

ECO₂ project number: 265847



**Deliverable Number D7.3: ECO₂ project brochure;
WP7; lead beneficiary number 1 [IFM-GEOMAR]**

ECO₂ project brochure

The ECO₂ brochure is a 210x210 mm folder (see below) that will be available as a printed brochure and as a digital version on the ECO₂ webpage.

The brochure is an evolving document in its nature and will be updated periodically.

This first issue is from September 2011.

Additional to the ECO₂ brochure we produced an ECO₂ flyer (zigzag flyer 490x210 mm) giving a brief overview of the ECO₂ project. This flyer will as well be available as a printed version and digital on our webpage.



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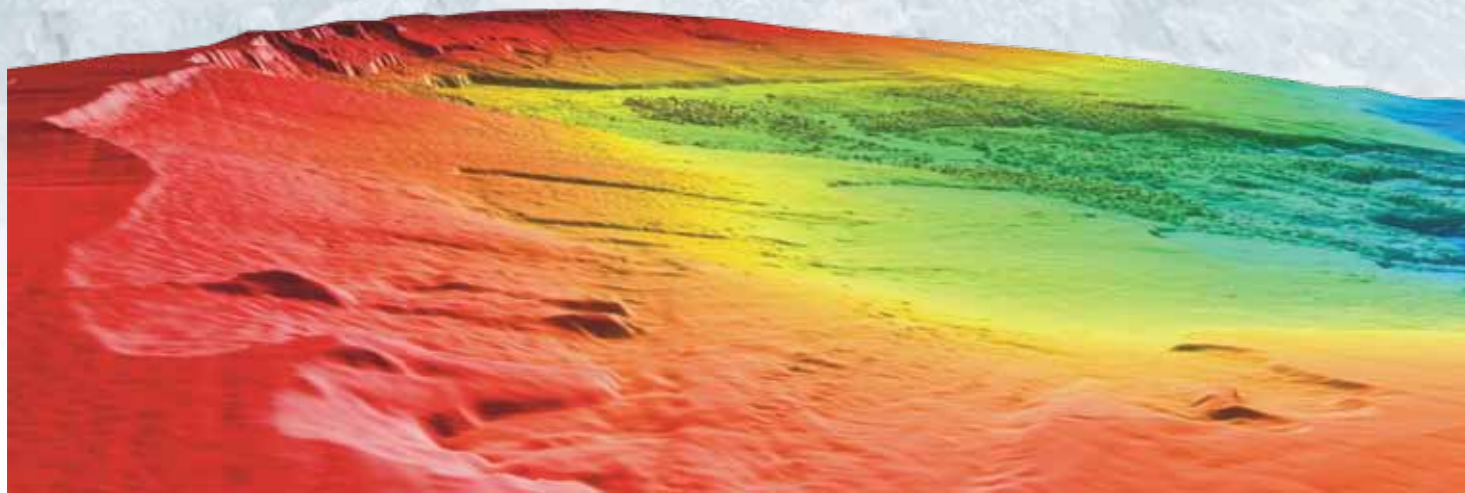


ECO₂ - Sub-seabed CO₂ storage: Impact on Marine Ecosystems is a large scale integrating collaborative project funded by the European Commission (EC) FP7 work program topic OCEAN.2010.3 Sub-seabed carbon storage and the marine environment. The ECO₂ consortium consists of 27 partners - 24 research institutes, one independent foundation (DNV), and two commercial entities (Statoil AS and Grupa Lotos) - from nine European countries (Germany, Norway, U.K., Italy, the Netherlands, Poland, Belgium, Sweden, France). The project is coordinated by GEOMAR in Kiel, Germany. The entire lifetime of ECO₂ is from 1st May 2011 to 30th April 2015.

Carbon dioxide capture and storage (CCS) is regarded as a key technology for the reduction of CO₂ emissions from power plants and other industrial facilities at the European and international level. Hence, the EC will support selected demonstration projects to promote, at industrial scale, the implementation of CCS in Europe.

Consequently, several European states (U.K., Norway, the Netherlands, Italy) aim to store CO₂ below the seabed. However, little is known about the short-term and long-term impacts of CO₂ storage on marine ecosystems even though CO₂ has been stored sub-seabed at industrial scale in the Norwegian North Sea since 1996 (*Sleipner*) and in the Barents Sea since 2008 (*Snøhvit*).

