British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Screening, selection and characterisation CO_2 storage sites, UK northern North Sea

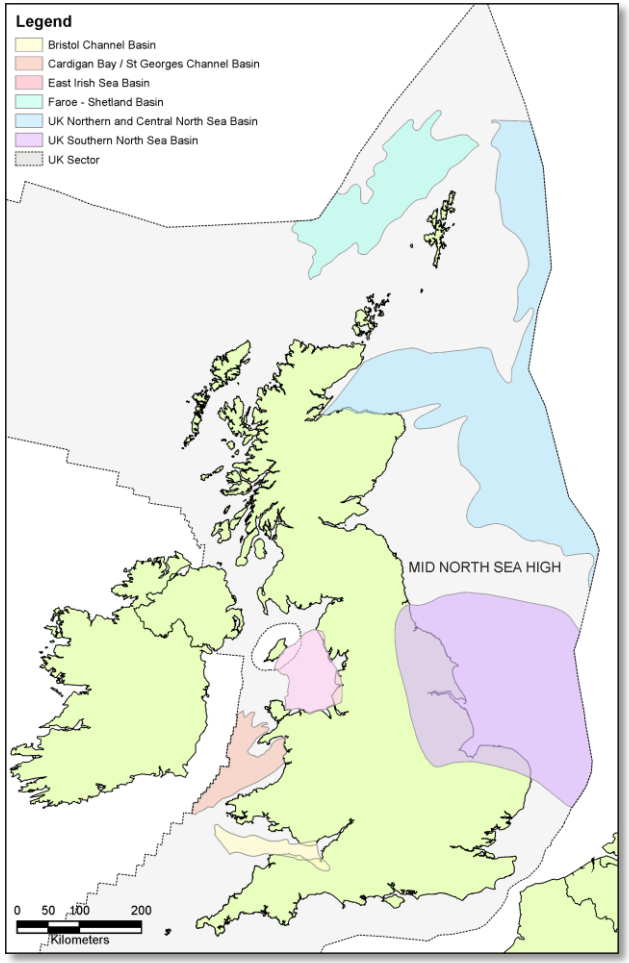
Maxine Akhurst
British Geological Survey

China Australia Geological Storage of CO_2 School
Chengdu, 14-17 October 2013

Outline of presentation

- Outline estimates of UK storage capacity
- Screening of storage sites in northern North Sea
- Selection of sites for storage research
- Characterisation of sites for storage research
- Calculated storage capacities from dynamic modelling

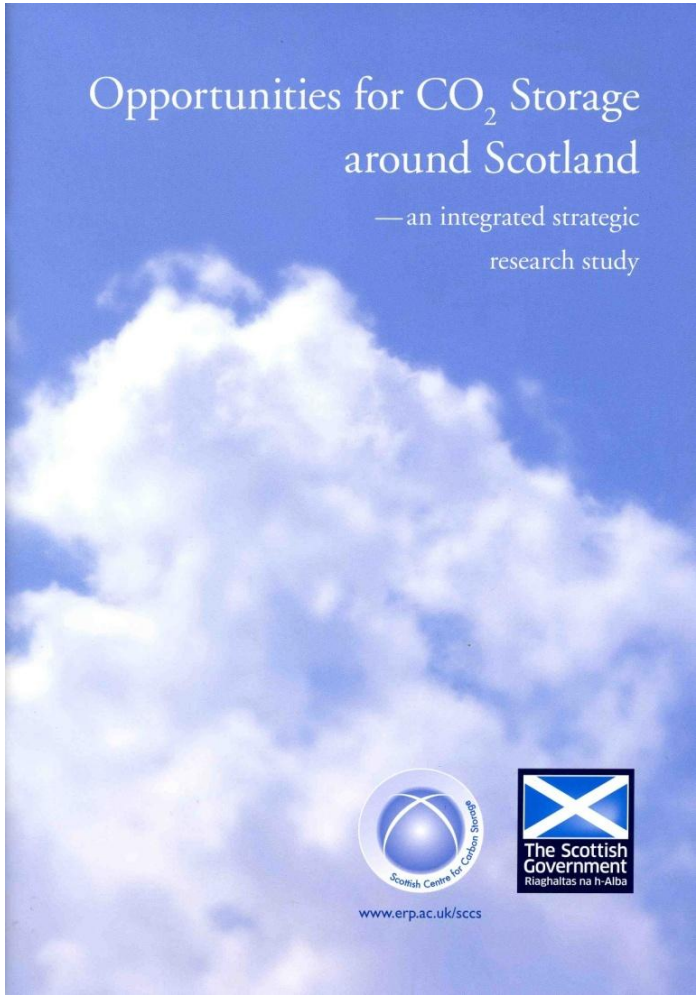
Estimates of CO_2 Storage Capacity in 2006



Northern and central UK North Sea (blue area)

- Oil fields (all offshore) 1 175 Mt CO_2
- Gas condensate fields ~1 200 Mt CO_2
- Gas fields ~210 Mt CO_2
- Saline aquifer sandstones >3 000 Mt CO_2 in structural traps alone

