

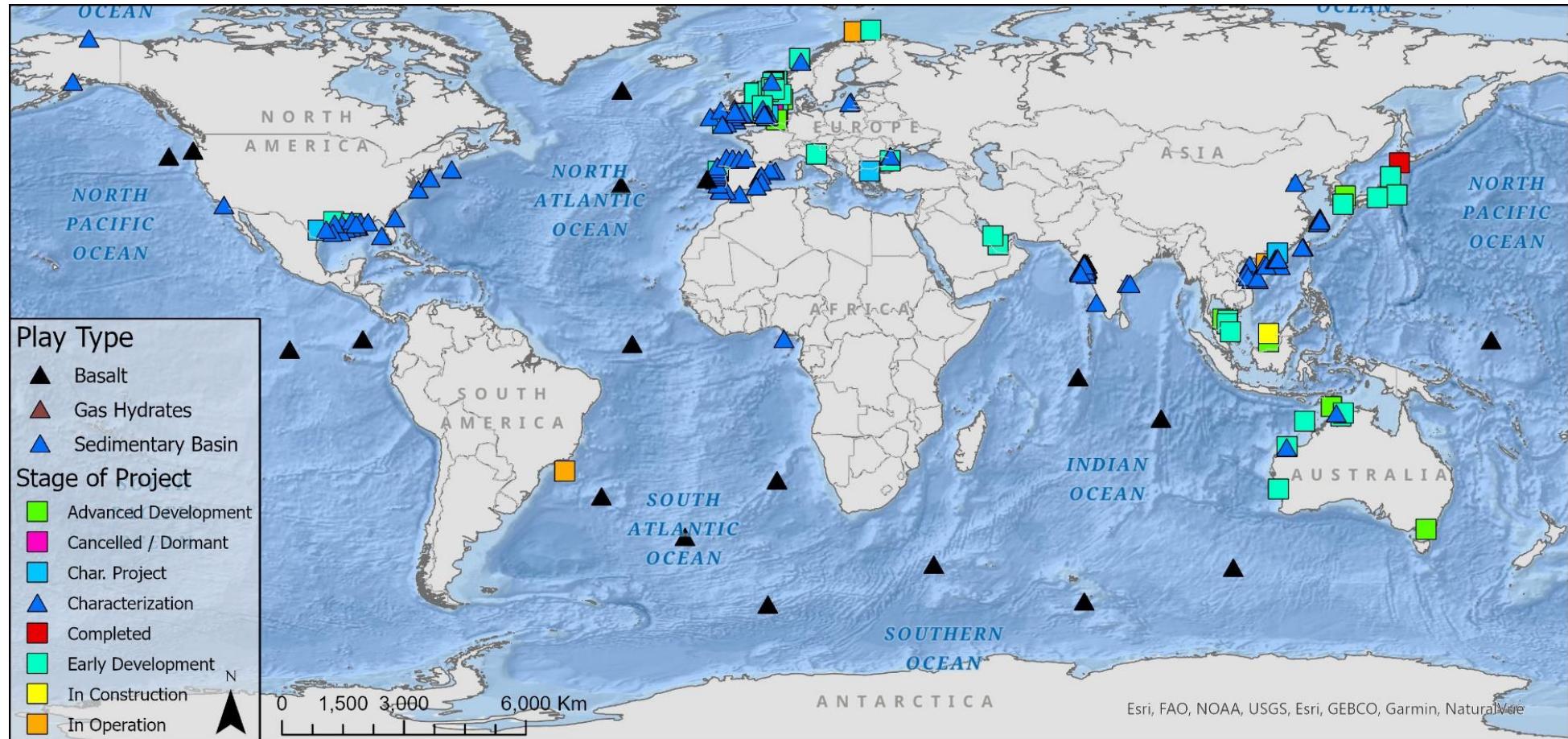
Offshore Geologic Carbon Storage Data Collection and International Project Inventory



Carbon Storage Data FWP, Task 4

Julia Mulhern

Geologist/NETL Support Contractor



Disclaimer



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Authors and Contact Information



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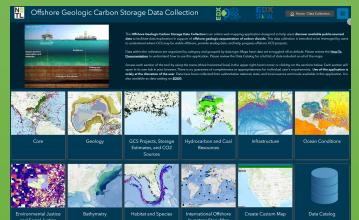
Offshore Geologic Carbon Storage (GCS) Products

