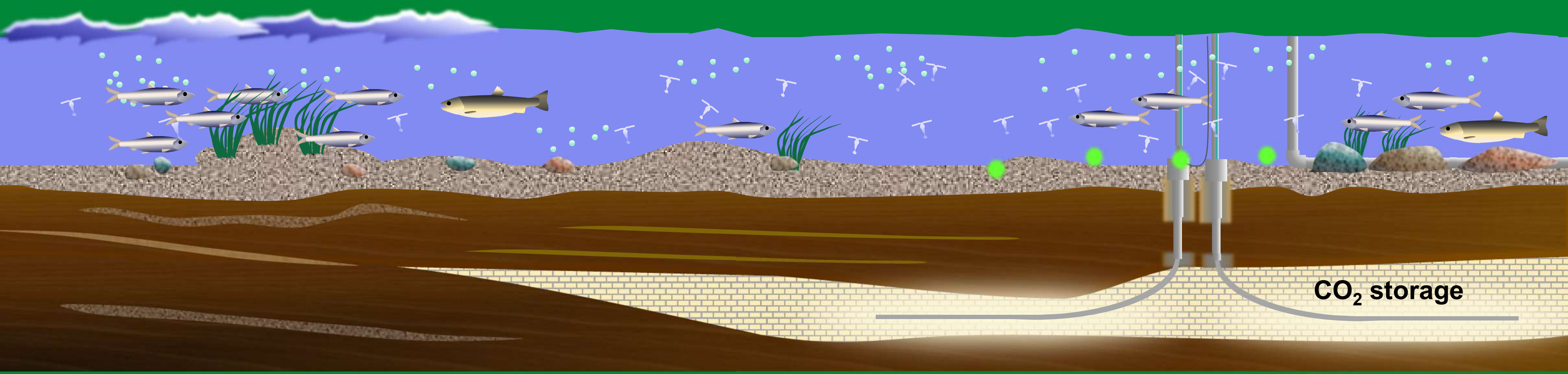
Danish Offshore Technology Center

A Key player in the Energy Transition



DTU Offshore

DTU Offshore was founded in 2014 as part of the Danish long-term national strategy on energy production

Taylor made research

2014 and on-going: Efficient and responsible oil and gas operations

2020 and on-going: Environmentally sustainable oil and gas production, Abandonment and CO_2 storage

Resources

- 1 billion DKK over 10 years, tax-deductible grant by Danish Underground Consortium (DUC)
- Network organization
- World class R&D environment and employees with many years of industry experience

DTU Offshore - Consortia and collaboration ecosystem

DUC partners

BlueNord

TotalEnergies

nordsøfonden

70+ Corporate partners, including:

AkerBP

ABB

Geo

RAMBOLL

Ocean Team Scandinavia as

Technical University of Denmark

DTU

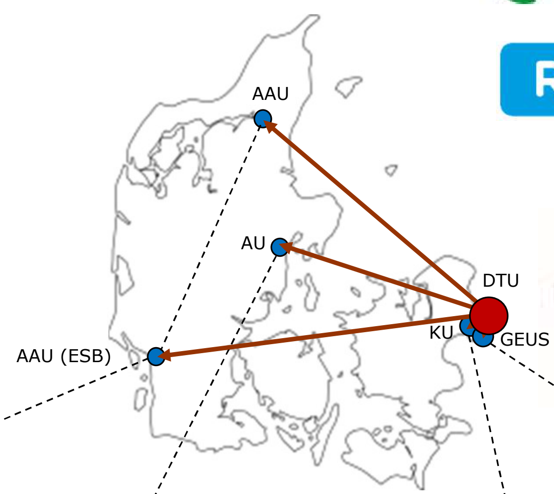
10 Research partners, including:

SINTEF

University of Leeds

HERIOT WATT UNIVERSITY

NORCE



DOTC = DTU + partner institutes

AALBORG UNIVERSITY DENMARK

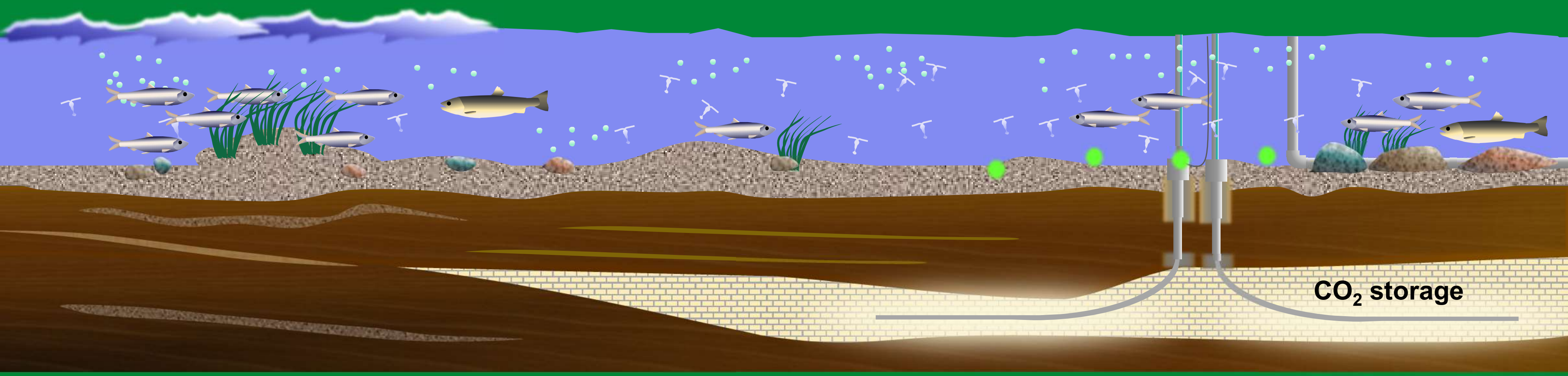
AARHUS UNIVERSITY

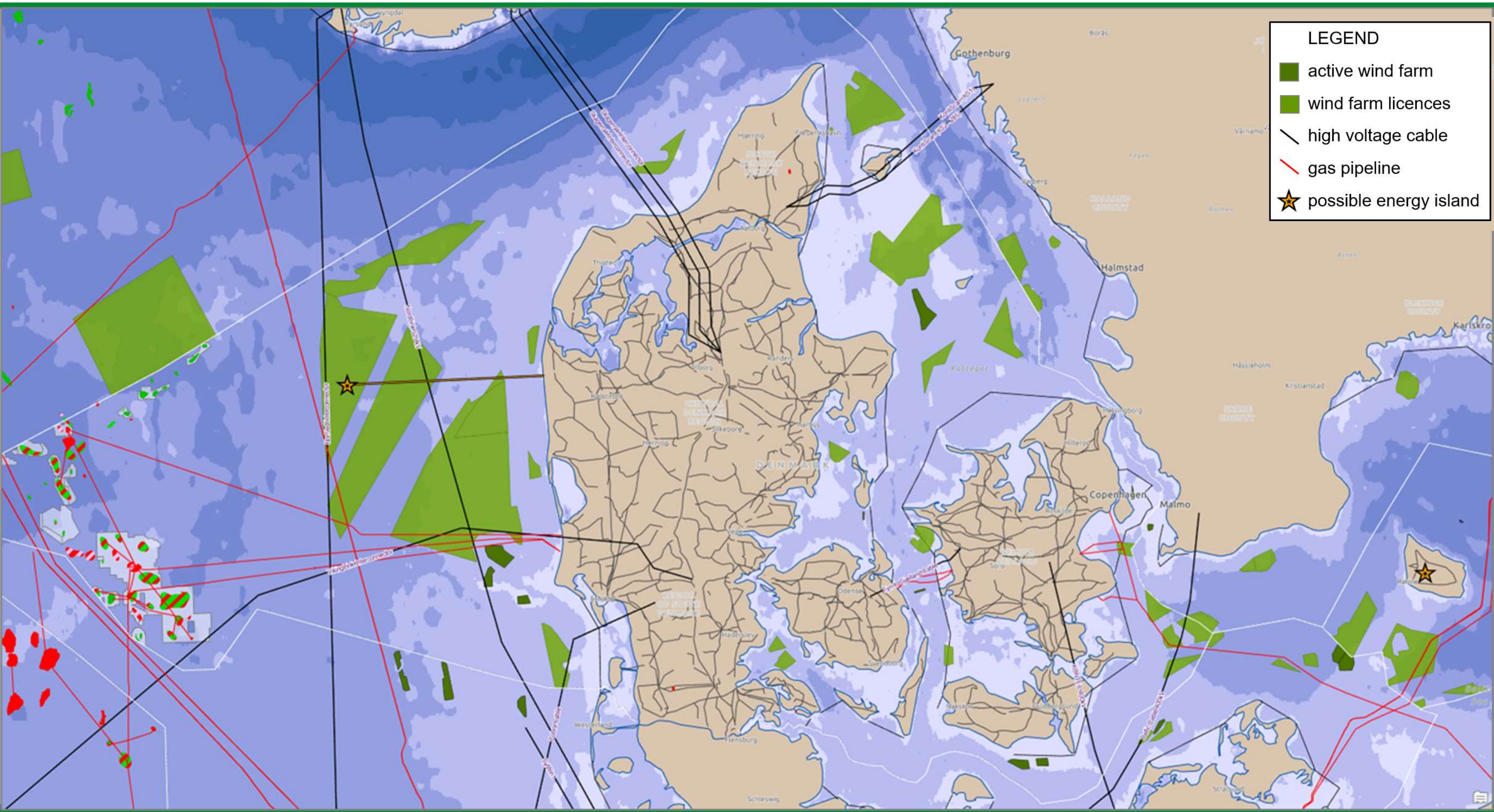
UNIVERSITY OF COPENHAGEN

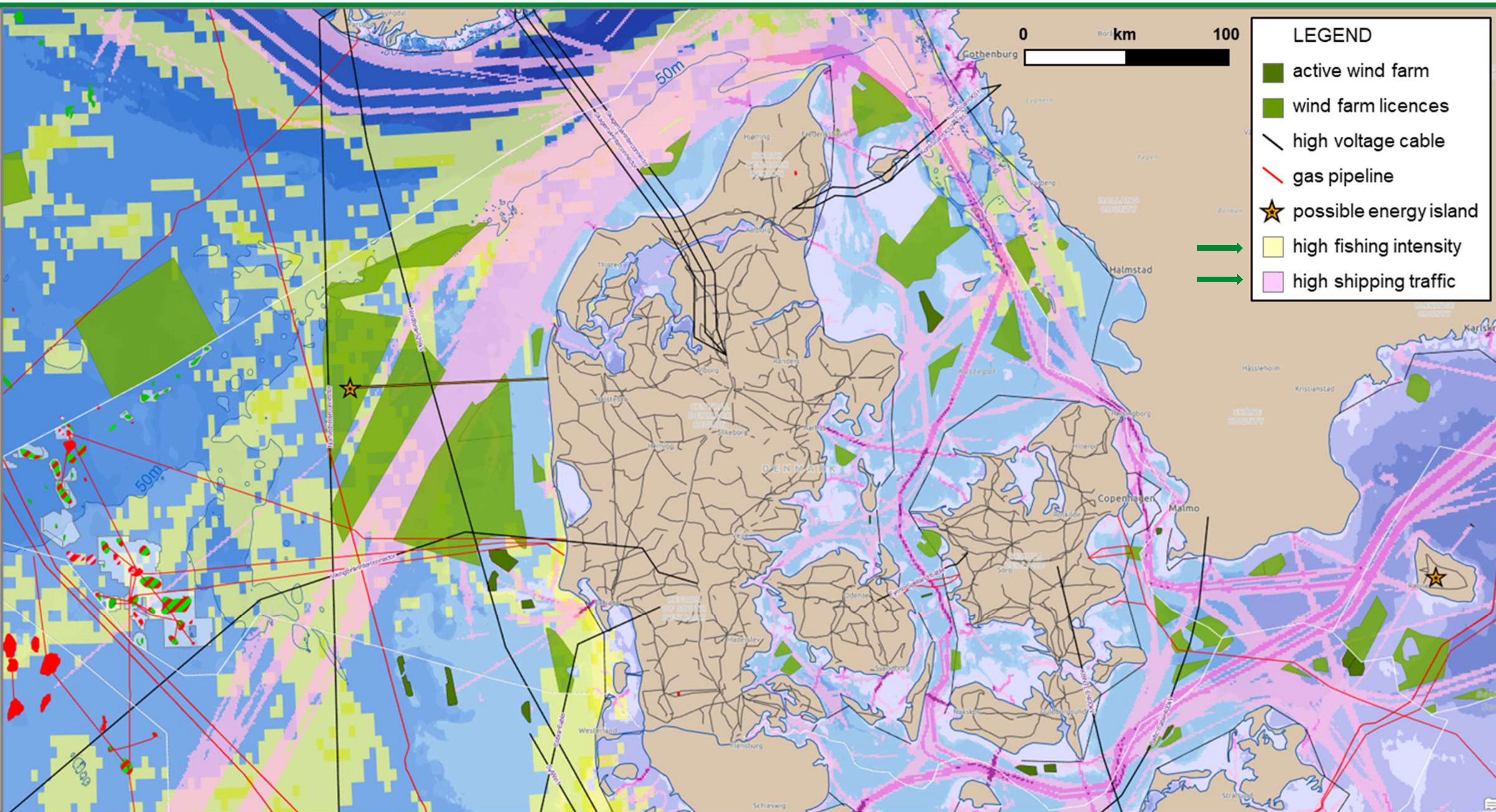
GEUS

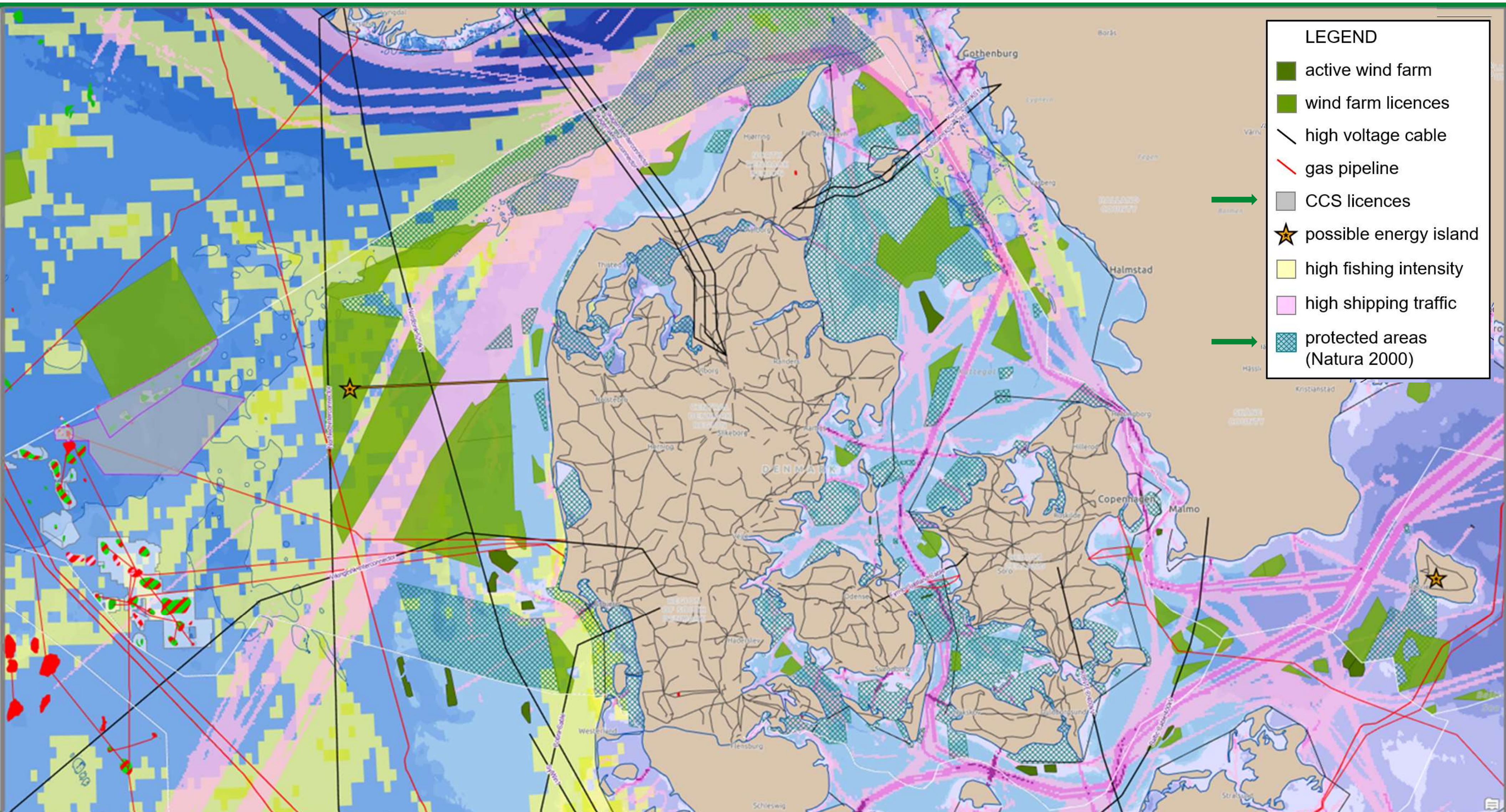
