

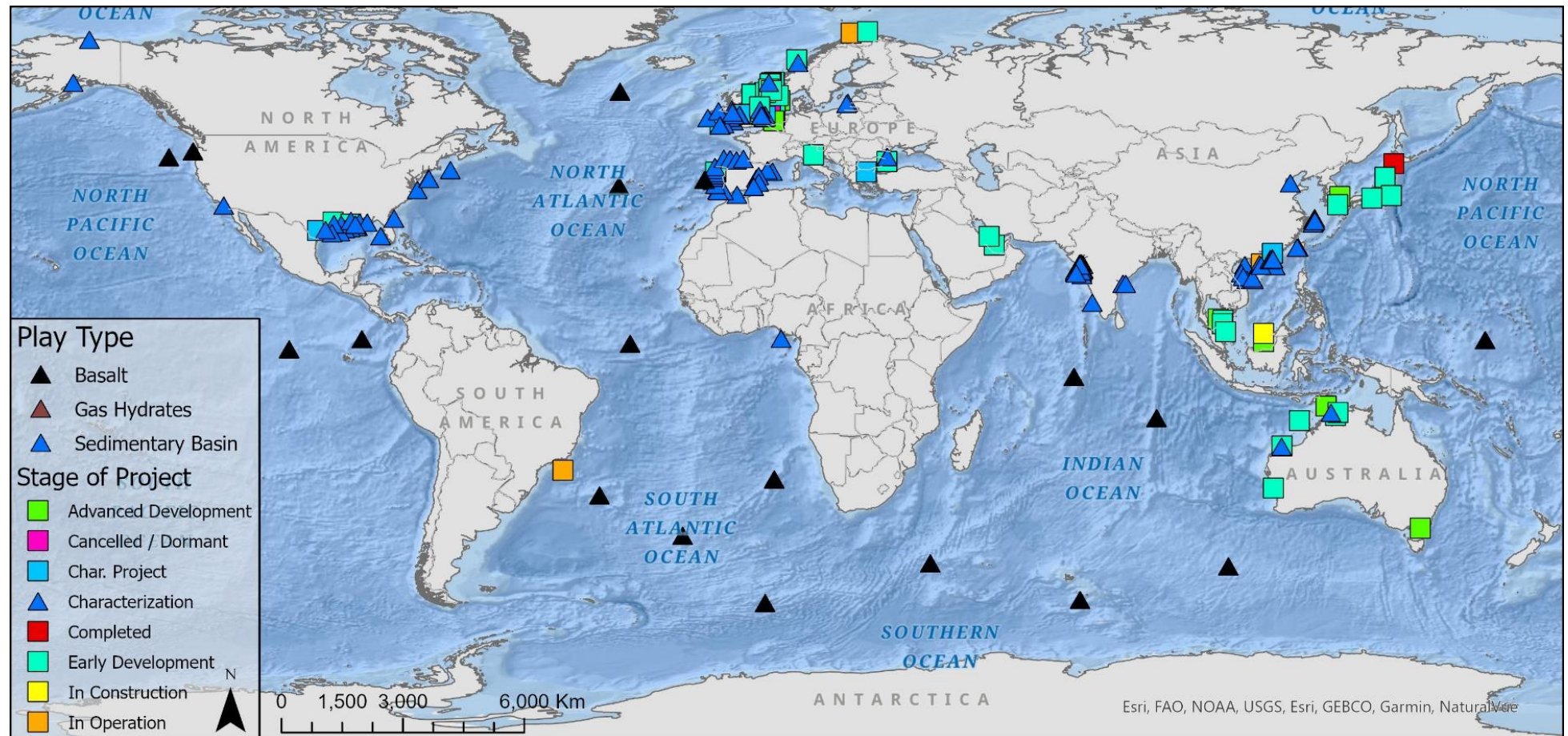
Offshore Geologic Carbon Storage Data Collection and International Project Inventory



Carbon Storage Data FWP, Task 4

Julia Mulhern

Geologist/NETL Support Contractor



**NETL Carbon
Management
Review Meeting**

Aug. 8, 2024

Disclaimer



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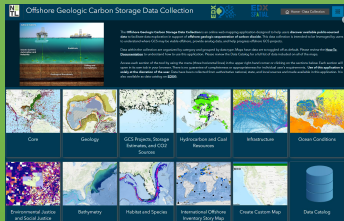
²NETL Support Contractor, 1450 Queen Avenue SW, Albany, OR 97321, USA

Offshore Geologic Carbon Storage (GCS) Products

Variety of Deliverables Launched and Ready to Use

Offshore GCS Data Collection

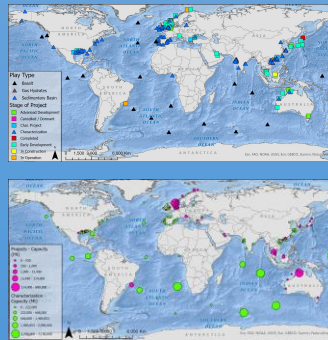
Data Collection Web App



Data Gaps Assessment Report

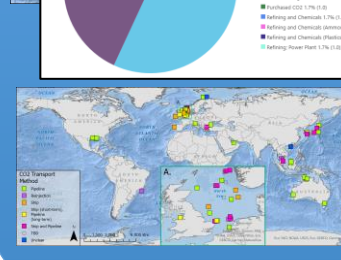
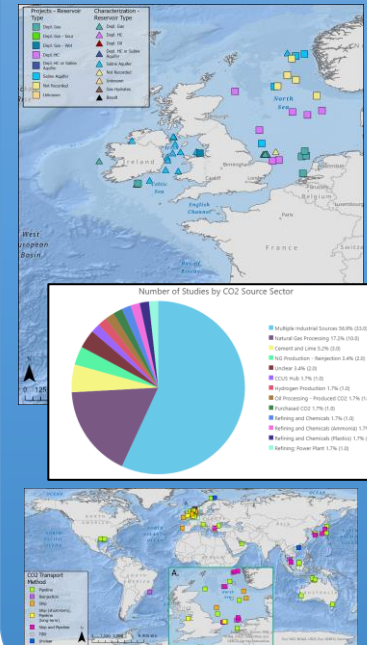