In consequence of this lack of knowledge, the EC supports the ECO₂ project to assess the risks associated with storage of CO₂ below the seabed. The project will evaluate the likelihood of leakage, the possible impacts on marine ecosystems, and its potential economic and legal consequences by studying existing sub-seabed storage sites in saline aquifers in the Norwegian North Sea and the Barents Sea, and a potential storage site in a depleted oil reservoir as well as natural seeps at the seafloor (North Sea, Barents Sea, Mediterranean Sea, Okinawa Trough).



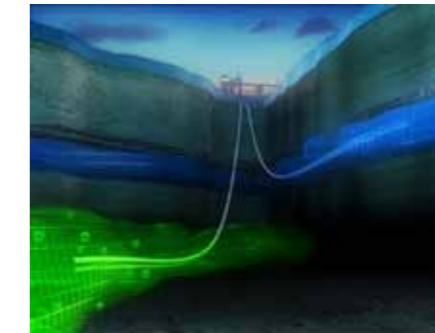
To give consideration to this complex assignment the ECO₂ consortium defined the following 5 key objectives:

1. **To investigate** the likelihood of leakage from sub-seabed storage sites
2. **To study** the potential effects of leakage on benthic organisms and marine ecosystems
3. **To assess** the risks of sub-seabed carbon storage
4. **To develop** a comprehensive monitoring strategy using cutting-edge monitoring techniques
5. **To define** guidelines for the best environmental practices in implementation and management of sub-seabed storage sites

ECO₂ will investigate storage sites and potential storage sites that cover the major geological settings to be used for sub-seabed CO₂ storage including depleted oil and gas reservoirs and saline aquifers on the continental shelf and upper continental slope. Fieldwork at storage sites will be supported by modelling and laboratory experiments at natural CO₂ seep sites.

CO₂ storage sites and potential storage sites

- *Sleipner* (North Sea) - in operation since 1996 by Statoil, stores ~1 Mt of CO₂ separated from natural gas per year within the Utsira sand formation (saline aquifer) in ~900 m sediment depth in ~80 m water depth. More than 48 million m³ of CO₂ have already been injected.



Carbon storage at Sleipner; photo: Alligator film / BUG / Statoil

- *Snøhvit* (Barents Sea, Norwegian continental slope) - in operation since 2008 by Statoil, stores ~0.7 Mt of CO₂ separated from natural gas per year within a saline sandstone formation in ~2.6 km sediment depth in ~330 m water depth. The high pressures and low temperatures at the seabed allow for solid CO₂ hydrate formation.
- *B3 field site* (Polish Baltic Sea) - potential storage site in ~80 m water depth that is currently exploited for oil by the Polish companies Grupa Lotos and Petrolbaltics; exploitations will be closed by 2016. The Polish operators plan to store CO₂ from a nearby oil refinery in the depleted B3 field site oil reservoir.

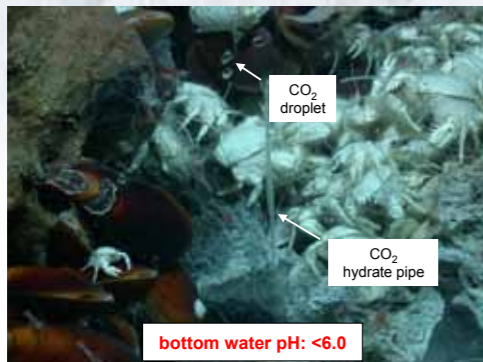
Natural CO₂ seep sites

- **Panarea area** (Southern Tyrrhenian Sea) - is part of the Aeolian Arc north of Sicily; it is a submarine exhalative field located east of Panarea Island. The gas vents are aligned along tectonic features and emit CO₂ originating from degassing magma.



Eddy correlation experiments at Panarea, D. F. McGinnis et al., Eurofleets Project PaCO₂ with RV Urania

- **Southern Okinawa Trough** (NE off Taiwan) - is a back arc basin hosting several hydrothermal fields. Three of these seeps emanate liquid CO₂ droplets at a water depth of 1300 m and CO₂-hydrates form in the surface sediments.



CO₂ droplet release and CO₂-hydrate formation at hydrothermal CO₂ seep sites in the Okinawa Trough; photo: ROV Quest, MARUM Bremen

- **Jan Mayen Vent Field** (North Atlantic) - is situated on the Western Jan Mayen Fracture Zone in ~700 m water depth; its hydrothermal fluids are characterised by high carbon dioxide but low methane and hydrogen concentrations.
- **Salt Dome Juist** (Southern North Sea) - is located in the southern German North Sea in 30 m water depth above the Salt Dome Juist; it is a sedimentary seep where CO₂ levels are ~10-20 times above background.