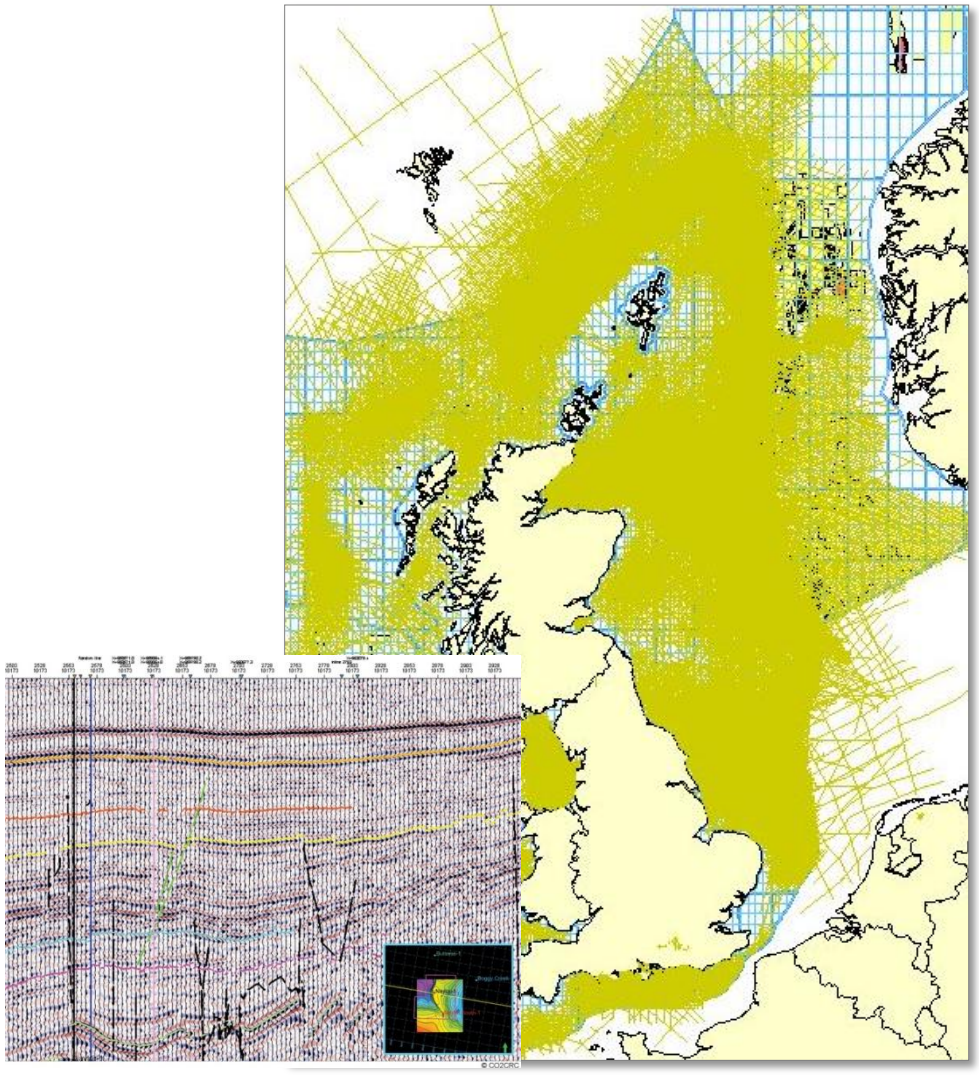
‘Opportunities for CO_2 storage around Scotland’



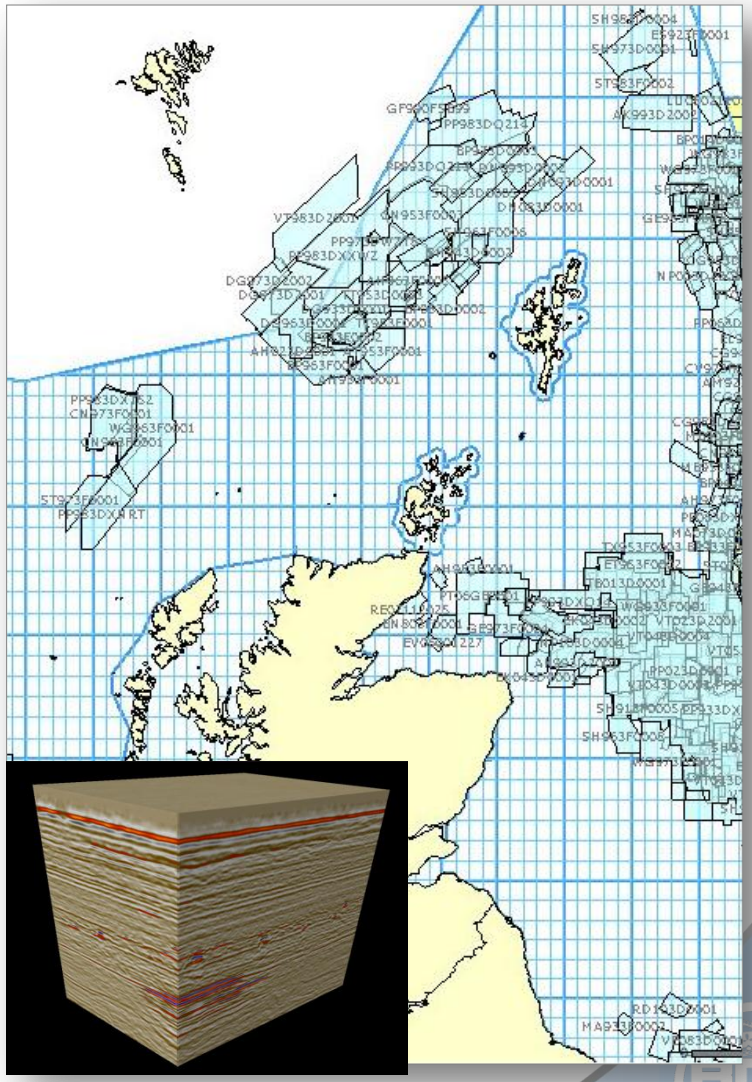
- Identified principal CO_2 sources
- High-level model for a transport network
- Enhanced oil recovery using CO_2
- Created economic models for CCS in Scotland
- Further steps to make CCS in Scotland a reality
- **Screening of potential storage sites for CO_2**