The Danish Offshore O&G industry and the energy transition

Navigating the Environmental Implications of Energy Transition:
Understanding the impact of Oil & Gas Decommissioning and CO_2 Storage.

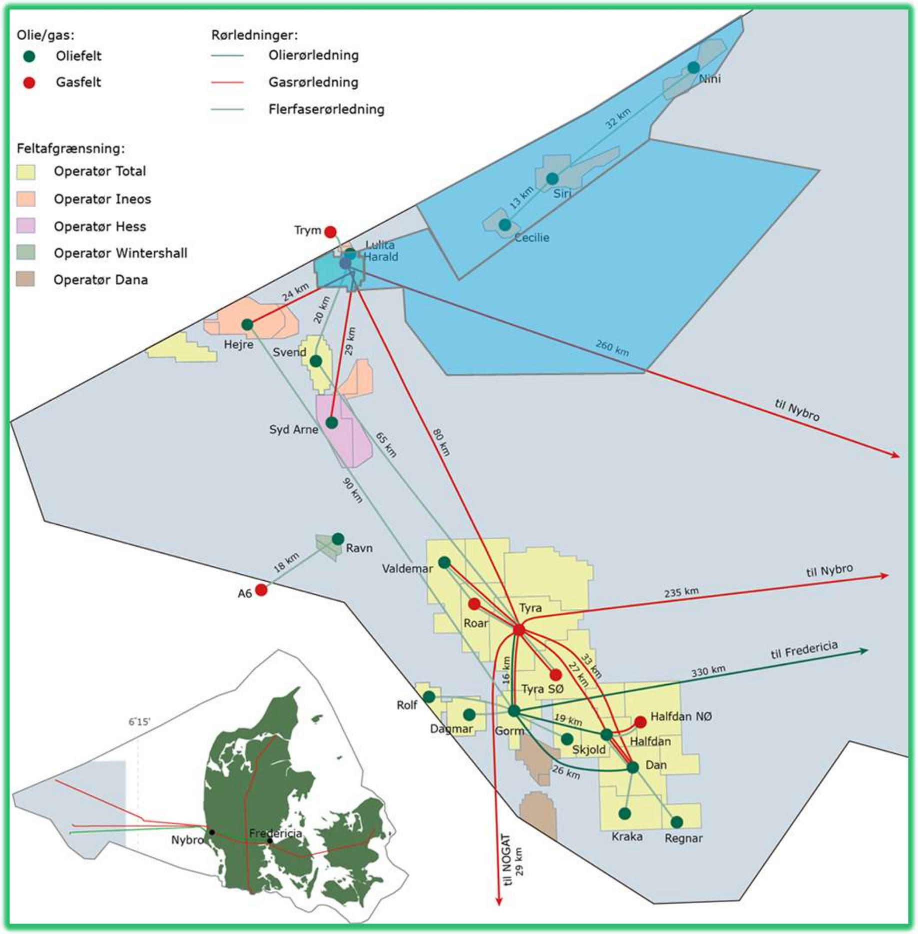



LEGEND
active wind farm
wind farm licences
high voltage cable
gas pipeline
possible energy island
Gothenburg
Halmstad
Copenhagen
Malmo
Karlskro