Variety of Deliverables Launched and Ready to Use



Offshore GCS Data Collection

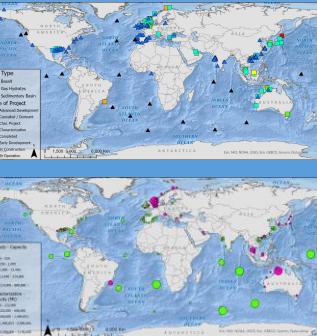
Data Collection Web App



Data Gaps Assessment Report

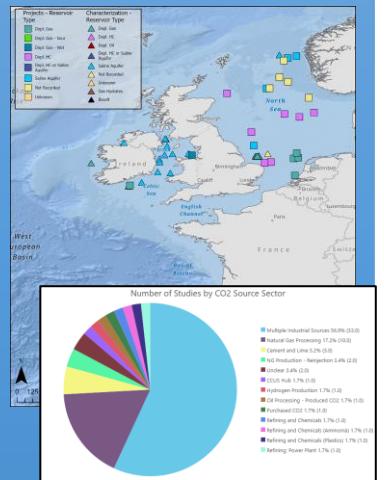


Inventory of Offshore Projects and

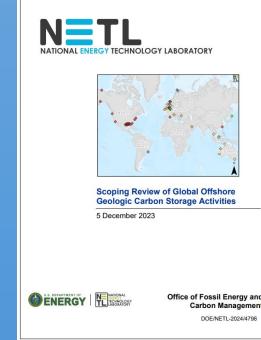


International Offshore GCS Inventory

Meta-Analysis of Offshore



Inventory and Global Project Summary



Inventory Story Map



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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

The Offshore Geologic Carbon Storage Data Collection is an online web mapping application designed to help users discover available public-sourced data to facilitate data exploration in support of offshore geologic sequestration of carbon dioxide. This data collection is intended to be leveraged by users to understand where GCS may be viable offshore, provide analog data, and help progress offshore GCS projects.

Data within the collection are organized by category and grouped by data type. Maps have data set to toggled off as default. Please review the [How-To Documentation](#) to understand how to use this application. Please review the Data Catalog for a full list of data included on all of the maps.

Access each section of the tool by using the menu (three horizontal lines) in the upper right-hand corner or clicking on the sections below. Each section will open in its own tab in your browser. There is no guarantee of completeness or appropriateness for individual user's requirements. Use of this application is solely at the discretion of the user. Data have been collected from authoritative national, state, and local sources and made available in this application. It is also available as data catalog on EDX®.

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



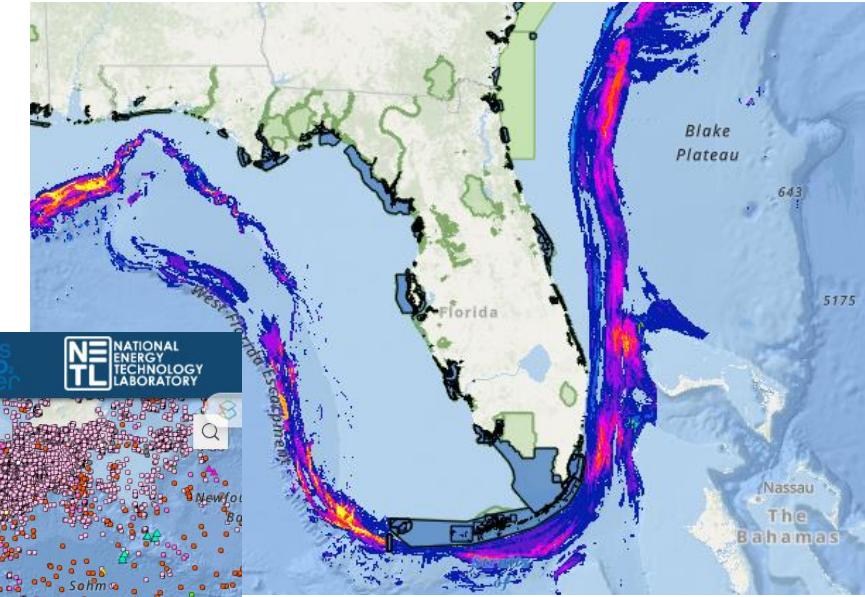
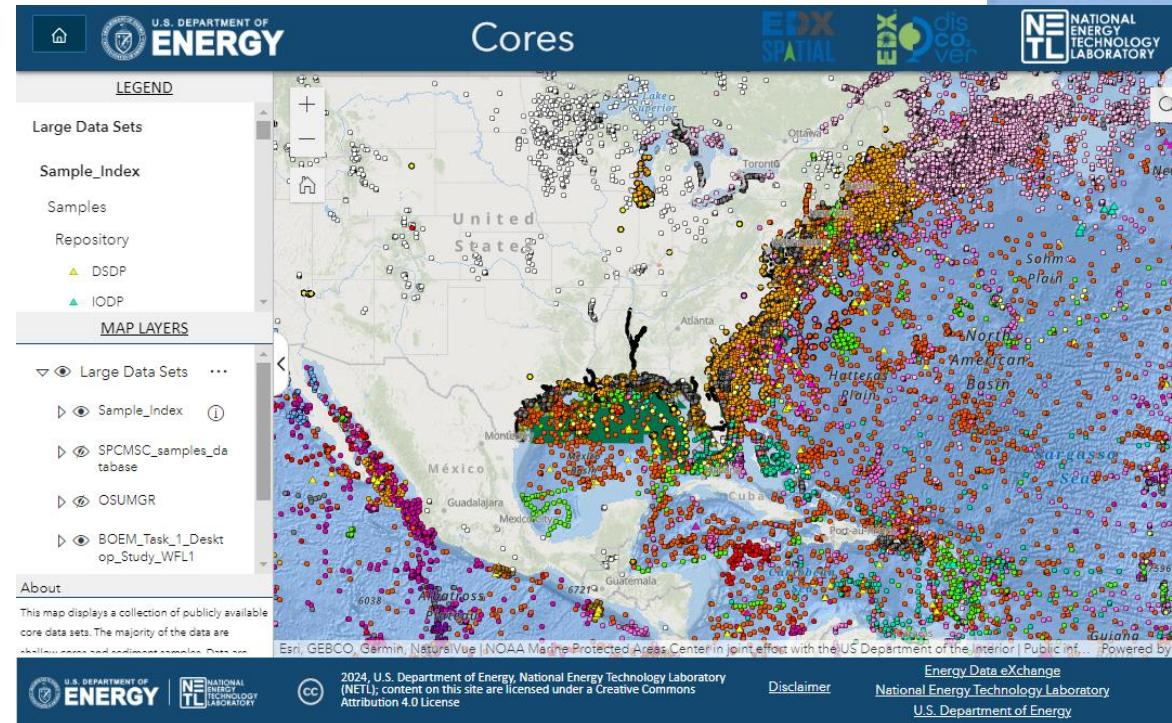
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Interactive Maps Enable Quick Data Visualization