www.sccs.org.uk/expertise/reports.html

Screening - existing available data

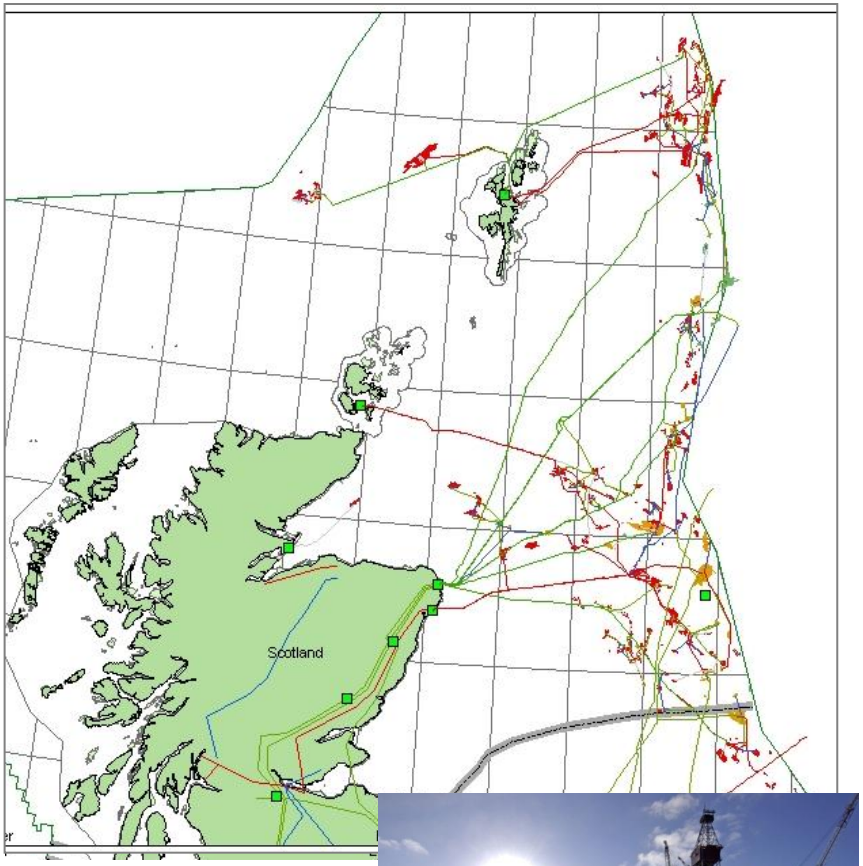


2D seismic surveys



3D seismic surveys

Screening - existing resources for CCS projects



- Data from exploration and production
- Infrastructure of pipelines and platforms
- Knowledge and experience of North Sea offshore operations including Sleipner CO_2 storage site

Screening – geological criteria for selection

Geological criteria

- Depth
- Permeability
- Porosity
- Storage capacity > 50 Mt CO_2

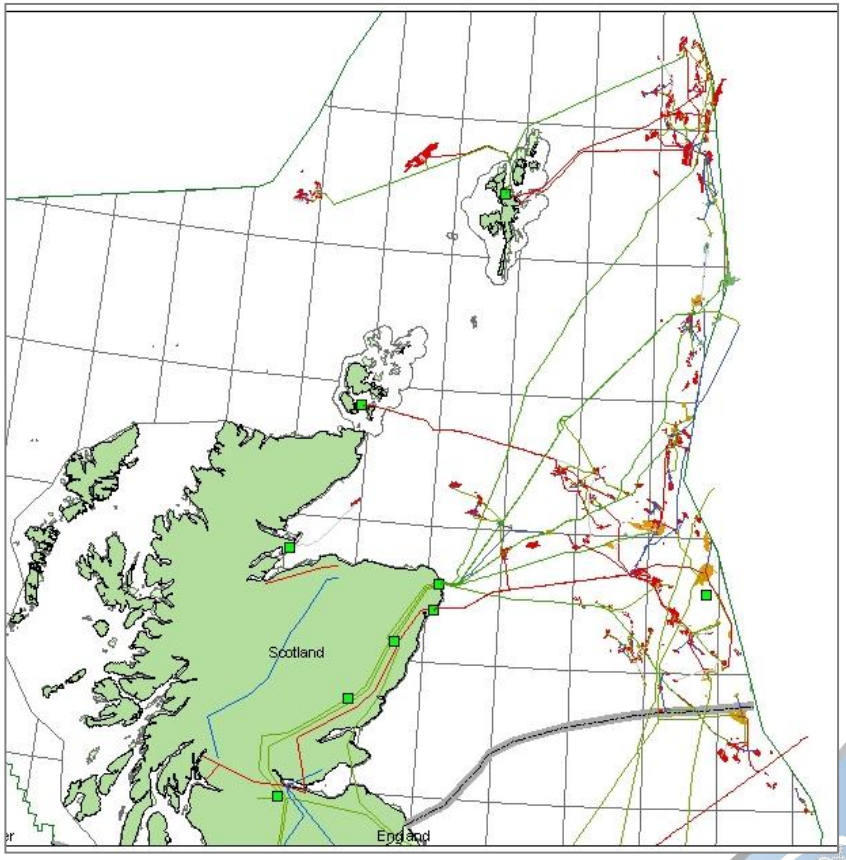
Reservoir Attribute	Best practice requirements	Minimum technical requirements
Depth	>1000 m and < 2500 m	>800 m and <1000m
Permeability	> 500 mD	>200 mD and <500 mD
Porosity	> 20%	>10% and <20%

