations (43)
- Manuals & Standards (101)
- Legal (53)
- Economic (27)

Online Database: http://www.myendnoteweb.com
Login: boembmps@gmail.com
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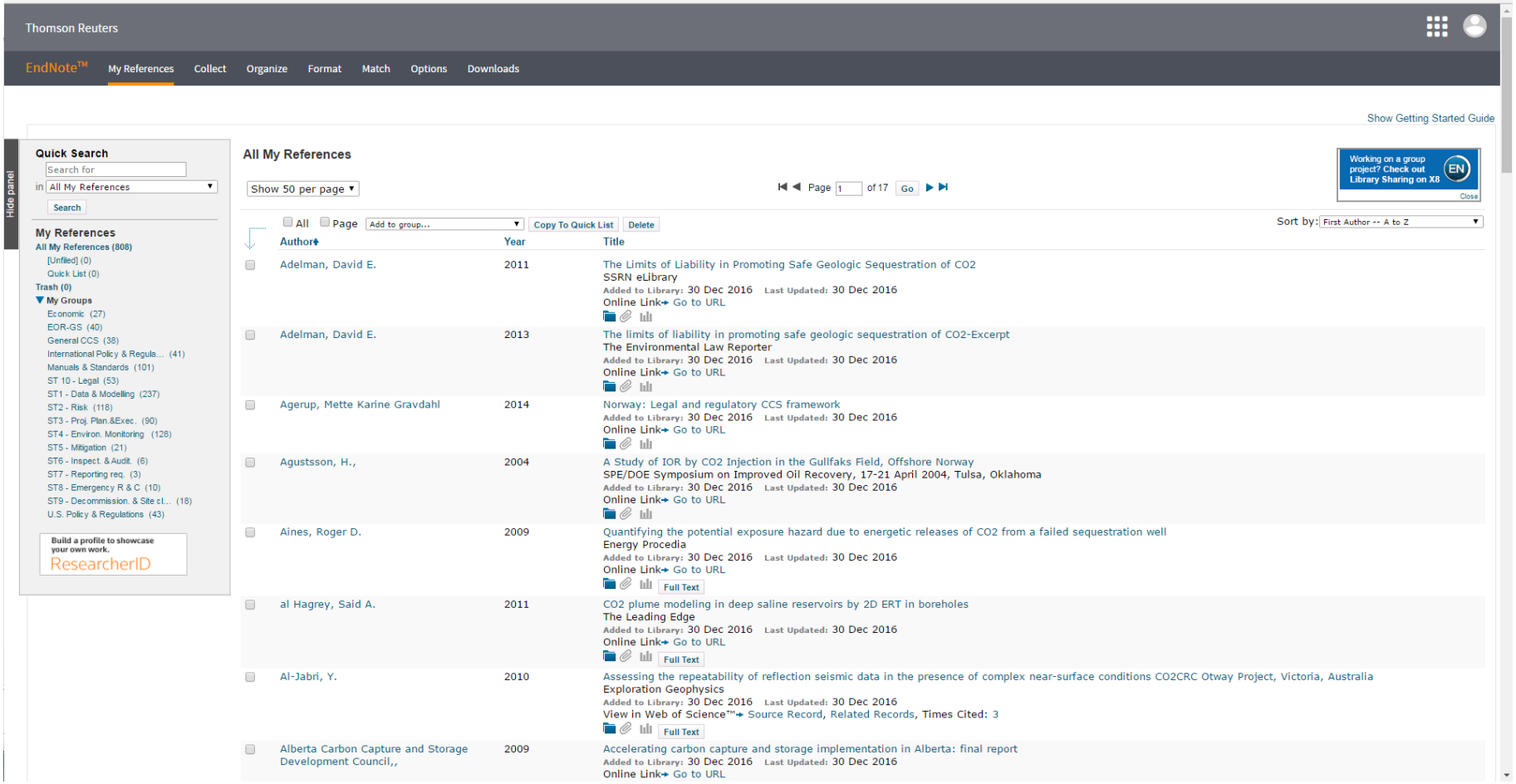