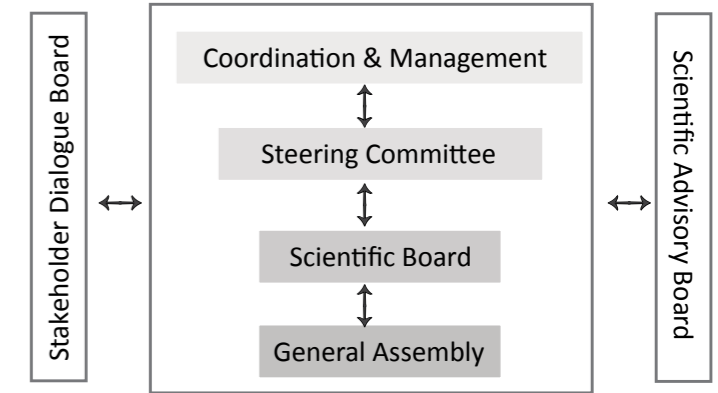
- ★ CO₂ storage sites and potential storage sites
- ★ natural CO₂ seep sites

Plus potential CO₂ storage sites off Australia and natural seeps off Japan

The ECO₂ investigations cover a wide range of approaches from basic marine research to ocean governance. The work is divided into seven work packages (WPs) and four cross-cutting themes (CCTs) forming a matrix structure. The WPs are cross-cut by four themes to support information flow and strengthen cooperation across the WPs. Additionally, the CCTs provide vital ECO₂ products by integrating and evaluating the results of the individual WPs.

- WP1:** Caprock integrity
 - WP2:** Fluid and gas flux across the seabed
 - WP3:** Fate of emitted CO₂
 - WP4:** Impact of leakage on ecosystems
 - WP5:** Risk assessment, economic & legal studies
 - WP6:** Public perception
 - WP7:** Coordination & Data Management
-
- CCT1:** Monitoring techniques & strategies
 - CCT2:** Numerical Modelling
 - CCT3:** International collaboration
 - CCT4:** Best environmental practices

The **Project Coordinator** (PC) will be supported by the **Project and Data Management Office**, the **Steering Committee** and the **Scientific Board** to ensure the project remains focused.

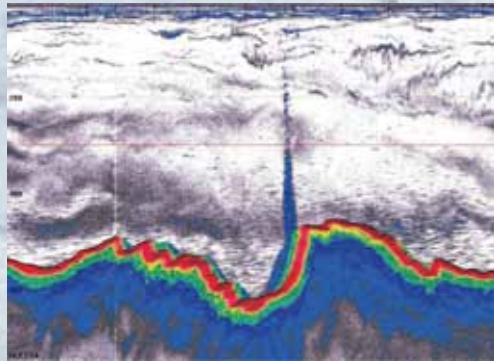


Management and governance structure of the ECO₂ consortium

The internal management structure will be supplemented scientifically by the **Scientific Advisory Board** (renowned scientists covering the ECO₂ research fields) and politically by the **Stakeholder Dialogue Board** (high-level policy consultative group).

Architecture and Integrity of the Sedimentary Cover at Storage Sites

will undertake geophysical acquisition, modelling, and hydro-acoustic monitoring to characterise the range of performance and efficiency of sub-seabed geological CO₂ storage, including existing and potential storage sites as well as natural CO₂ seepage sites. State-of-the-art technology will be employed for an enhanced imaging of the seafloor and its sub-surface at unprecedented resolution.



Echogram showing CO₂ gas flares above Troll Wall Vent Field (Jan Mayen); Image: University of Bergen

Objectives:

- to characterise the sedimentary cover to better assess CO₂ migration mechanisms and pathways
- to optimise existing techniques and tools for monitoring CO₂ migration
- to provide a catalogue for possible leakage scenarios, to document the key elements of effective risk management
- to constrain potential leakage pathways

Fluid and Gas Fluxes across the Seabed at Storage Sites and Natural CO₂ Seeps

will carry out a program of fieldwork at existing storage sites as well as natural CO₂ seeps, including analysis of the chemical composition of reservoir fluids. Fieldwork will be supplemented by laboratory studies focussing on CO₂-induced mobilisation of toxic metals and the ability of CO₂-hydrate formation to seal leaks. A key part of the work will be to assess the utility of various high-end sensor systems.