Inventory of Offshore Projects and



International Offshore GCS Inventory

Meta-Analysis of Offshore



Inventory and Global Project Summary



Inventory Story Map



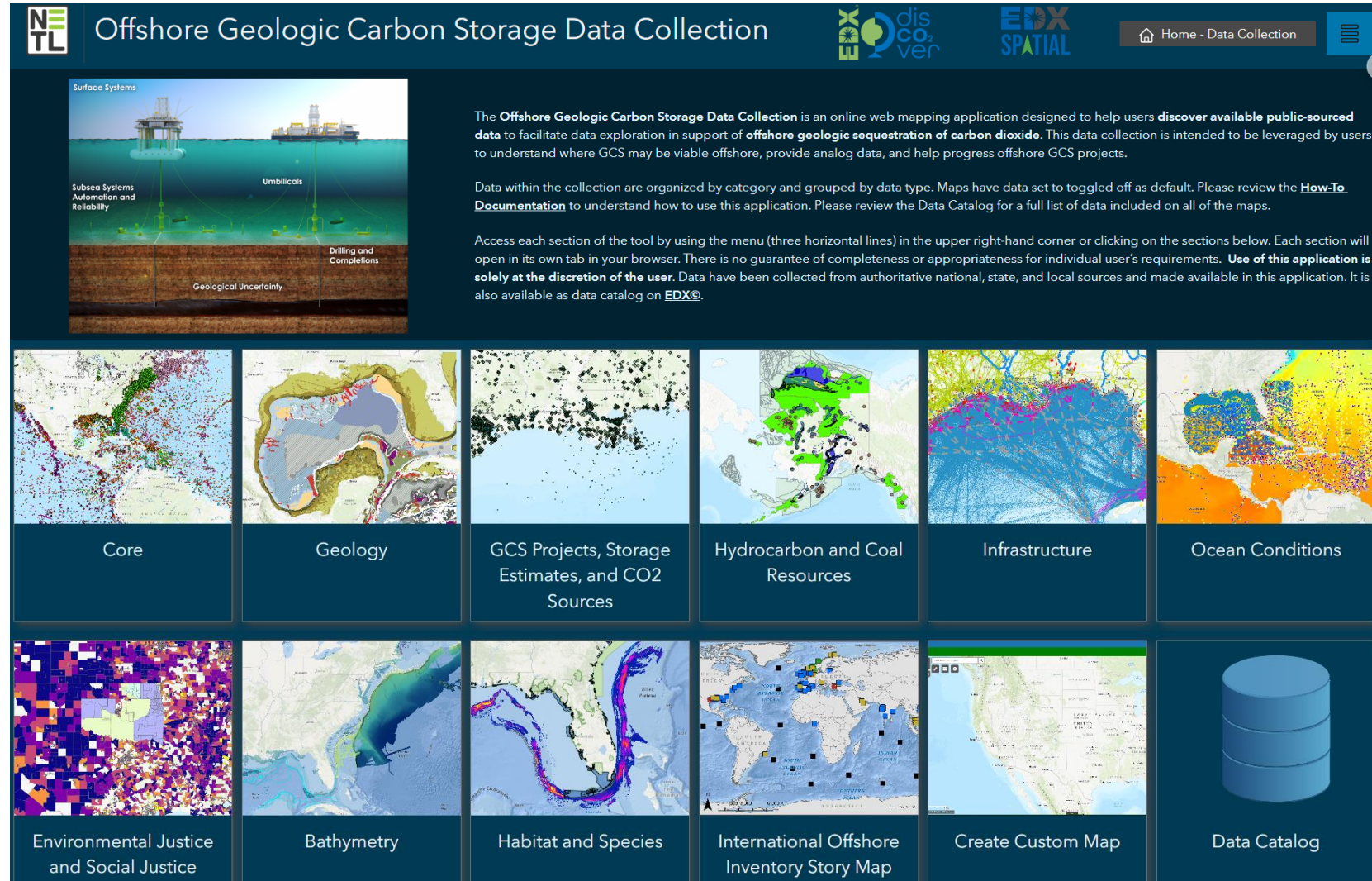
Offshore Geologic Carbon Storage Data Collection

Interactive Web Application to Visualize Novel Data Collection

Nine interactive maps with categorized data

- Data catalog with REST API links which can be downloaded and queried for full data access
- Web app also includes a link to the Offshore Inventory Story Map as well as a link to EDX Spatial custom map development tool

Julia Mulhern, MacKenzie Mark-Moser, Kelly Rose, Offshore Geologic Carbon Storage (GCS) Data Collection Web Application, 5/28/2024, <https://edx.netl.doe.gov/dataset/offshore-geologic-carbon-storage-gcs-data-collection-web-application>, DOI: 10.18141/2367369

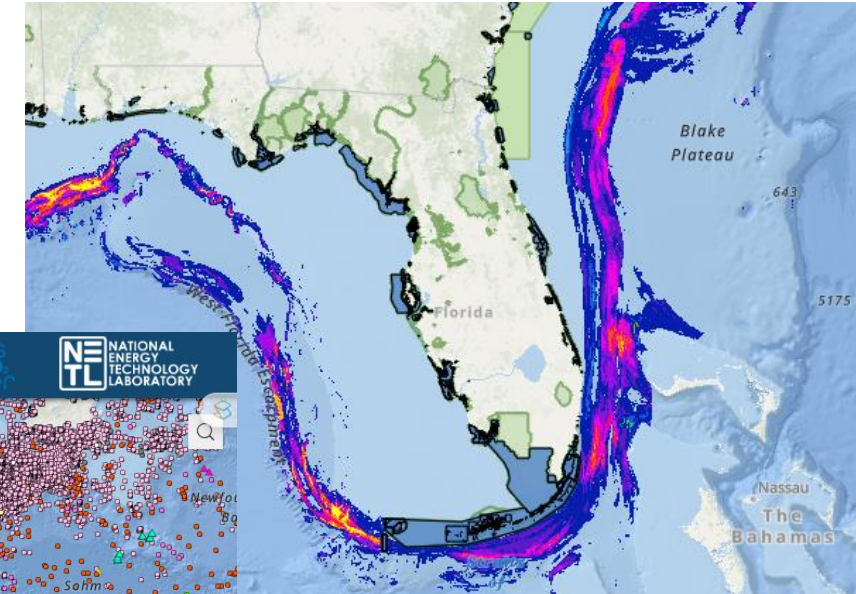
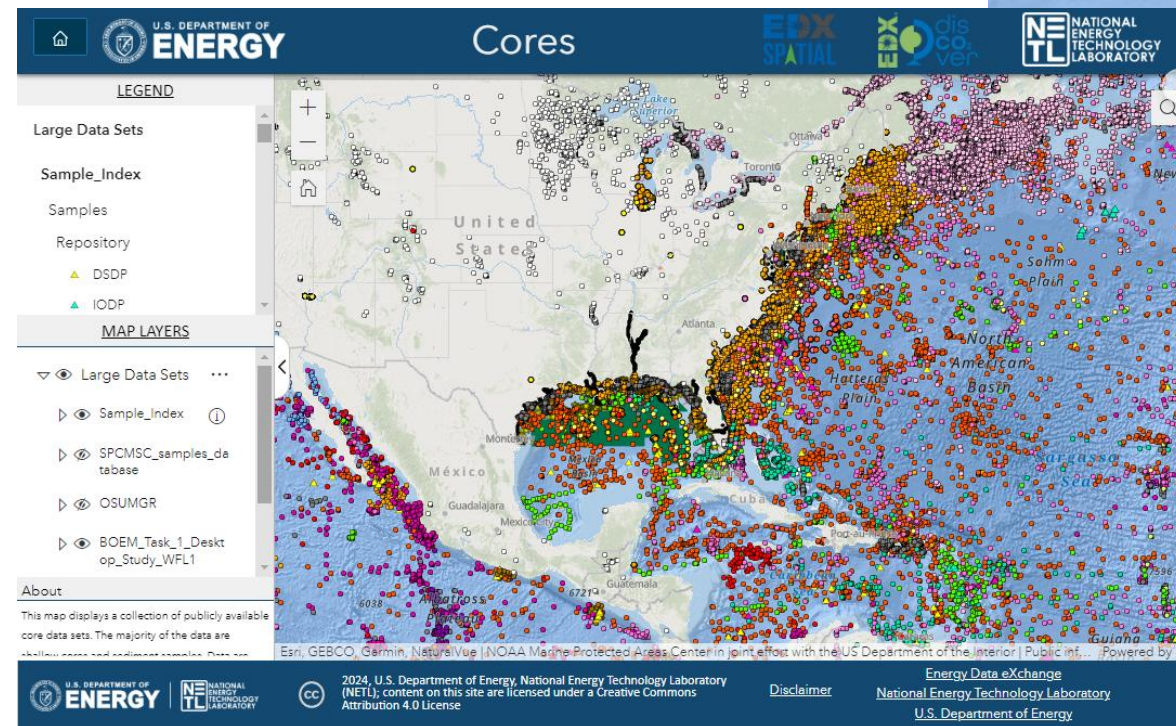