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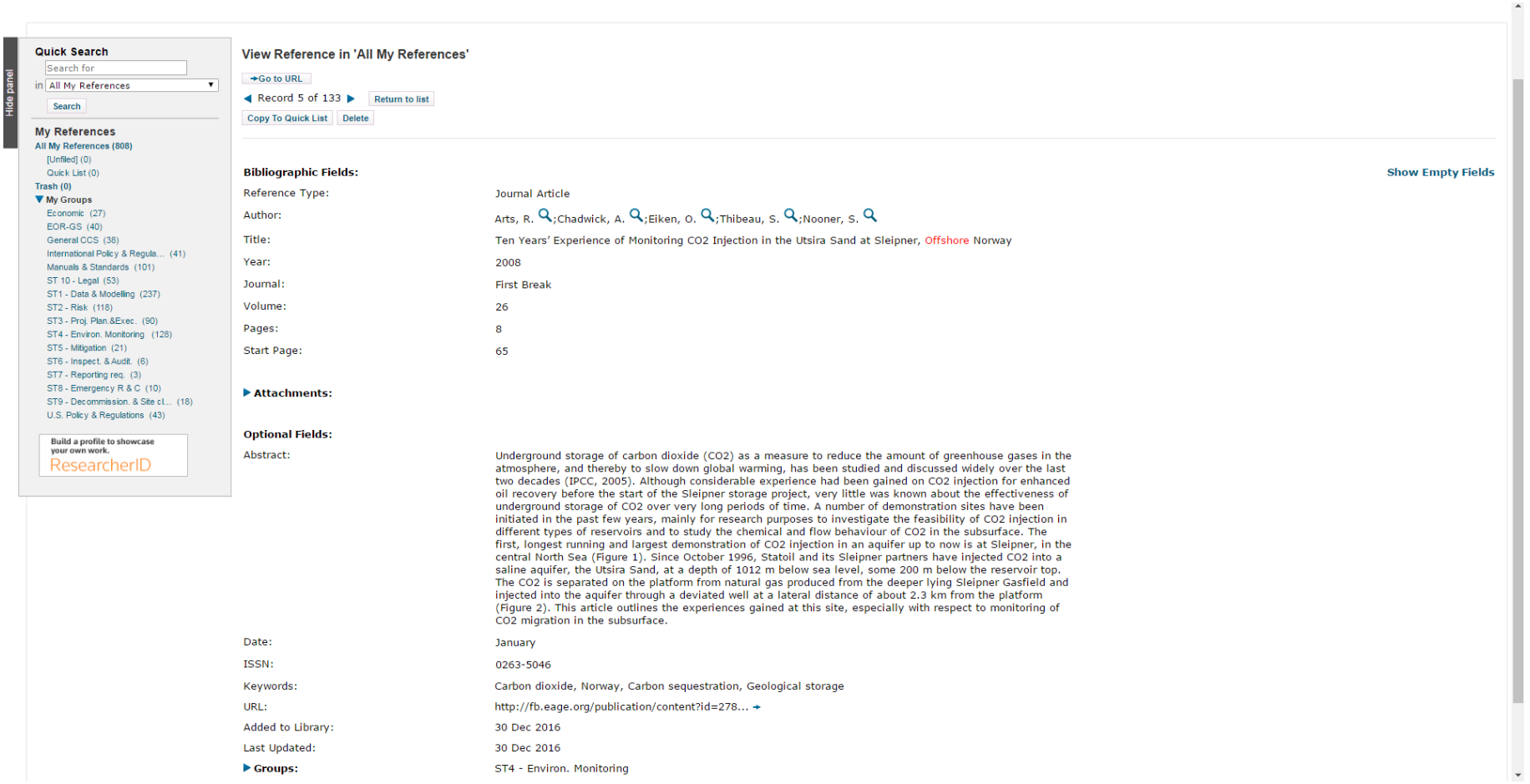

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Manuals & Standards (101)
ST 10 - Legal (53)
ST1 - Data & Modelling (237)
ST2 - Risk (118)
ST3 - Proj. Plan.&Exec. (90)
ST4 - Environ. Monitoring (128)
ST5 - Mitigation (21)
ST6 - Inspect. & Audit. (6)
ST7 - Reporting req. (3)
ST8 - Emergency R & C (10)
ST9 - Decommission. & Site cl... (18)
U.S. Policy & Regulations (43)