After Chadwick et al., 2008
www.bgs.ac.uk/downloads/start.cfm?id=1520

Screening – non-geological criteria for selection

Non-geological criteria

- Proximity to CO_2 sources;
- Proximity to existing infrastructure, such as oil and gas pipelines;
- Presence of hydrocarbon field data
- Data availability

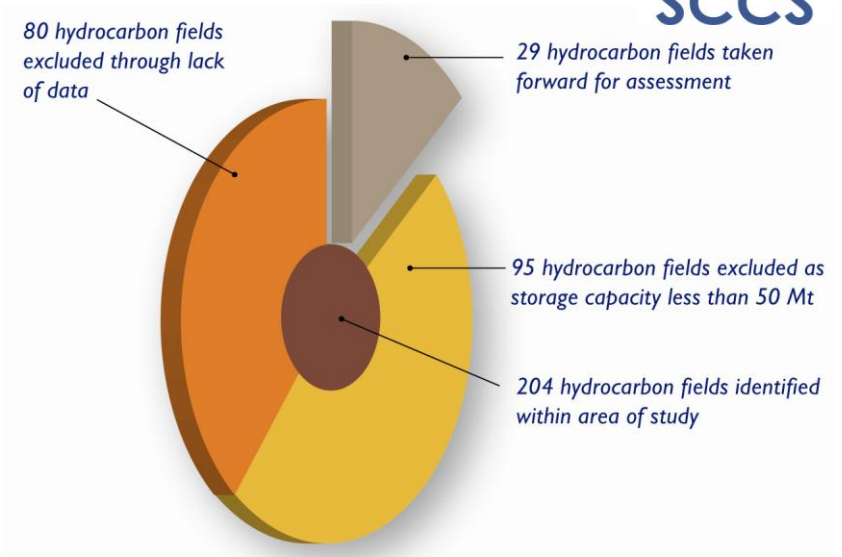


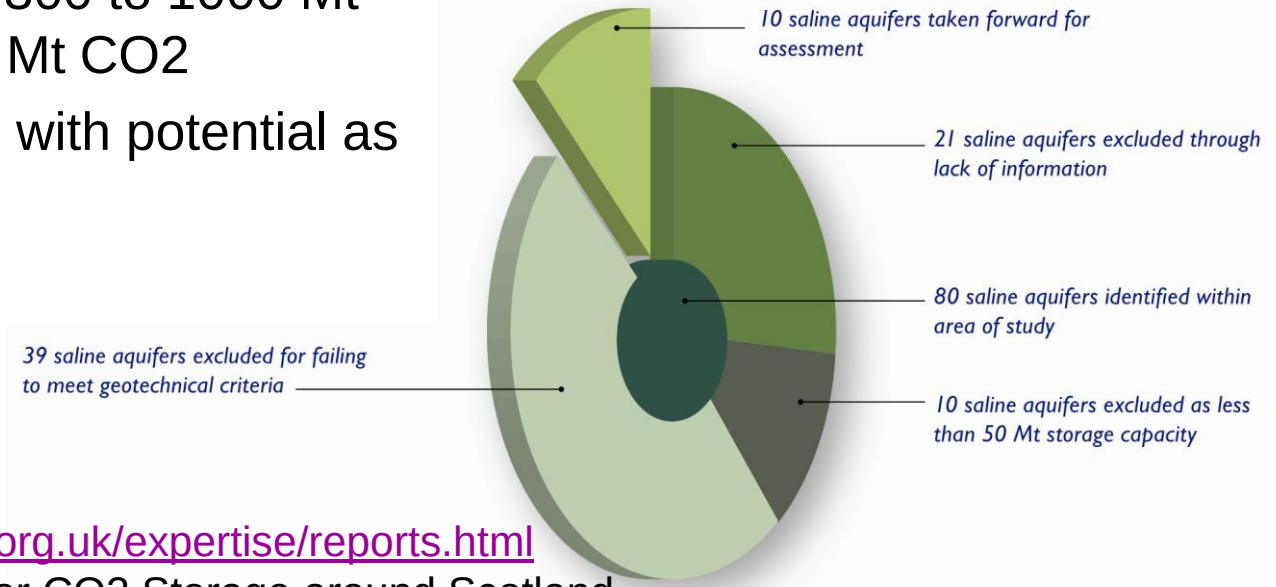
www.sccs.org.uk/expertise/reports.html

Opportunities for CO2 Storage around Scotland

Screening – results

- **Screened**
  - 204 hydrocarbon fields
  - 80 saline aquifers
    - > 50 Mt CO_2 capacity
    - Based on available information
- **Outcome**
  - 29 hydrocarbon fields, capacities of top nine fields are 300 to 1000 Mt CO_2 , total of 1360 Mt CO2
  - 10 saline aquifers with potential as stores