The screenshot displays the web application's interface. At the top, the title "Offshore Geologic Carbon Storage Data Collection" is prominently displayed alongside logos for NETL, EDX, and the Discover EDX Spatial platform. A navigation bar includes a "Home - Data Collection" link and a menu icon. Below the header, a large diagram illustrates the offshore geologic carbon storage process, showing surface systems, subsea systems, umbilicals, drilling and completions, and geological uncertainty. To the right of this diagram, a text block explains the application's purpose: to help users discover available public-sourced data for offshore geologic sequestration of carbon dioxide. It also provides information on data organization, map toggling, and a link to the "How-To Documentation". Below the text, a grid of nine interactive map thumbnails is shown, each with a corresponding label: Core, Geology, GCS Projects, Storage Estimates, and CO2 Sources, Hydrocarbon and Coal Resources, Infrastructure, Ocean Conditions, Environmental Justice and Social Justice, Bathymetry, Habitat and Species, International Offshore Inventory Story Map, and Create Custom Map. A final thumbnail labeled "Data Catalog" features a database cylinder icon.

Interactive Maps Enable Quick Data Visualization

Web Hosted Maps Facilitate Data Access

- Each of the nine web maps have datasets aggregated by topic which can be toggled on and off
- The corresponding database can be used to sort and filter data for all nine maps



Coral Reefs and Fish Habitats

Sediment Cores

Interactive Web Maps Enable Data Visualization

Example showing layer groupings

MAP LAYERS

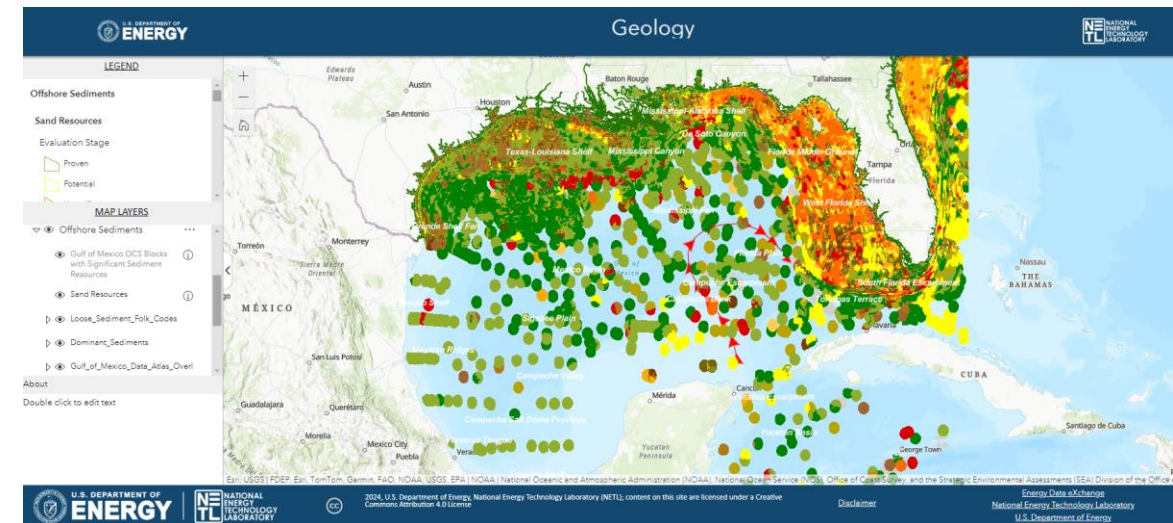
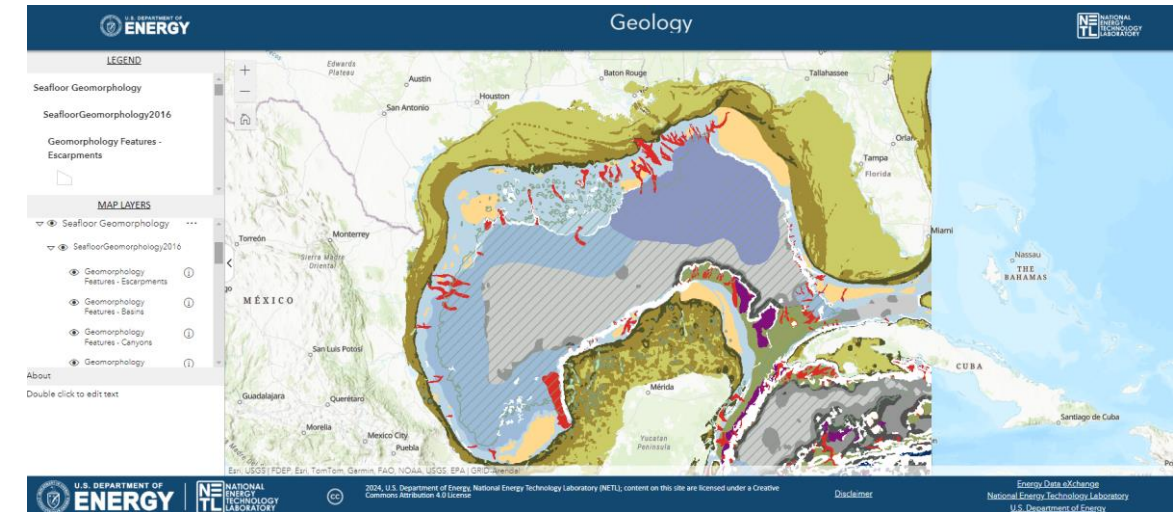
- ▶ Seismic Surveys
- ▶ Subsurface Geology
- ▶ Seafloor Geomorphology
- ▶ Offshore Sediments
- ▶ World Lithology
- ▶ Alaska Geology