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Reference Type:	Journal Article
Author:	Arts, R.;Chadwick, A.;Eiken, O.;Thibeau, S.;Nooner, S.
Title:	Ten Years' Experience of Monitoring CO2 Injection in the Utsira Sand at Sleipner, Offshore Norway
Year:	2008
Journal:	First Break
Volume:	26
Pages:	8
Start Page:	65

Attachments:

Optional Fields:

Abstract: Underground storage of carbon dioxide (CO2) as a measure to reduce the amount of greenhouse gases in the atmosphere, and thereby to slow down global warming, has been studied and discussed widely over the last two decades (IPCC, 2005). Although considerable experience had been gained on CO2 injection for enhanced oil recovery before the start of the Sleipner storage project, very little was known about the effectiveness of underground storage of CO2 over very long periods of time. A number of demonstration sites have been initiated in the past few years, mainly for research purposes to investigate the feasibility of CO2 injection in different types of reservoirs and to study the chemical and flow behaviour of CO2 in the subsurface. The first, longest running and largest demonstration of CO2 injection in an aquifer up to now is at Sleipner, in the central North Sea (Figure 1). Since October 1996, Statoil and its Sleipner partners have injected CO2 into a saline aquifer, the Utsira Sand, at a depth of 1012 m below sea level, some 200 m below the reservoir top. The CO2 is separated on the platform from natural gas produced from the deeper lying Sleipner Gasfield and injected into the aquifer through a deviated well at a lateral distance of about 2.3 km from the platform (Figure 2). This article outlines the experiences gained at this site, especially with respect to monitoring of CO2 migration in the subsurface.

Date:	January
ISSN:	0263-5046
Keywords:	Carbon dioxide, Norway, Carbon sequestration, Geological storage
URL:	http://fb.eage.org/publication/content?id=278...
Added to Library:	30 Dec 2016
Last Updated:	30 Dec 2016
Groups:	ST4 - Environ. Monitoring

BMP GENERAL FINDINGS

Topic	Finding
General	• Offshore CO2 EOR-GS and GS technologies are emerging; fully developed BMPs will require more knowledge gained through offshore pilot-scale projects and additional offshore industry experience
Site Selection and Characterization Risk Analysis, Project Planning and Execution, & Monitoring	• Site selection and characterization, risk analysis, and monitoring will need to be iterative. Monitoring data will increase understanding of characterization and risk management • These are integral to operations design and execution
Monitoring, Project Planning and Execution, & Decommissioning and Site Closure	• Understand the importance of proactive monitoring throughout injection operations to minimize the need for environmental mitigation or long-term monitoring after site closure

BMP FINDINGS

Topic	Finding
Site Selection and Characterization	• Most important BMP topic for the success of CO_2 storage; affects all other BMPs • Primary considerations include – data collection, storage capacity assessment, and modeling • Many onshore methodologies can be applied to offshore • Characterization of overburden intervals is lacking offshore (U.S.) • BEG complied a workflow framework for CO_2 EOR-GS and GS site characterization (Report Appendix)
Risk Analysis	• Primary considerations include – health and safety of workers, protection of sub-seabed resources, and isolation of CO_2 from the water-column and atmosphere (environmental impacts) • Assessment of risk requires definition of what constitutes a leak and what volume or rate of leakage is significant (action level) • Similarities exist between risks associated with onshore and offshore CCS (e.g., wellbores) • Some aspects of risk may be less in the offshore environment (e.g., USDWs) • Example offshore guidelines: London Convention/London Protocol

BMP FINDINGS

Topic	Finding
Project Planning and Execution	• Planning and execution for all subtopics plus CO_2 sourcing, studies, stakeholder engagement, leasing, plans, environmental analysis, design, permitting, construction, drilling, transport, injection, fluid processing (EOR), iterative updates to plans (e.g., risk, emergency, H&S, monitoring, injection) based on monitoring data, etc. • Most relevant information for offshore CO_2 transport and injection operations are associated with North Sea and Brazilian projects and planning done by UK and EU countries • Existing O&G and onshore CO_2 regulations and standards may apply for pipelines, platforms and wells – with adaptations for offshore CO_2 • BEG complied a workflow framework for project planning and construction (Report Appendix) that includes: Concept Development, Pre-FEED (Front End Engineering Design), FEED, Detailed Design, Construction, and Startup stages • BEG complied a workflow framework for project planning and operations stages for CO_2-GS and CO_2 EOR-GS (Report Appendix) • These workflows have the potential to become BMPs with testing