LEGEND
active wind farm
wind farm licences
high voltage cable
gas pipeline
possible energy island
high fishing intensity
high shipping traffic
0
km
100
50m
50m
Gothenburg
Halmstad
Copenhagen
Malmo
Karlskro


LEGEND
active wind farm
wind farm licences
high voltage cable
gas pipeline
CCS licences
possible energy island
high fishing intensity
high shipping traffic
protected areas
(Natura 2000)
Gothenburg
Halmstad
Copenhagen
Malmo

Oil and Gas decommissioning and CO_2 storage



End of oil and gas production in Denmark in 2050

- 26 fields in Denmark
- 55 platforms in Denmark
- Appx 400 wells in Denmark

CO_2 storage options in Denmark:

- Onshore storage
- Offshore aquifers
- Existing Oil and Gas fields

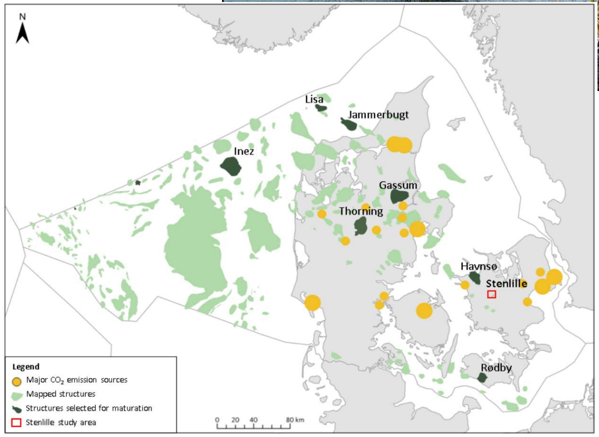
All three options have advantages and disadvantages

CO_2 storage needs to be on large scale to ensure storage is cost effective and climate effective

Why CO_2 storage in existing oil and gas fields?

Opportunity for accelerated implementation of CO_2 storage:

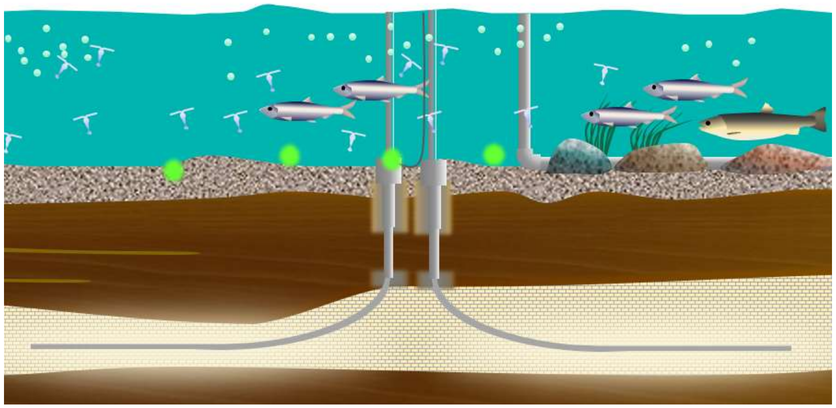
- a large, well described and proven storage capacity
- decades of accumulated knowledge on subsurface behaviour
- existing subsurface and surface infrastructure
- distance to shore and inhabited areas
- area already in use for energy generation



But added complexity:

- Adds a potential risk of leaks through abandoned wells
- COP date of existing fields

Main environmental risks associated with decommissioning

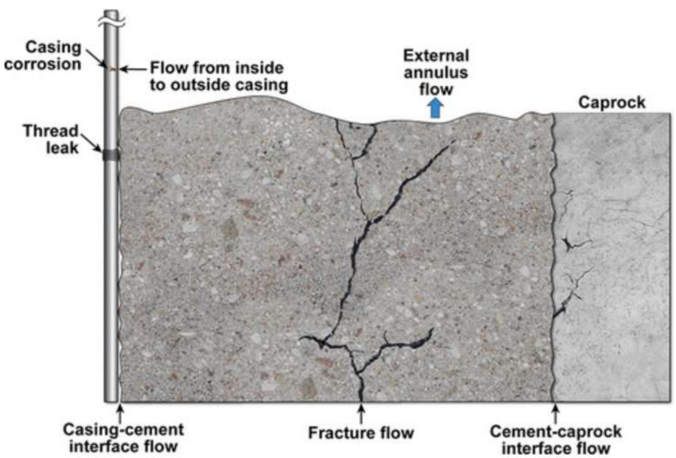


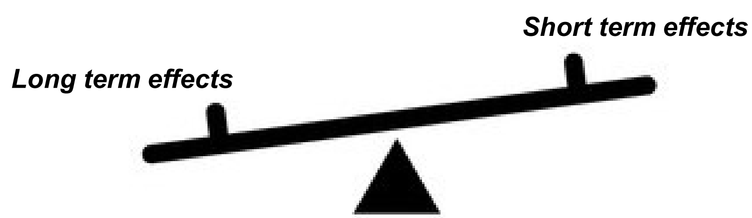
Long term effects:

- Leaking wells - leaks from either O&G reservoir or shallower hydrocarbon bearing layers, due to O&G activities
- Impact of removing structures on marine habitats

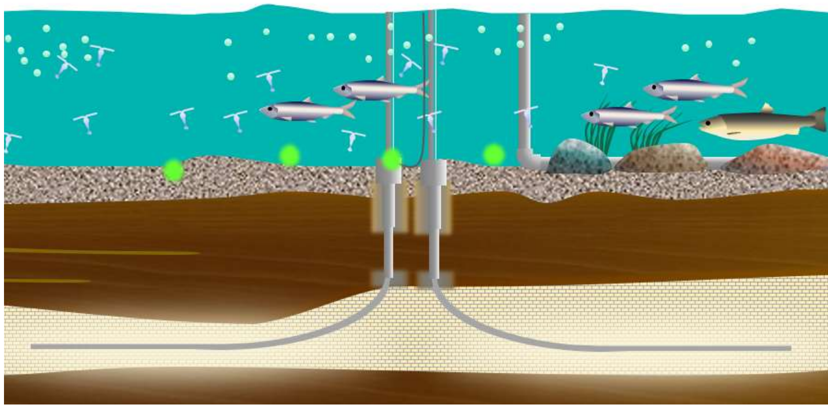
Short term effects:

- Impacts of the abandonment operation (emissions, unintentional discharge, noise ….)