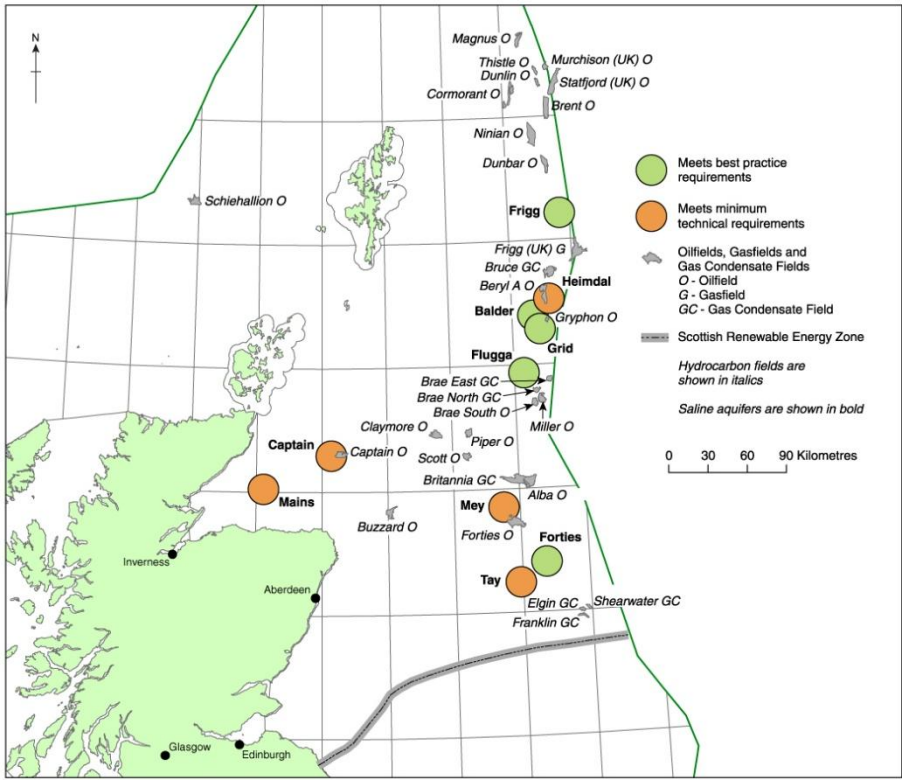




www.sccs.org.uk/expertise/reports.html

Opportunities for CO2 Storage around Scotland

Screening – potential CO_2 storage sites



Shortlist of 10 aquifers
Geological characteristics
Acceptable - orange
Optimal – green

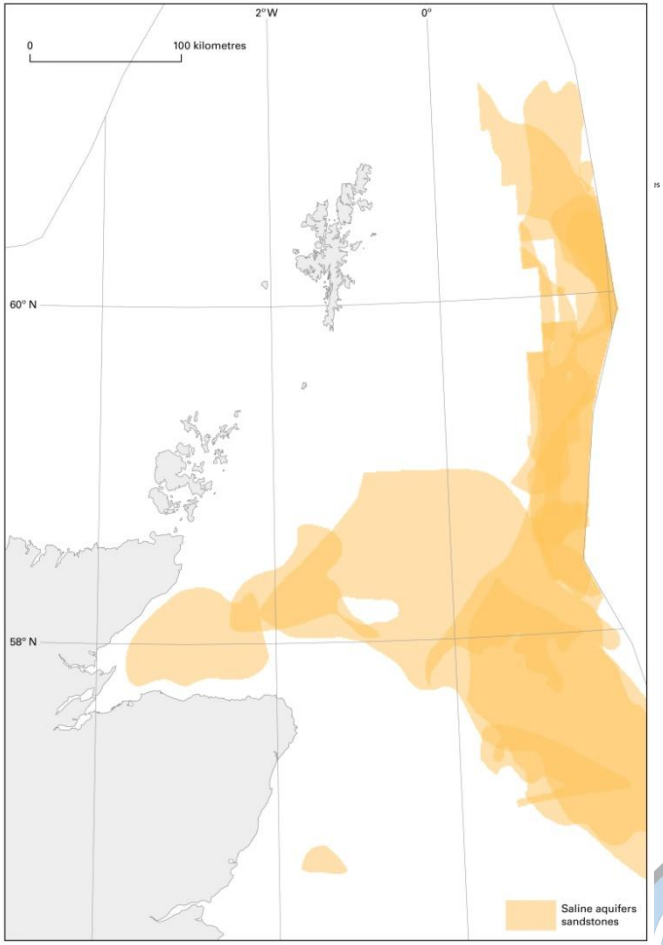
Hydrocarbon fields - grey

www.sccs.org.uk/expertise/reports.html
Opportunities for CO2 Storage around Scotland

Selection of aquifer sites for storage research

- 10 saline aquifer sandstones
- Very large extent, 1 700 to 33 000 km^2
- Many are overlapping
- Geological character is not well known
- Storage efficiency assumed to be 0.2% to 2.0% of pore volume
- Total storage capacity for all 10 aquifers is wide ranging
- 4 600 to 46 000 million tonnes