Objectives:

- to identify effective tracers of leakage
- to develop a monitoring strategy to quantify leakage rates
- to assess the potential for mobilisation of toxic metals
- to quantify fluxes of CO₂ and other chemicals across the seabed and reactions in the surface sediments



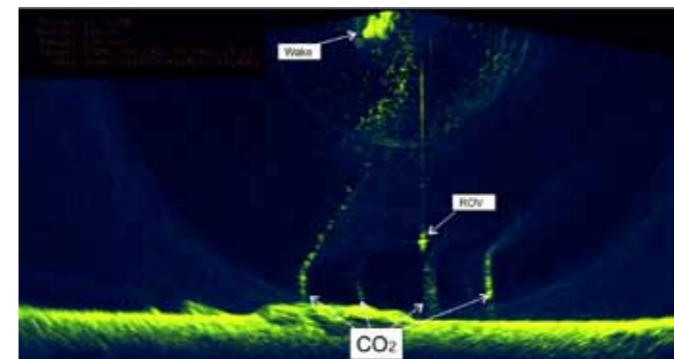
Biogeochemical Observatory (left figure) Microsensors (right figure); photos: GEOMAR

Fate of CO₂ and other Gases emitted at the Seabed

will conduct process studies and model simulations to underpin risk and impact assessments of potential leakage from CO₂ storage sites in the overlying waters. An Ocean General Circulation Model (OGCM) considering the various processes will be built to simulate local and regional oceanic dispersion of CO₂. Natural CO₂ seeps, as analogues of storage leakage, will provide a detailed database on the processes involved.

Objectives:

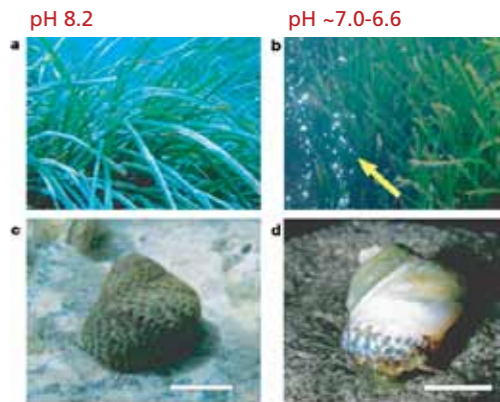
- to understand CO₂ transport mechanisms
- to develop appropriate monitoring methods to quantify CO₂ leakage and detect precursors
- to develop a simulation framework for risk assessment
- to develop best practices for detecting CO₂ leakage to the overlying water column



Multibeam echosounder water column image showing natural release of CO₂ bubbles at Panarea (Italy); image: Eurofleets Project PaCO₂

Impact of Leakage on Benthic Organisms and the Marine Ecosystems

will determine the biological impacts and risks associated with CO₂ leakage by controlled exposure experiments or in-situ observations at natural seeps, and identify appropriate methods to monitor the marine environment above a storage site.



Benthic ecosystems may be affected by local acidification; figure: Hall-Spencer et al., 2008, Nature 454, 96-99

Objectives:

- to quantify the consequences of CO₂ leakage for the health and function of organisms
- to assess the ability of organisms to adapt to locally elevated CO₂ levels
- to increase our capability to predict ecosystem response to leakage
- to identify biological indicators for CO₂ leakage
- to formulate environmental best practices for monitoring, protection and management of marine biota at offshore CO₂ storage sites

Risk Assessment, Economics, Legal Studies and Policy Stakeholder Dialogue

will consider the environmental risks associated with CCS and how these risks may impact on the financial, legal, and political considerations surrounding the future geological storage of CO₂.

Objectives:

- to conduct an environmental risk assessment (ERA) including the entire operational life cycle, closure and post-closure of the reservoir.
- to estimate the potential costs associated with monitoring, intervention in the case of CO₂ leakage, compare against the economic and environmental benefits deriving from CCS activities, and assess the financial risks.
- to review the existing legal framework with respect to the precautionary principle and the polluter pays principle.
- to determine the potential applicability of liability with respect to CCS activities.
- to communicate the knowledge produced in ECO₂ to relevant implementation bodies to improve transparency of decision-making for CCS