MAP LAYERS

- ▼ Seafloor Geomorphology
 - ▼ SeafloorGeomorphology2016
 - Geomorphology Features - Escarpments
 - Geomorphology Features - Basins
 - Geomorphology Features - Canyons
 - Geomorphology

MAP LAYERS

- ▼ Offshore Sediments
 - Gulf of Mexico OCS Blocks with Significant Sediment Resources
 - Sand Resources
 - Loose_Sediment_Folk_Codes
 - Dominant_Sediments
 - Gulf_of_Mexico_Data_Atlas_Ov



Data Collection and Data Availability Report



Technical report which leverages Carbon Storage Technical Viability Approach Matrix as a framework for data gaps assessment by region

- Report documents how the web application was developed, detailing development process



Offshore Geologic Carbon Storage Data Collection and Data Gaps Analysis

30 June 2024



Office of Fossil Energy and Carbon Management
DOE/NETL-2024/4804

Retention and Geomechanical Risk					
Sub-Cat	Components	Gulf of Mexico	Atlantic	Pacific	Alaska
Seals and Pressure	Proven/Demonstrated Effectiveness of Top Seal	Some aggregated well data and regional geologic interpolations of seal properties exist. Included in some interpretations of nationwide datasets.	Understanding of seals limited by sparse drilling and seismic data for the region.		Seals mapped in regions where oil and gas exploration has taken place.
	Top Seal Thickness and Spatial Variability				
	Top Seal Viability, Fracture Pressure, Lithology, Porosity, and Permeability				
	Secondary Confining Unit Presence and Viability				
	Bottom Seal, Downward Flow, and Induced Seismicity				
Trap	Pressure Communication with Reservoir	Aggregated data on traps available. Some information can be garnered from existing hydrocarbon field information.	Limited data on traps for the region based on limited subsurface mapping.		Some information can be garnered from existing hydrocarbon field information.
	Geological Trap Type and Certainty				
Faulting	Trap Viability and Previously Demonstrated Integrity	Mapped faults from USGS. Some earthquake occurrence data aggregated.	Mapped faults from USGS. Some earthquake occurrence data aggregated.	Mapped faults from USGS. Some earthquake occurrence data aggregated.	Mapped faults from USGS. Faults mapped for Alaska included in dataset.
	Fault Presence, Depth, Spacing, Magnitude, Status (Active vs. Inactive)				
	Fracture Type and Density				
	Fault Reactivation Likelihood with Increased Pressure				
	Fault Gouge and Cementation/Fault Seal Viability				
	Earthquake Prevalence and Likelihood				

Mulhern, J. S.; Mark-Moser, M., Rose, K. Offshore Geologic Carbon Storage Data Collection and Data Gaps Analysis; DOE.NETL-2024.4804; NETL Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Albany, OR, 2024; p 24.
<https://doi.org/10.2172/2382659>



Data Gaps Assessment by Region Using CS TVA Matrix

Siting, Regulatory, and Jurisdictional Feasibility

Siting, Regulatory, and Jurisdictional Feasibility					
Sub-Cat	Components	Gulf of Mexico	Atlantic	Pacific	Alaska
Land Rights/ Use	Surface - Land Ownership and Access	Leases and boundaries included in dataset.			
	Subsurface Pore Space Rights				
Population and Habitats	Protected Areas and Sensitive Habitats	Lots of species and habitat data included. Census data available.	Some species and habitat data available. Census data available.		
	Population Density				
Jurisdiction	Jurisdictional Boundaries, Support, and Stability	Maps of tax credit eligibility distribution. County maps by various eligibility labels.			
	Governmental Policies and Incentives				
Regulatory	Maturity of Regulatory Framework	Class VI permit locations and status. Ongoing and historic GCS projects.			
	Maturity of CCS Activity in Area				

Reservoir Suitability

Sub-Cat	Components	Gulf of Mexico	Atlantic	Pacific	Alaska
Reservoir Quality	Reservoir Porosity	Some aggregated well data and regional geologic interpolations for reservoir properties exist, primarily for the Gulf of Mexico.	A limited number of wells (~30) were drilled in the late 1970s and no drilling has taken place since then. Core data available for seafloor sediments.	Drilling data and information for coastal California are limited. Core data available for seafloor sediments.	Extensive well data for oil and gas regions is available. Core data available for seafloor sediments.
	Reservoir Permeability				
	Depositional Environment, Lithology, Grainsize, and Sorting				
	Diagenesis, Grain Scale Deformation, Secondary Alteration, Reservoir Fractures				
Reservoir Geometry	Reservoir Thickness Distribution, Spatial Extent, and Lateral Variability	Some mapped extent layers and interpreted well data exist with limited coverage. Seismic datasets are available. Some depth to reservoir top layers included.	Limited to no information available.	Data status uncertain but no data included in current collections.	Data likely exist are not currently included in collection.
	Reservoir Internal Variability, Geobody Architecture, and Net-to-Gross				
	Depth to Top of Formation				
Reservoir Conditions	Reservoir Temperature	Some aggregated well data and regional geologic interpolations for reservoir properties exist, primarily for the Gulf of Mexico.	Limited to no information available.	Data status uncertain but no data included in current collections.	Data likely exist are not currently included in collection.
	Reservoir Pressure				
	In-situ Fluids, Salinity, and CO ₂ Density				

Data Gaps Assessment by Region using CS TVA Matrix

Environmental Justice, Social Justice, and Community Impacts

Sub-Cat	Components	Gulf of Mexico	Atlantic	Pacific	Alaska
Community Sentiment	Community Familiarity with Drilling Process	Social well-being and vulnerability data available. Maps of county types. Some information within publications available.	Nationwide Environmental Justice and Social Justice census datasets available; localized data on carbon storage impacts unknown.		
	Community Attitude Toward Industrial Development				
	Community Attitude Toward Climate Change and Net Zero Ambitions				
	Community Cohesiveness and Jurisdiction Authority				
Impact on Community	Environmental Impact of Operations	Existing infrastructure data available. Some pollution datasets available. Economics and trade data available.	Nationwide Environmental Justice and Social Justice and census datasets available; localized data on carbon storage impacts unknown.		
	Infrastructure and Resource Impacts				
	Workforce Development and Job Creation				

	Data are available
	Insufficient data available
	Limited or no data available within current collection.