Need to select a single sandstone for storage research



www.sccs.org.uk/expertise/reports.html

Progressing Scotland's CO2 storage opportunities

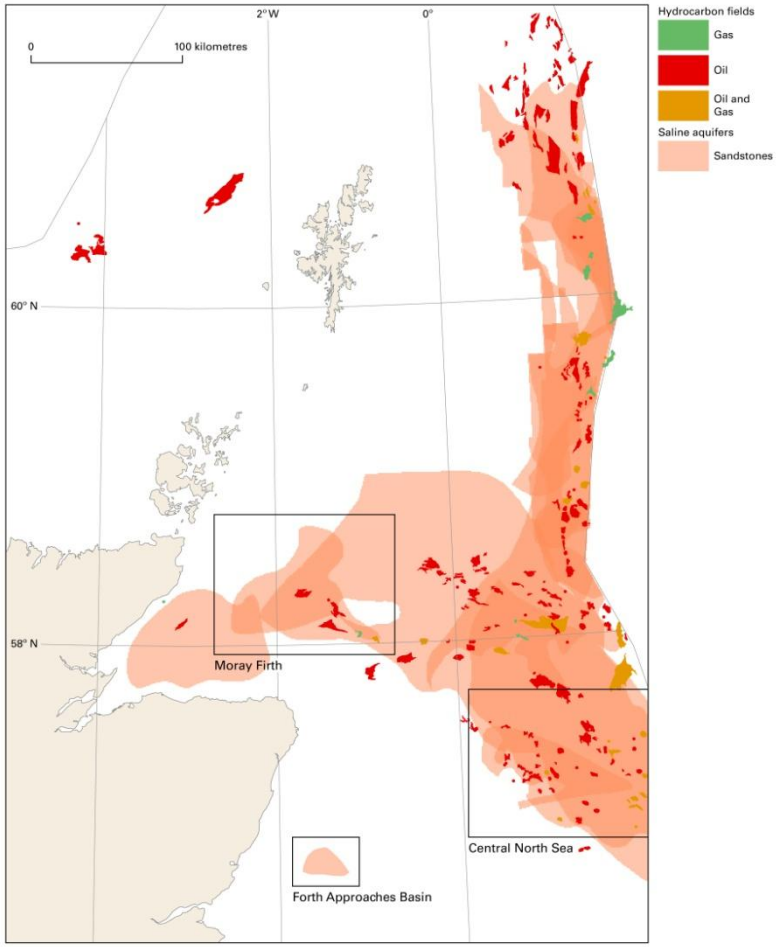
‘Progressing CO_2 storage opportunities around Scotland’

Study objectives

- ‘Pathway’ for CCS in Scotland
- Skills and capacity requirements for a future CCS industry
- A strategy for public communication and engagement for CCS projects in Scotland
- **Investigation of the Captain Sandstone as a potential CO_2 store**
- **British Geological Survey & Heriot-Watt University**

www.sccs.org.uk/expertise/reports.html

Selection of aquifer sites for storage research

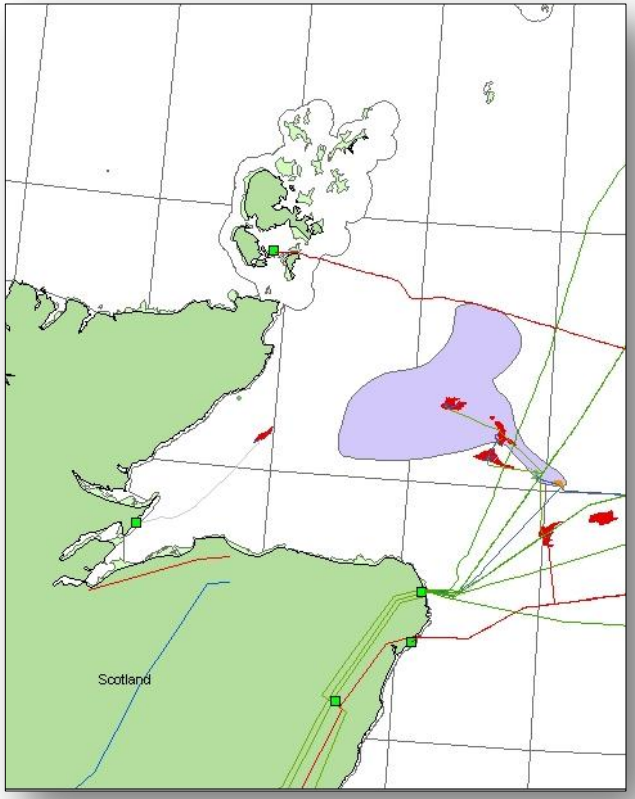


Sandstone extents from UKOOA

- Detailed mapping of individual saline aquifers is necessary to fully scope their CO_2 storage potential
- Reviewed three areas
  - Moray Firth
  - Central North Sea
  - Forth Approaches
- Geological criteria
- Non-geological criteria
  - Close to CO_2 sources;
  - Close to existing pipelines;
  - Presence of hydrocarbon field data
  - Data available within research resources

www.sccs.org.uk/expertise/reports.html

Selection of aquifer sites for storage research



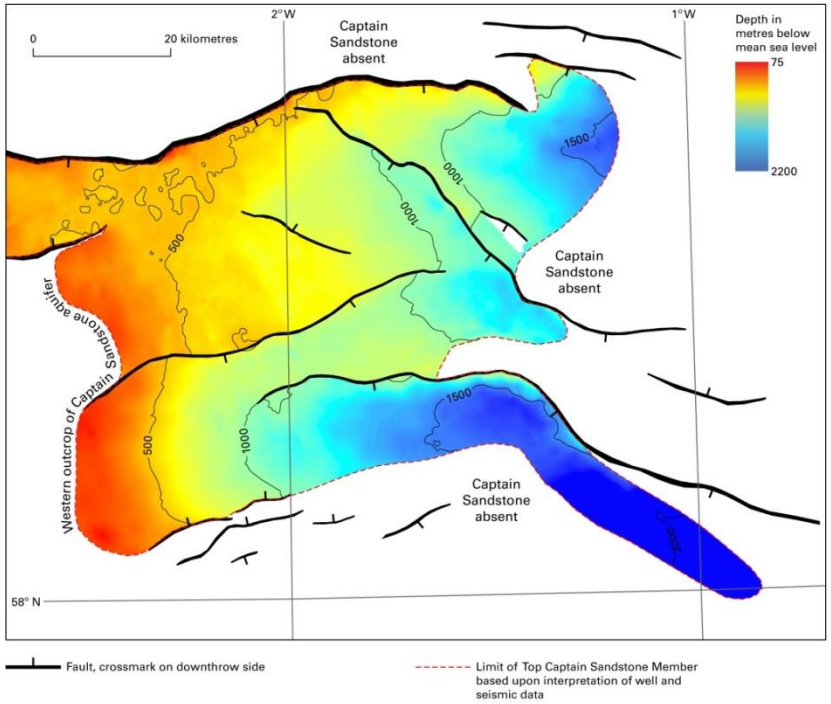
Sandstone extent from UKOOA

- Reviewed three offshore aquifer sandstones
- Selected the Captain Sandstone in Moray Firth
  - Close to CO_2 sources and existing infrastructure, sufficient hydrocarbon field data and available to project.