Public Perception Assessment

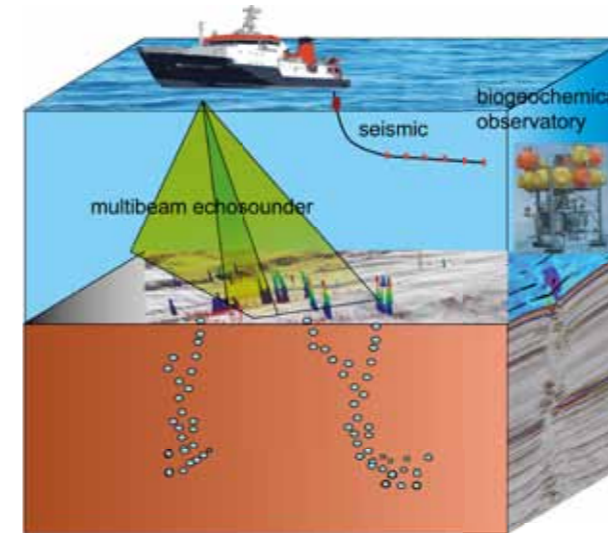
will investigate two important factors influencing the configuration of public perception patterns: trust and context. Intensive interaction with the public and major stakeholders will be sought to promote dialogue, while at the same time increasing knowledge and awareness of the different public and stakeholders' perspectives. As a result of this process a common framework for CO₂ storage communication and understanding will be proposed.

Objectives:

- to agree and clarify the use of CO₂ storage research terms and concepts to facilitate effective communication
- to explore the use of novel methods for capturing and understanding CO₂ storage public perception
- to identify the social processes involved in the formation of public perception of CO₂ storage
- to understand how the scope and the characteristics of the CO₂ storage technology and its costs-benefits are perceived by different social agents
- to provide guidance on public and stakeholder communication activities to meet information needs and concerns

Monitoring Techniques and Strategies

will provide a focus for the synthesis and integration of knowledge towards the optimisation of monitoring methods for different scenarios of CO₂ leakage.



Sketch illustrating different monitoring techniques; figure: GEOMAR

Objectives:

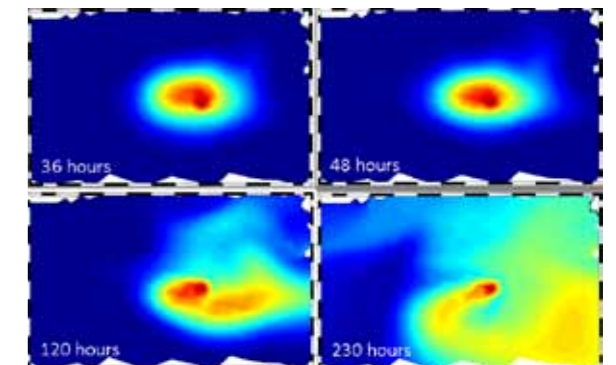
- to coordinate the development of monitoring technologies within ECO₂
- to develop guidelines for innovative and cost-effective monitoring strategies to detect and quantify potential leakage of CO₂ from storage sites and its effects on the marine ecosystems

Interfacing of the Numerical Models

intends to model the whole system from reservoir leakage through to CO₂ transfer into the ocean and to the atmosphere, including biological impacts. Subsequently, the physical, chemical and biological knowledge will be transferred into an economic valuation of the costs of leakage, monitoring, and mitigation measures as well as underpin a concept for risk management.

Objectives:

- to define common leakage scenarios that will enable the delivery of integrated risk assessments, economic valuation and the development of conceptual monitoring practices
- to identify model synergies, overlaps and interfaces, and the development of the appropriate computational coupling tools to support data transfer
- to quantify and evaluate the geological, physical, chemical and ecological risks, impacts and associated uncertainties of key CO₂ leakage scenarios