What are the main risks associated with CO_2 Storage?

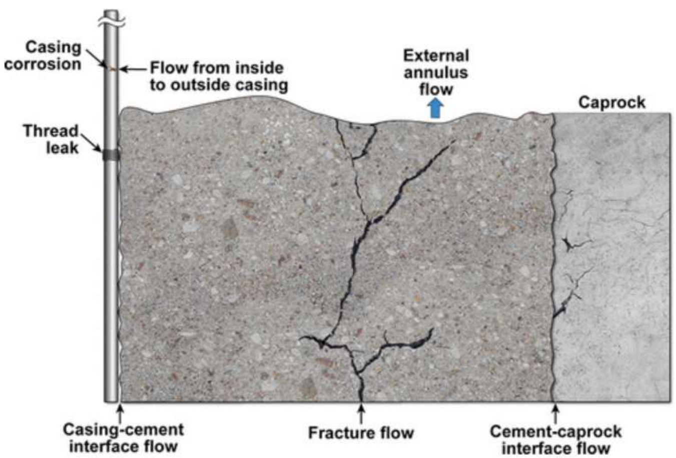


Long term effects:

- Leak through faulting or insufficient caprock
- **Leaking through legacy well penetrations**
- **Impact of new infrastructure on marine life**

Short term effects:

- Impacts of the injection operation and construction of infrastructure (emissions, unintentional discharge, noise ….)



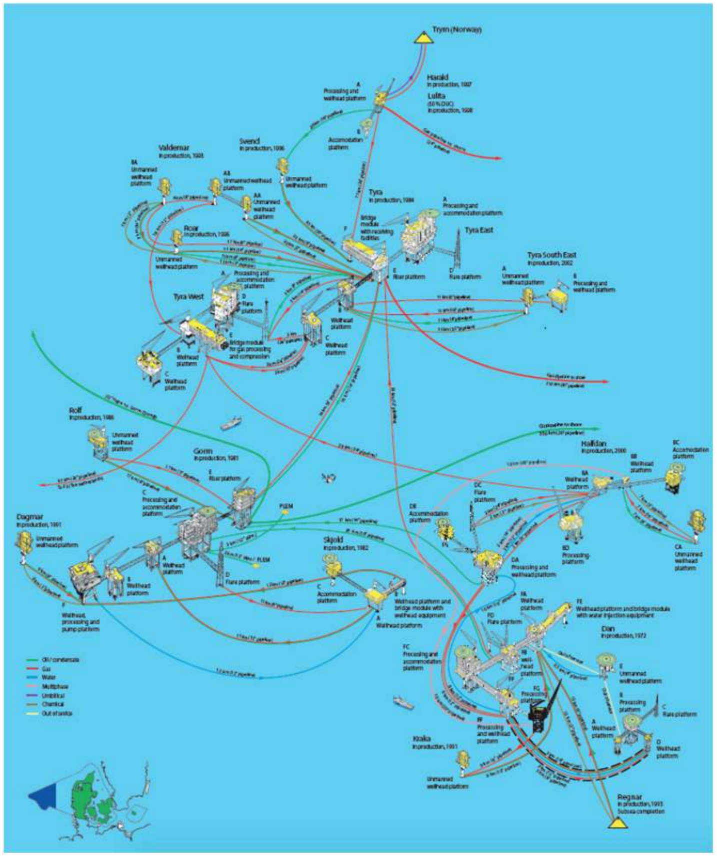
Storage Reservoirs
Accounts of Chemical Research (IF 18.3) Pub Date: 2017-07-25 , DOI:10.1021/acs.accounts.7b00094
Susan A. Carroll [1] , Jaisree Iyer [1] , Stuart D. C. Walsh [2]

Decommissioning of Oil and Gas fields and of Offshore CO_2 storage have similar environmental risks.

- ➢ *Need to understand the risk*
- ➢ *Need to understand the delta from CO_2*

Long term environmental impact – main components

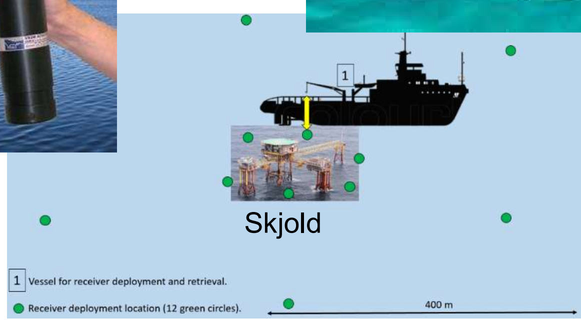
Impact of new infrastructure on marine life

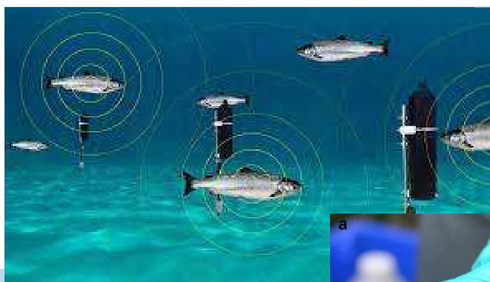


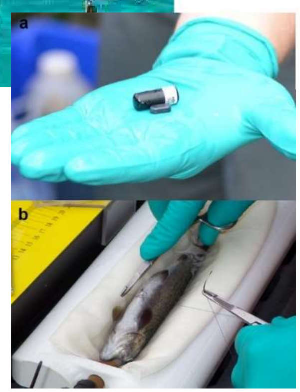
Long term environmental impact – main components

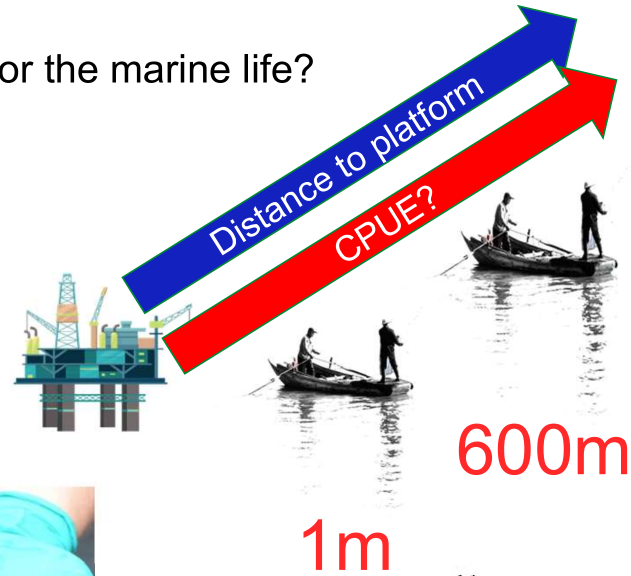
Impact on marine life of removing infrastructure