Hazards

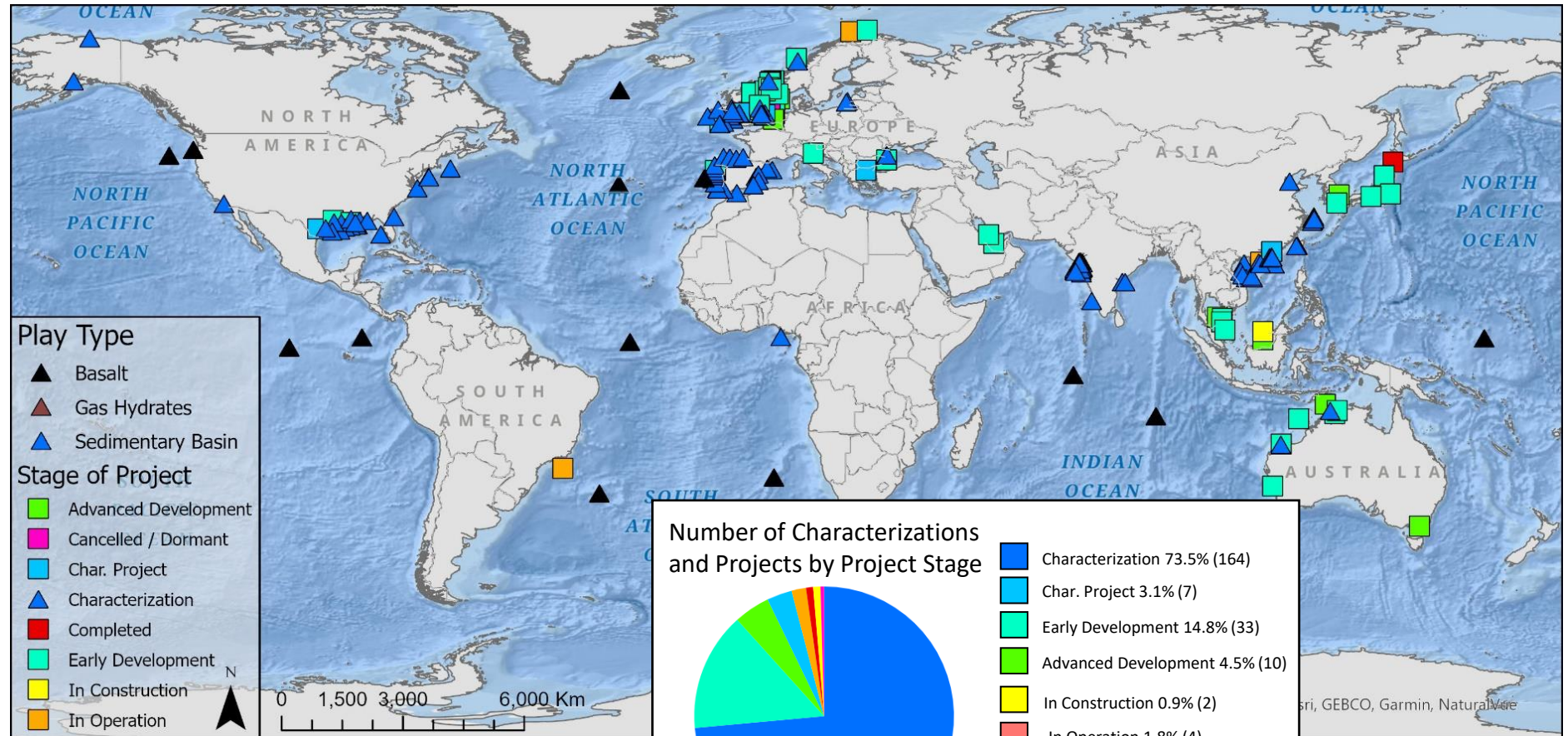
Hazards					
Sub-Cat	Components	Gulf of Mexico	Atlantic	Pacific	Alaska
Subsurface Hazards	Overburden Drilling Hazards	Some geologic layers are mapped and included. Overburden hazards can be interpreted from seismic.	Limited drilling has taken place in the region therefore subsurface hazards are relatively unconstrained.	Subsurface hazards are understood where drilling has taken place but more information is needed for unexplored areas.	Some geologic layers are mapped and included. Overburden hazards can be interpreted from seismic.
	Pre-existing Well Density, Depths, and Ages				
Surface Hazards	Depth and Certainty of Drinking Water Aquifers in Overburden	Hurricane paths available for the Gulf of Mexico. Wind speed data are included. Seafloor geomorphology and offshore sediments data available. Multiple types of infrastructure layers are available.	Multiple types of infrastructure layers are available.		
	Water Depth (if offshore)				
	Topography or Location Risks				
	Climate, Weather, and Met-ocean				
	Natural Hazards - Land Surface or Seafloor Hazards				
	Infrastructure Hazards				

NETL's Offshore Geologic Carbon Storage Inventory

Updated Global Project Inventory

International projects,
sites, and
characterizations

- Extensive review for >200 locations globally
- Support analog analysis (**reservoir type, CO₂ transportation and sources, project stages, regulations**)



National Energy Technology Laboratory, Offshore Geologic Carbon Storage Inventory, 9/18/2023, <https://edx.netl.doe.gov/dataset/offshore-gcs-data-inventory>, DOI: 10.18141/1963815