Site characterisation research

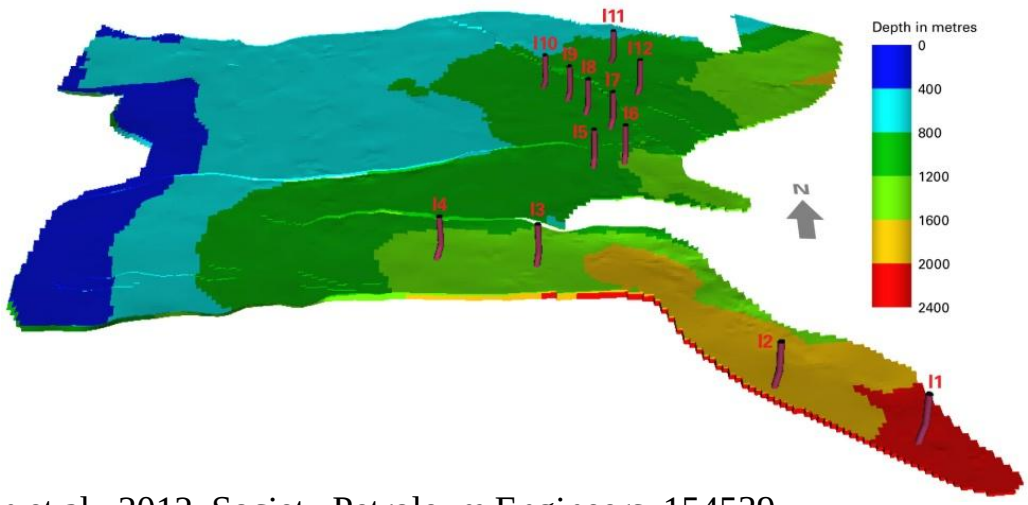
- 3D modelling of the sandstone and its geological attributes
- Simulation of CO_2 injection into the aquifer, assessment of store capacity and predicted migration of injected CO_2

Characterisation of sites for storage research - 3D static geological modelling



- Estimated storage capacity
  - 36 Mt if 0.2% pore volume
  - 363 Mt if 2% pore volume
- Revised mapping of the sandstone
- 3D geological model
- Attribute model cells with sandstone properties
- Selection of injection wells positions for dynamic modelling:
  - Retain CO_2 >800 m depth
  - Avoid localised increases in pressure
  - Avoid oil and gas fields

Characterisation of sites – dynamic modelling of CO_2 injection



Jin et al., 2012, Society Petroleum Engineers, 154539

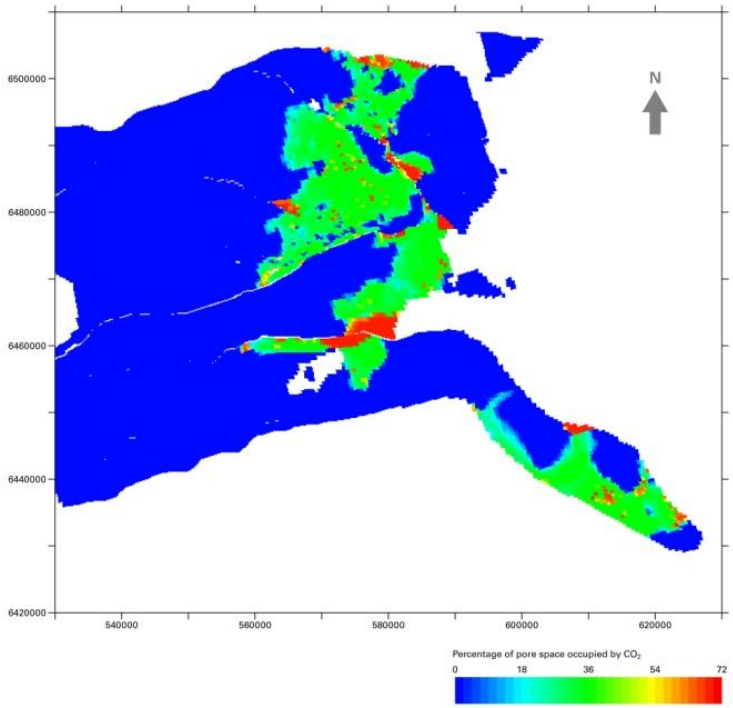
Heriot-Watt University

Injection calculations

- Tested 12 well sites.
- Simulated injection of 2.5 Mt CO_2/year
- Less than a maximum allowed pressure
- Predicted migration 5000 years

- Dynamic modelling endorsed the upper value of previous capacity estimate (up to 363 Mt)
- At least 358 Mt if all boundaries are closed to flow, 0.6% of pore volume
- Up to 1558 Mt (1.5 Gt) if western boundary is open to flow