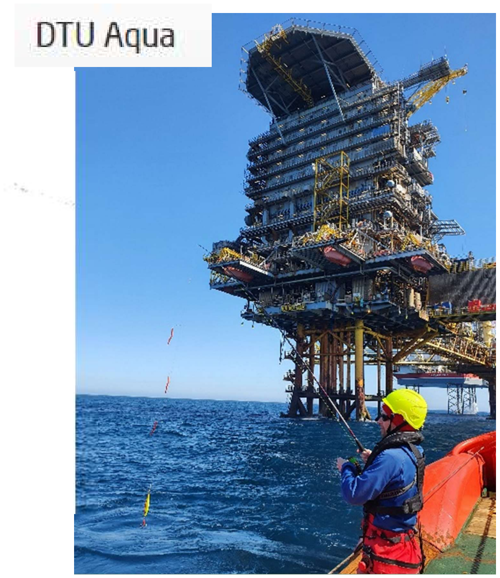
Are these structures important for the marine life?



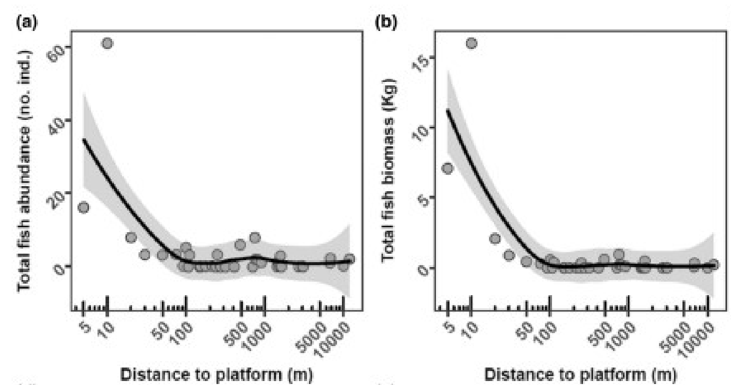








[Fish aggregations at oil and gas platform foundations in the North Sea (dtu.dk)]



Long term environmental impact – main components

Leakage potential

If a leak is detected – remediation?

Well abandonment

Ensure barrier integrity over time with and without CO_2

- Shallow permeable zones
- Understand long term barrier durability
- Develop new barrier solutions

Understand origin of CH_4 and CO_2 and what is acceptable

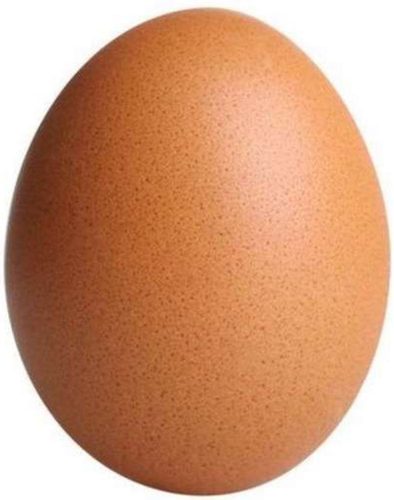
Post abandonment monitoring

Environmental Baseline

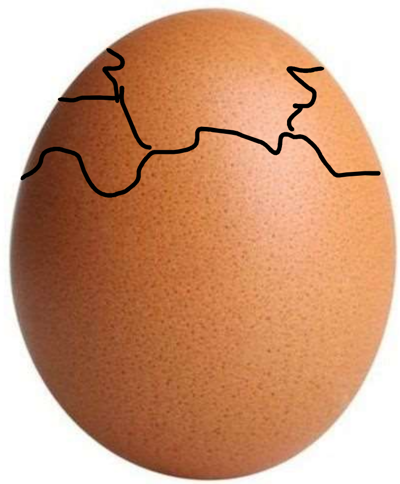
Equipment capable to monitor CH_4 and CO_2 in dynamic environment

Understand pre-drilling, pre-abandonment, pre-injection baselines

Public perception: poor integrity and cap rock can crack



time



catastrophe

CO_2/Methane

Monitoring is a requirement

SEEP - SEabed Environmental baseline for Platform abandonment

Challenge:

*When Oil and Gas wells have been **abandoned** there is a risk that one or more of the wells will leak over time. However, **natural hydrocarbon seepage** might mask the monitoring results.*

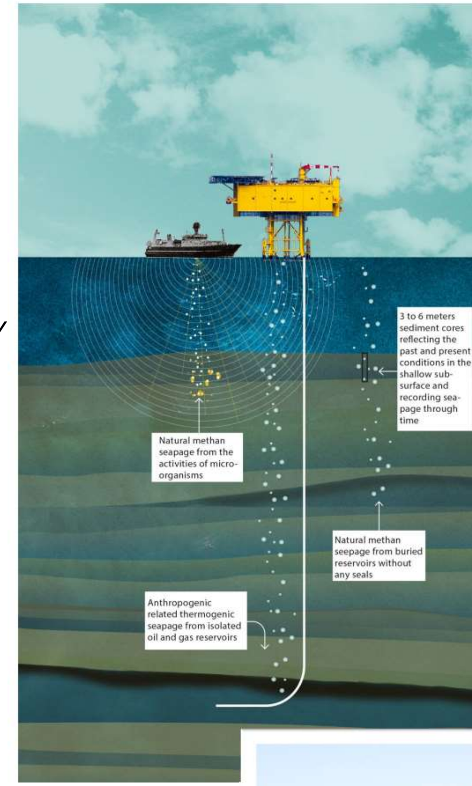
***Crucial to understand the natural seepage** through the seabed both locally at platforms and regionally – EU requirements for monitoring of Abandoned well expected in near future.*

Aim of Project:

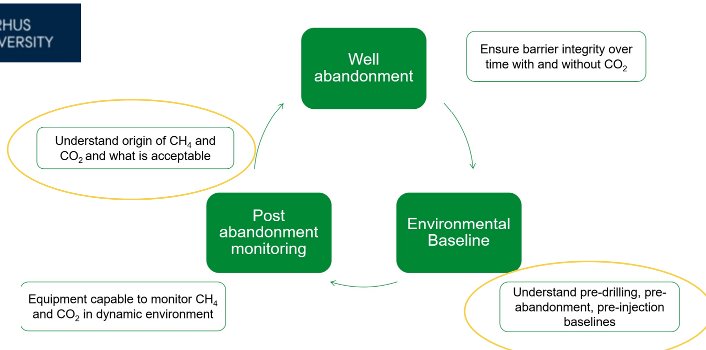
*To develop a **baseline toolbox for methane seepage** in the shallow subsurface, near oil and gas platforms and in areas without any hydrocarbon production **(pre-drilling and pre-abandonment)***

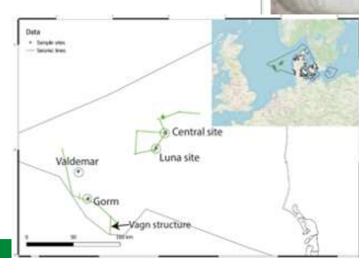
Data:

*Using **newly collected geophysical data** combined with deep industry seismic data, various types of shallow methane seeps have categorized, and placed in a geological context. Integrated with results from **sediment core analysis,** including **facies analysis** of cores, **benthic faunal** (foraminifera and bivalves) variations between core sites, **dating and geochemistry** of selected bivalves and foraminifera.*

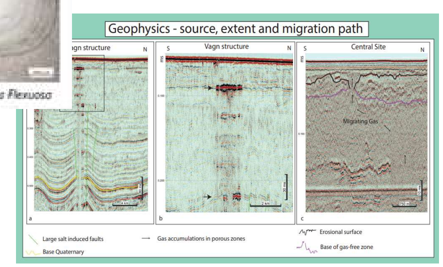


Drawings from GEUS





bivalve: Thyrasia Flexuosa



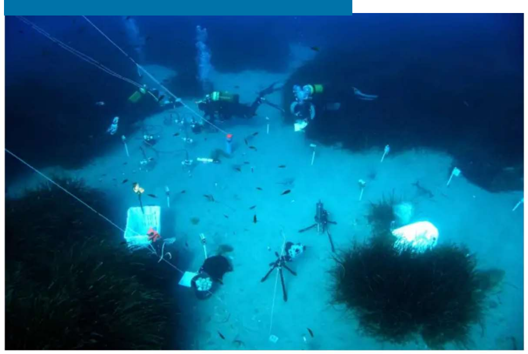
LoCo2 - the journey of CO_2 from storage to seabed

Challenge:

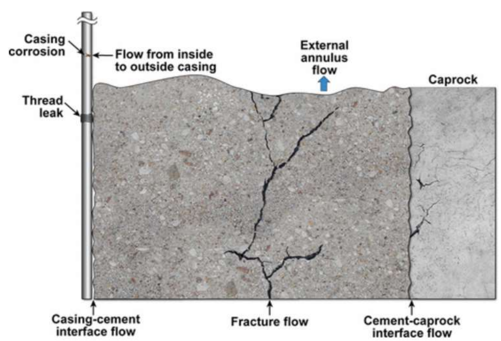
On its leakage path, **CO_2 and its impurities alter through (bio)chemical processes**. Understanding this transformation is essential for both **monitoring** and the assessment of the impacts of a leakage on the **marine environment**.

LoCo2 will develop an **intelligent tool** to predict the effect of a possible CO_2 leakage on microbial and faunal life in seabed sediments and couple it with a predictive Thermo-Hydro-bio-Chemical model of CO_2 (and impurities) flow through the overburden layers to the seabed. The tool can be used to **design monitoring systems.**

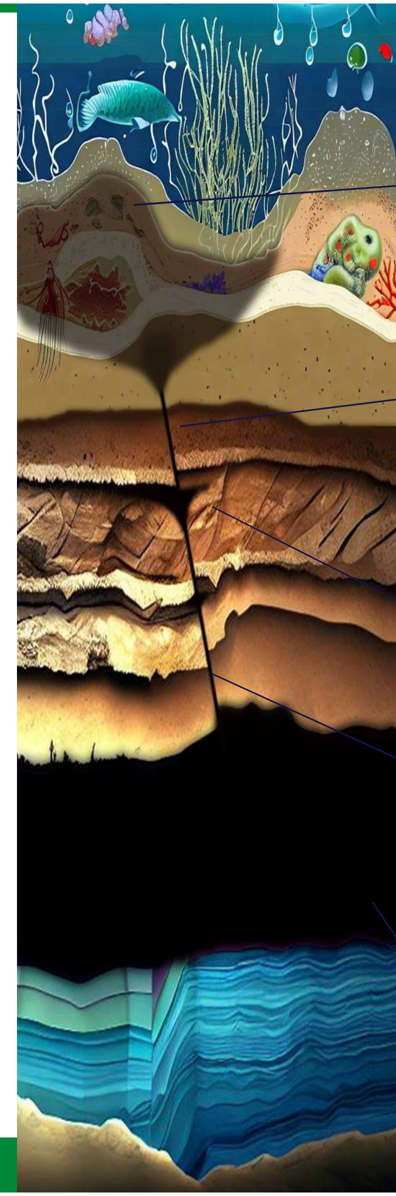
THE VELUX FOUNDATIONS
VILLUM FONDEN ✕ VELUX FONDEN



The seafloor as a natural laboratory: Divers at work. Credit: HYDRA/C. Lott



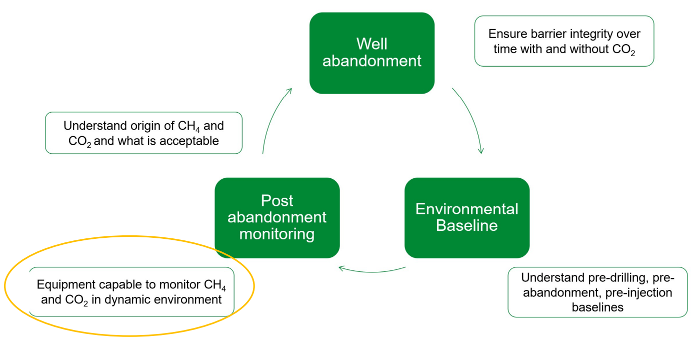
Influence of Chemical, Mechanical, and Transport Processes on Wellbore Leakage from Geologic CO2 Storage Reservoirs
Accounts of Chemical Research (IF 18.3) Pub Date: 2017-07-25 , DOI:10.1021/acs.accounts.7b00094
Susan A. Carroll [1] , Jaisree Iyer [1] , Stuart D. C. Walsh [2]