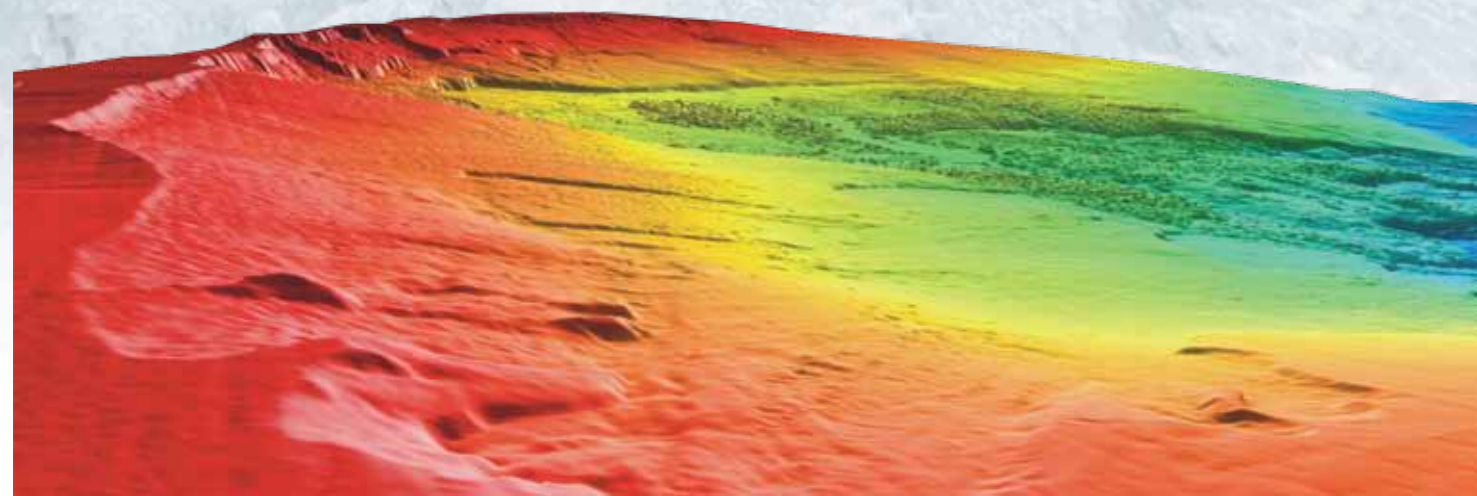
Dispersing CO₂ plume (domain: ~ 4x7 km²); graphic: PML

International Collaboration

will enhance the international profile of European environmental CCS research.

Objectives:

- to enhance collaboration with Australian CCS research groups, with specific topics of sub-seafloor storage monitoring technology and legal concepts and principles, including environmental liability
- to expand collaboration with Japanese CCS research groups, with specific topics of theoretical modelling of CO₂ plume and deep-sea biogeochemistry of natural CO₂ vent sites in Japanese waters
- to strengthen collaboration with US CCS research groups, particularly those working on experimental submarine CO₂ release and theoretical CO₂ buoyancy constraints and benefits of sub-seafloor storage at water depth of >3000 m.



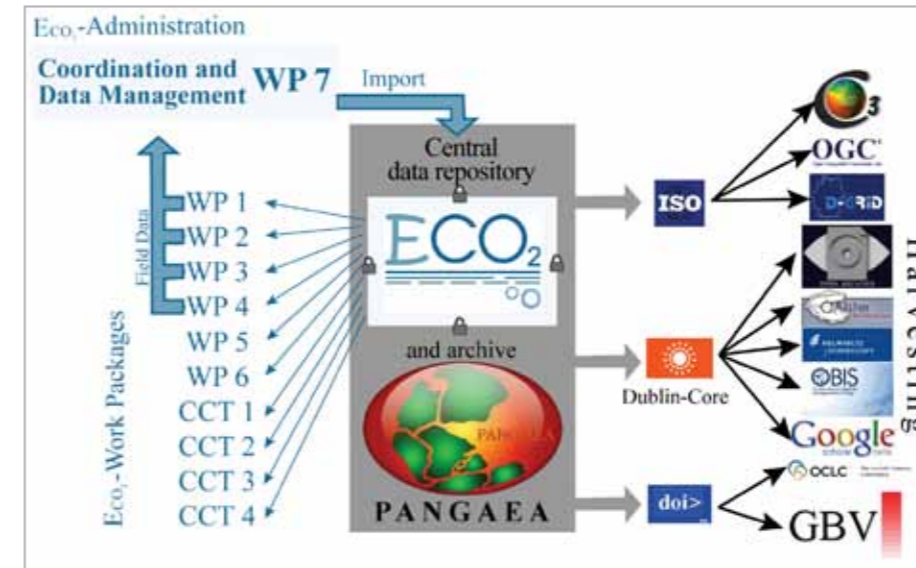
Framework of Best Environmental Practices of Off-shore CO₂ Injection and Storage

will utilise the knowledge of the ECO₂ consortium to identify considerations associated with operating storage facilities and managing the potential environmental impact of CO₂ storage.

Objectives:

- to construct a Framework of Best Environmental Practices in the preparation, operation and management of offshore storage sites.
- to review and test the applicability of the draft Framework of Best Environmental Practices guidance.

The data management facilitates the flow of data from field work, lab experiments and numerical simulations to all WPs and CCTs. The central data repository is part of the PANGAEA data library with all benefits through a distribution via web services, search engines, portals and library catalogues.



ECO₂ data management concept; illustration: GEOMAR

Data management is combined with project management to guarantee the required data delivery for this multi-disciplinary project with alternating dependencies.