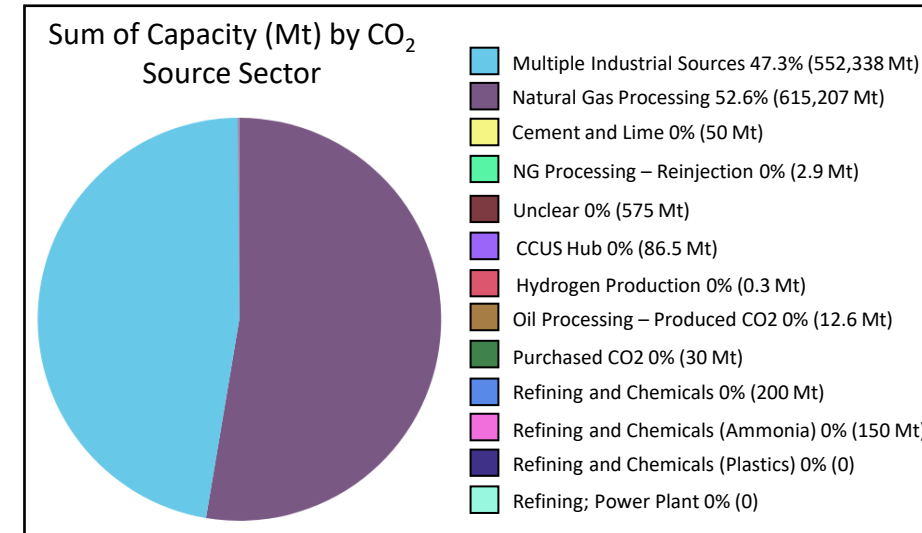
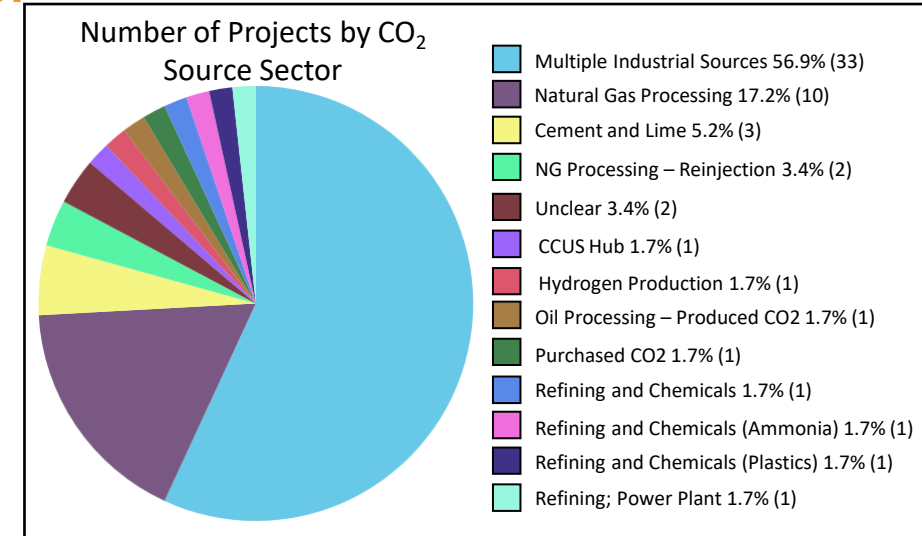
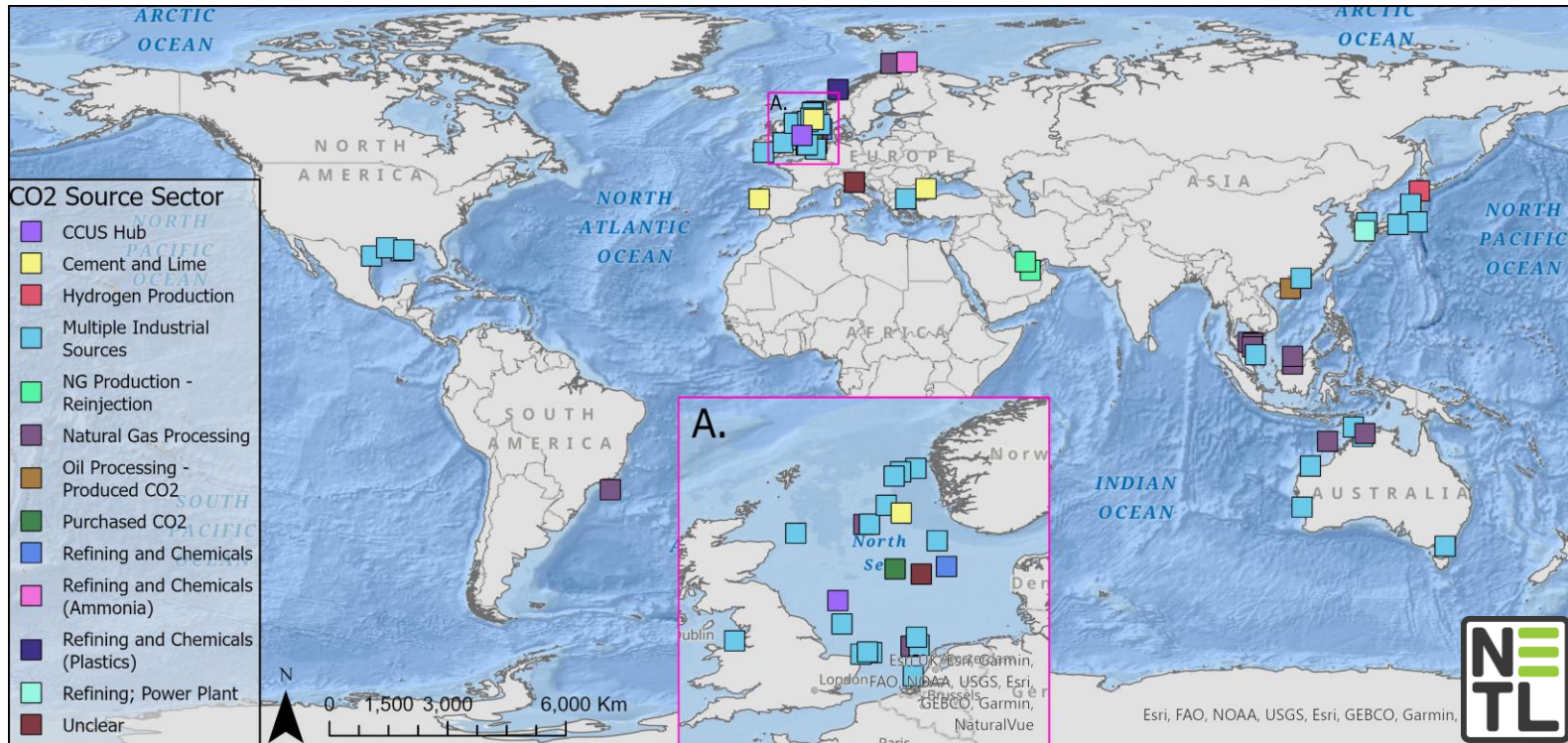