BMP FINDINGS

Topic	Finding
Monitoring	• Offshore CCS legislation does not currently exist; requirements are built upon existing legislation • Primary considerations include – conformance (modeling match), containment (within storage interval), and environmental monitoring (injectate-CO_2 isolation from sub-seabed resources, seafloor, ocean, and atmosphere) requirements are needed • Seismic (especially 4-D) and other geophysical methods are most practical for sub-seabed (shallow and deep strata) monitoring • Deep-focused monitoring may be essential to demonstrate proper site performance over the relevant time period • Effective monitoring validates and refines the injection plan, geologic characterization, risk assessment, mitigation and modeling.

BMP FINDINGS

Topic	Finding
Mitigation	• Primary consideration – Mitigation requires definition of what constitutes a leak and what volume or rate of leakage is significant (action level) • Mitigating measures may be incorporated as project design criteria • Unintended migration may be mitigated by cessation of CO_2 injection and fluid injection (brine) to form pressure barriers • Limited references associated with mitigation of offshore CO_2 transport, injection, and storage • Existing O&G regulations and standards may serve as an analog
Inspection and Auditing	• Limited references specific to inspection and auditing associated with offshore CO_2 transport and injection • Existing offshore O&G regulations, onshore CO_2 project analogs, and operating or planned offshore projects can serve as benchmarks to regulation development.

BMP FINDINGS

Topic	Finding
Reporting Requirements	• Reporting requirements should include operational and safety aspects and environmental concerns • Limited references specific to reporting requirements associated with offshore CO_2 transport and injection • Aspects of existing offshore O&G and CO_2 regulations (DOT, EPA) may translate to offshore CO_2 operations.
Emergency Response and Contingency Planning	• Maintain emergency preparedness such that worst-case-scenario incidents (e.g., BLEVE or worst-case leakage scenarios) are quickly identified and responded to by following an emergency response plan • Must consider the properties and pressure variations of CO_2 or CO_2-mixed gas streams. • Ensure material compatibility with liquid-phase and especially supercritical CO_2 • Require emergency response planning , training, and drills • Limited references specific to emergency response and contingency planning for offshore CO_2 transport and injection

BMP FINDINGS

Topic	Finding

Decommissioning and Site Closure	• Existing DOI regulations for decommissioning of offshore O&G facilities and site clearance may translate to offshore CO_2 transport and injection facilities
	• Includes decommissioning of platform, pipelines, wells, umbilicals, and other related equipment
	  • Address the corrosive properties of CO_2 on the steel casings and cement of wells
	• Closure of the storage complex must address CO_2 migration to shallower depths and expansion to gas
	  • Test post-closure risk in the early stages of the project such that uncertainties about the long-term performance of a CO_2 storage site are resolved prior to injection of large volumes of CO_2
	• If effectively executed…an extensive post-injection site care period with long-term monitoring may not be needed for assuring either the effectiveness of CO_2 containment or protection of offshore environments