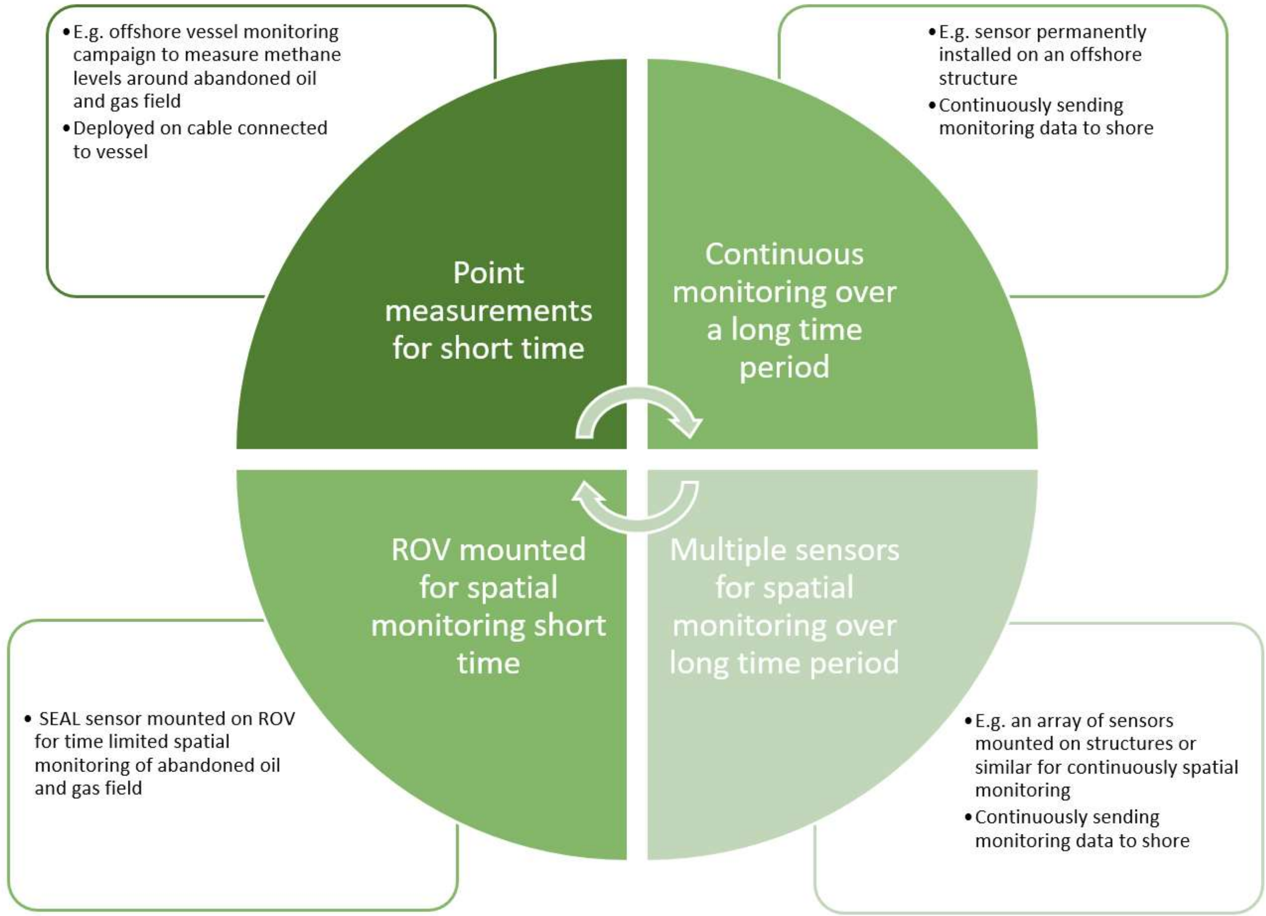


Monitoring modes for CH_4 and CO_2

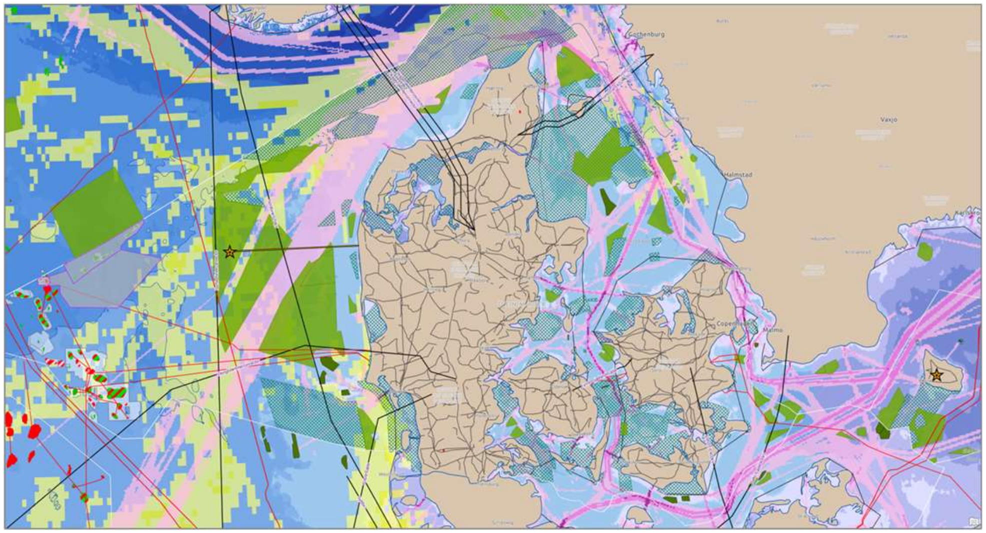
Depending on area to be monitored and future regulatory requirements

Flexible solution which can cover all scenarios





Energy Transition vs offshore marine environment



<u>The energy transition will have a significant impact on the marine environment</u>

Does not mean that we should stop the transition:

- *Understand the impact*
- *Mitigate impact as much as possible*
- *Ensure sufficient monitoring*

Significant synergies between decommissioning and CO_2 injection mitigation, monitoring and environmental impact

DTU

CCS conference – 2024

CO_2 storage in Denmark – Risks and Uncertainties

Storage of CO_2 is a key part of Denmark's road towards negative emissions in 2050 and at the same time Denmark has an ambition of becoming a CO_2 storage hub for Europe. The technologies behind the storage of CO_2 are mature, however, there are remaining risks and uncertainties when it comes to implementation. This conference will focus on the risks/uncertainties associated with CO_2 storage in Denmark, looking at both offshore and onshore storage sites. The risks and uncertainties which will be addressed are covering a wide range of issues from lack of high-quality data.

Confirmed speakers (more to come):

Energistyrelsen

INEOS

TotalEnergies

GEUS

CarbonCuts

STOREGGA

Denmark's Youth Climate Council

CO_2Hub EUROPE

June 4th 2024 at Rungstedgaard