Meta-Analysis Example

Global Offshore GCS Projects by CO₂ Emission Source Sector

Expanded attribute fields within inventory enables meta-analysis

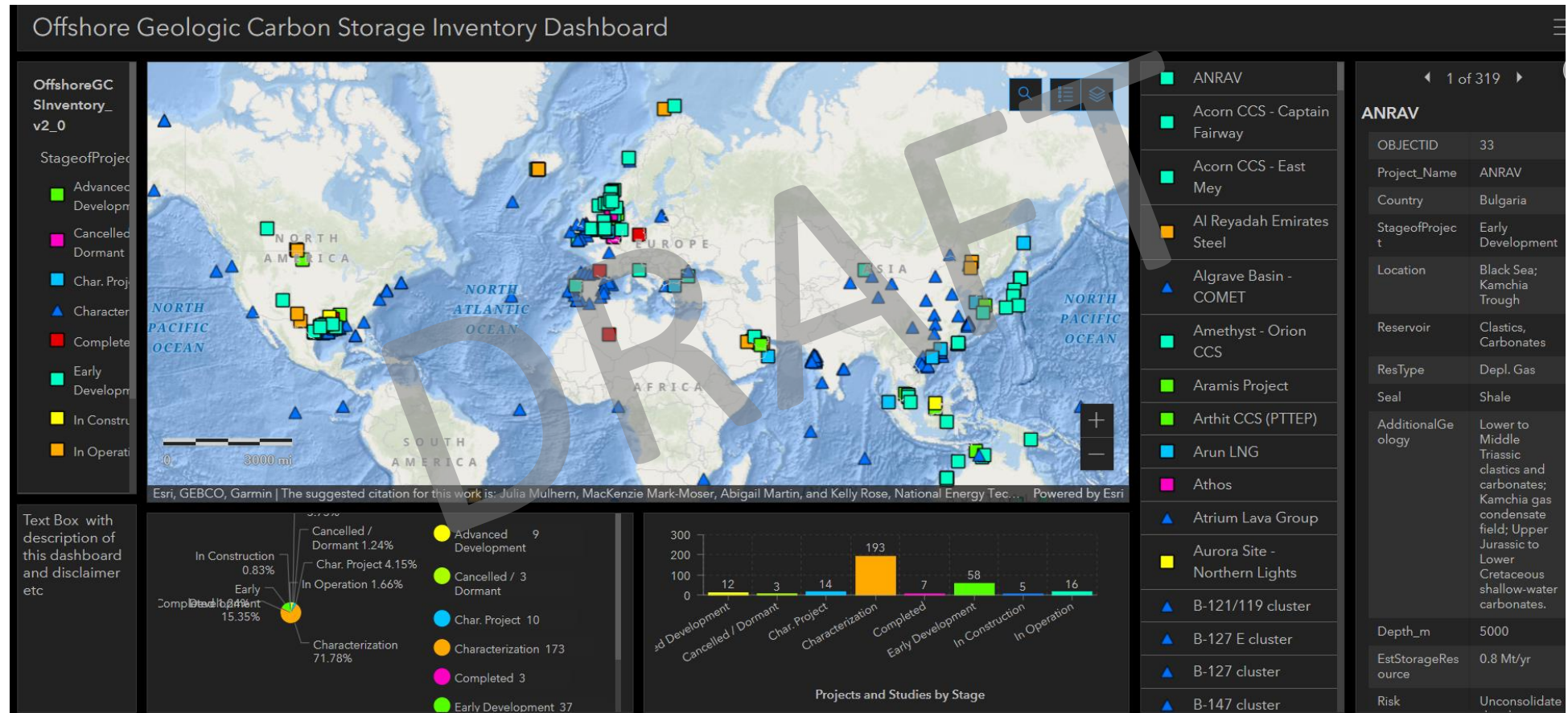
- Symbolizing and summarizing projects by characteristics allows shows distributions by various attributes
- Dashboard development ongoing



Upcoming Interactive Dashboard for Inventory

Dashboard will Enable Exploration of Inventory Using a Variety of Attributes

- Inventory will be published as an ArcGIS Enterprise layer with a REST API service link to allow access to an evergreen inventory version
- Attribute fields will be used to generate graphics with scale with map displays for easy usability



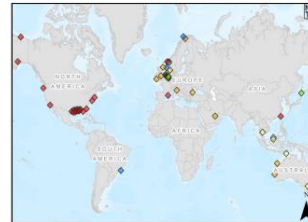
Offshore GCS StoryMap and Scoping Review Report

- **Story Map** provides review of global offshore GCS characterizations and operations, communicating progress, stages, locations
- **Report** summarizes global scoping and includes project descriptions and extensive references



Country	Offshore Projects	Characterization	Early Development	Advanced Development	In Construction	In Operation	Completed
United States	20	19	1				
Netherlands	3		1	1			1
Japan	1						1
Norway	6	1	2		1	2	
Brazil	1					1	
Malaysia	2			1	1		
United Kingdom	3		2	1			
Australia	3		2	1			
Denmark	2		1	1			
Thailand	1			1			
Timor-Leste	1			1			
Ireland	1		1				
Italy	1		1				
Bulgaria	1		1				
United Arab Emirates	1		1				
Spain	1	1					
Taiwan Province of China	1	1					

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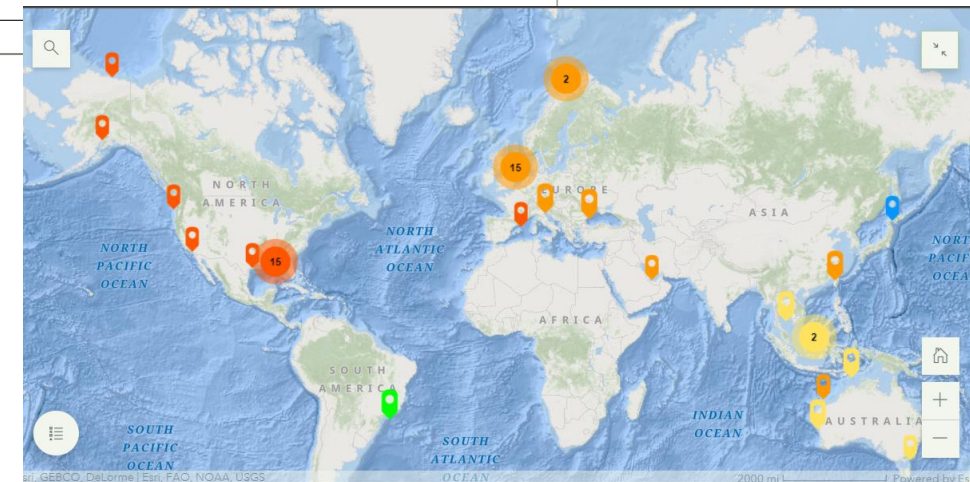