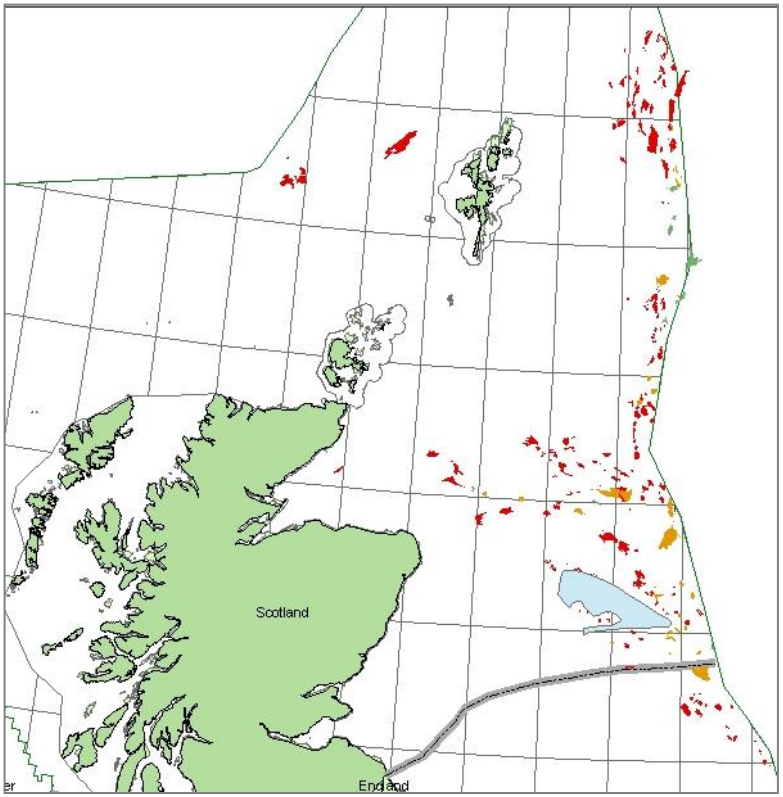
Characterisation of sites – modelled CO_2 migration



Predicted CO_2 saturation, west boundary open, 900 years after injection has ceased

- Migration of injected CO_2 modelled at 12 well sites for 5000 years
- Reached top of sandstone after 5 years and stopped moving after 1000 years
- After 1000 years all CO_2 retained >800 m depth
- Without significant localised pressure increase
- For all wells modelled

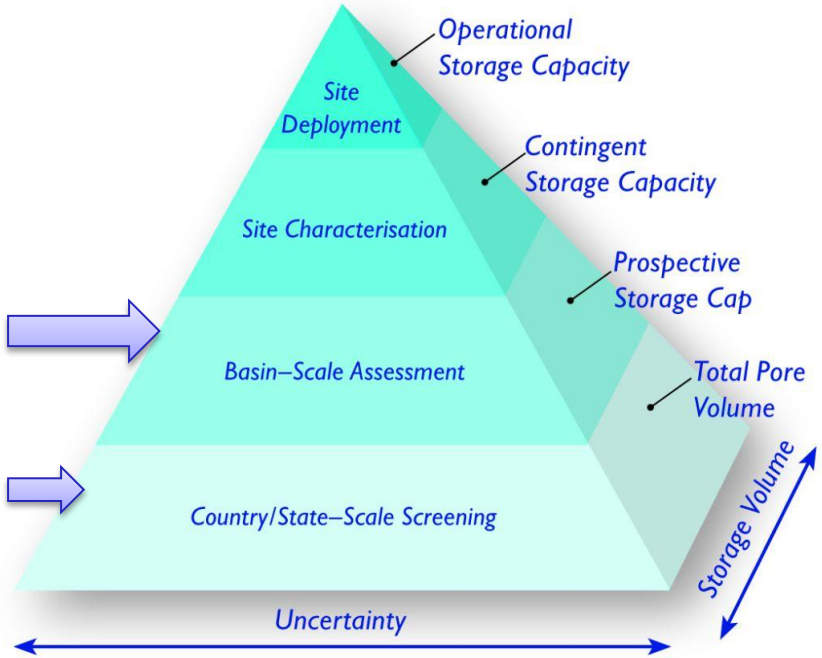
Characterisation of sites – Tay Sandstone, central North Sea



Sandstone extent from UKOOA

- **Estimated storage capacity**
  - 133 Mt if 0.2% pore volume
  - 1328 Mt if 2% pore volume
- **Dynamic modelling**
  - Calculated simulations of CO_2 injection
  - Sandstone boundaries open or closed to fluid flow
- **Endorsement of estimated capacity**
  - 0.4% of pore volume
  - minimum of 155 Mt if boundaries are closed
  - up to 375 Mt if boundaries are open

Characterisation of sites - calculated storage capacities



Moved up the storage pyramid and the expected amount of reduction in storage capacity was not found

- UK CO_2 potential storage capacity mostly within offshore saline aquifer sandstones
- Sandstones are very large but not well known, range of estimated storage capacities
- Site characterisation by static geological modelling and simulation of CO_2 injection
- Two sandstones investigated
- Even if boundaries are closed to flow the calculated storage capacities are bigger than the lowest estimated value

Summary

- UK CO_2 storage in offshore hydrocarbon fields and sandstones
- Screening of potential sites for their suitability for CO_2 storage
  - Used geological and non-geological criteria
  - 204 hydrocarbon fields screened and 29 were suitable
  - 80 sandstones screened and 10 sandstones were shortlisted
- Potential storage capacity is mostly within saline aquifer sandstones
- Sandstones are very large but not as well known as the fields
- Selection of sandstones for storage site research
  - Used geological and non-geological criteria
- Characterisation of two saline aquifer sandstones for storage research
  - Detailed mapping from seismic and well data
  - Construction of 3D model surfaces
  - Attribute cellular model with sandstone properties
  - Calculated storage capacity using dynamic modelling
- Model properties are very important (porosity, permeability, boundaries open/closed to fluid flow)
- Even if boundaries are closed to fluid flow the calculated storage capacities are bigger than the lowest estimated value and much higher if open to flow

“Thank you” for your interest and attention

Any questions?