BMP GAPS

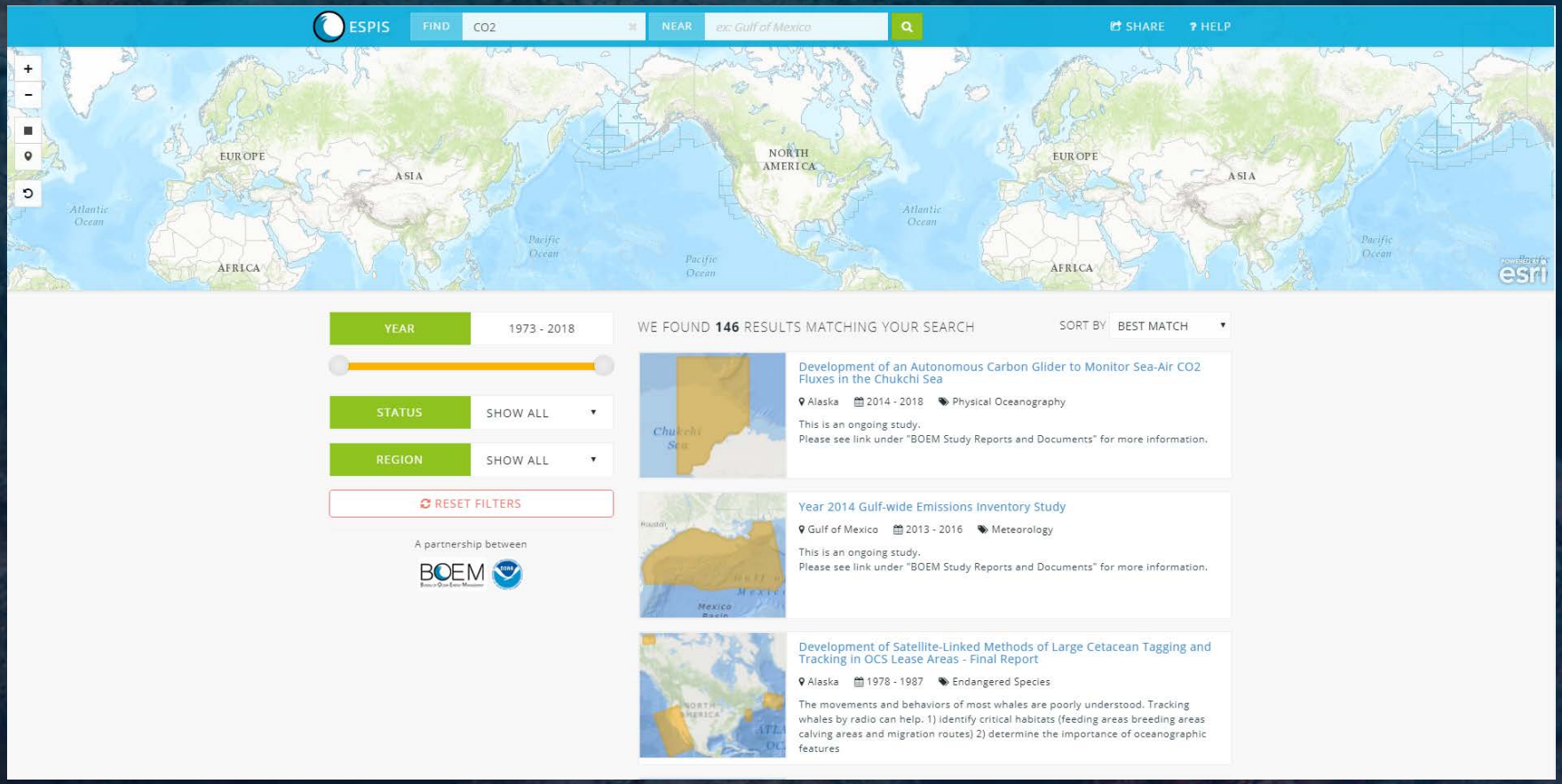
- **Technical Gaps:**

1. **Geological and Geophysical (G&G) Data:**
   - Geographic gaps – Atlantic
2. **Trap and Overburden Characterization:**
   - Often not characterized in O&G operations. Need additional G&G data
3. **Scale of Capacity Estimation:**
   - Controversy over best approach from basin-scale to site-specific
4. **Sub-Seabed Migration and Leakage:**
   - Leakage must be well defined to clarify monitoring, mitigation, and emergency response approaches.
5. **Storage Monitoring and Mitigation:**
   - Need clear link between identified risks and monitored plan that demonstrates their mitigation.
6. **CO_2 Transport:**
   - Ship vs. Pipeline. Pipeline integrity in ocean environments and maintaining supercritical state over long distances. Emergency response.
7. **Production Fluid Separation for EOR:**
   - Onshore vs. Offshore processing

REGULATORY RECOMMENDATIONS

- **Specific categories of offshore CO_2 transport and sub-seabed storage issues that should be addressed in future regulations include:**
  1. **Characterization and qualification of CO_2 storage sites**
  2. **Corrosion management for pipelines and injection well or platform infrastructure**
  3. **CO_2 transport and injection operations planning**
  4. **Risk management and monitoring**
  5. **Quantification of CO_2 storage**
  6. **Site closure**

Environmental Studies Program Information System (ESPIS)



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"Science for Informed Decisions"

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