Scoping Review of Global Offshore
Geologic Carbon Storage Activities

5 December 2023



Office of Fossil Energy and
Carbon Management
DOE/NETL-2024/4798



Abigail C. Choisser, MacKenzie Mark-Moser, Julia Mulhern, Kelly Rose,
International Offshore Geologic Carbon
Storage Story Map, 9/22/2023,
<https://edx.netl.doe.gov/dataset/offshore-geologic-carbon-storage-story-map>, DOI: 10.18141/1995986

Carbon Storage Data FWP, Task 4.0: Data Science for Offshore CCS

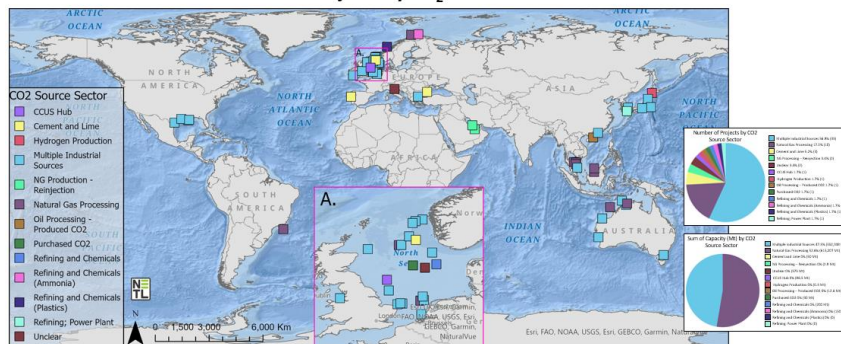
2022	2023	2024	Value (2022–2024)
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- Compilation of key data resources on information supporting offshore CCS including geologic setting, infrastructure, policy
- Comprehensive, up-to-date review of international CCS efforts
- Update and integrate available data into U.S. Offshore CCS evaluations
- Compile and release U.S. offshore CCS catalog and inventory
- Integrate additional data released from ongoing research and release U.S. offshore CCS open resource data collection
- Created web app in lieu of database for greater accessibility
- Share findings and products with stakeholders

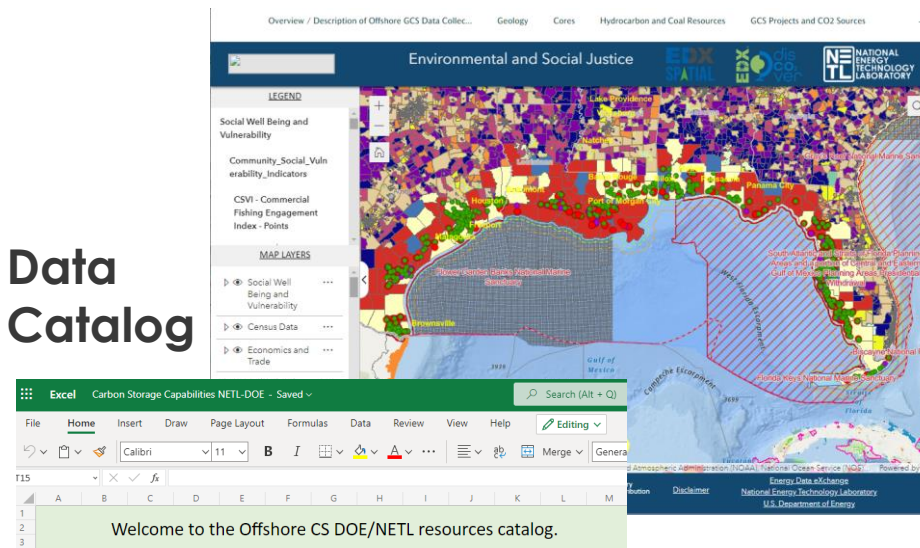
End Product:
Accessible data collections covering both international CCS project products and data for **potential U.S. Offshore CCS**, accompanied by web user interfaces and technical reports **summarizing global offshore CCS efforts** to date

Inventory

Global Offshore GCS Projects by CO₂ Emission Source Sector



Data Catalog



Web App

List of References Related to this Project



Offshore GCS Data Collection Web App and Data Gaps Assessment:

Mulhern, J.S., Mark-Moser, M., and Rose, K. Offshore Geologic Carbon Storage (GCS) Data Collection

Web Application, 5/28/2024, <https://edx.netl.doe.gov/dataset/offshore-geologic-carbon-storage-gcs-data-collection-web-application> DOI: 10.18141/2367369

Mulhern, J.S., Mark-Moser, M., and Rose, K., 2024. Offshore Geologic Carbon Storage Data Collection and Data Gaps Analysis. DOE.NETL-2024.4804; NETL Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Albany, OR, 2024; p 24. <https://doi.org/10.2172/2382659> <https://edx.netl.doe.gov/dataset/offshore-geologic-carbon-storage-data-collection-and-data-gaps-analysis-trs-report>

Offshore GCS Inventory:

National Energy Technology Laboratory, Offshore Geologic Carbon Storage Inventory, 9/18/2023,

<https://edx.netl.doe.gov/dataset/offshore-gcs-data-inventory>, DOI: 10.18141/1963815

Choisser, A.C., Mark-Moser, M., Mulhern, J.S., and Rose, K. International Offshore Geologic Carbon Storage Story Map. United States: N. p., 2023. Web. doi:10.18141/1995986. <https://edx.netl.doe.gov/dataset/offshore-geologic-carbon-storage-story-map>

Choisser, A.; Mark-Moser, M.; Mulhern, J.; Rose, K. Scoping Review of Global Offshore Geologic Carbon Storage Activities; DOE.NETL-2024.4798; NETL Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Albany, OR, 2023; p 80. DOI: 10.2172/2279183 <https://edx.netl.doe.gov/dataset/scoping-review-of-global-offshore-geologic-carbon-storage-activities>

This talk:

Mulhern, J.S., Mark-Moser, M., and Rose, K. International Offshore Geologic Carbon Storage Data Collection, Web Application, Inventory, and Meta-analysis. 2024 FECM / NETL Carbon Management Research Project Review Meeting. Pittsburgh, PA. August 5-9, 2024. *Oral presentation*

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