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



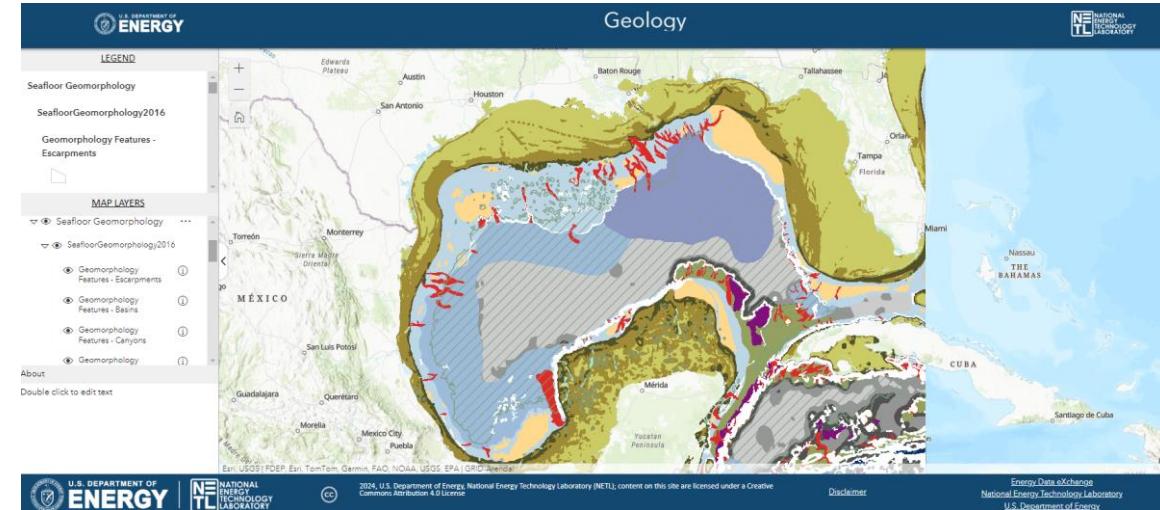
Example showing layer groupings

MAP LAYERS

- ▷ ⓘ Seismic Surveys
- ▷ ⓘ Subsurface Geology
- ▷ ⓘ **Seafloor Geomorphology**
- ▷ ⓘ Offshore Sediments
- ▷ ⓘ World Lithology
- ▷ ⓘ Alaska Geology

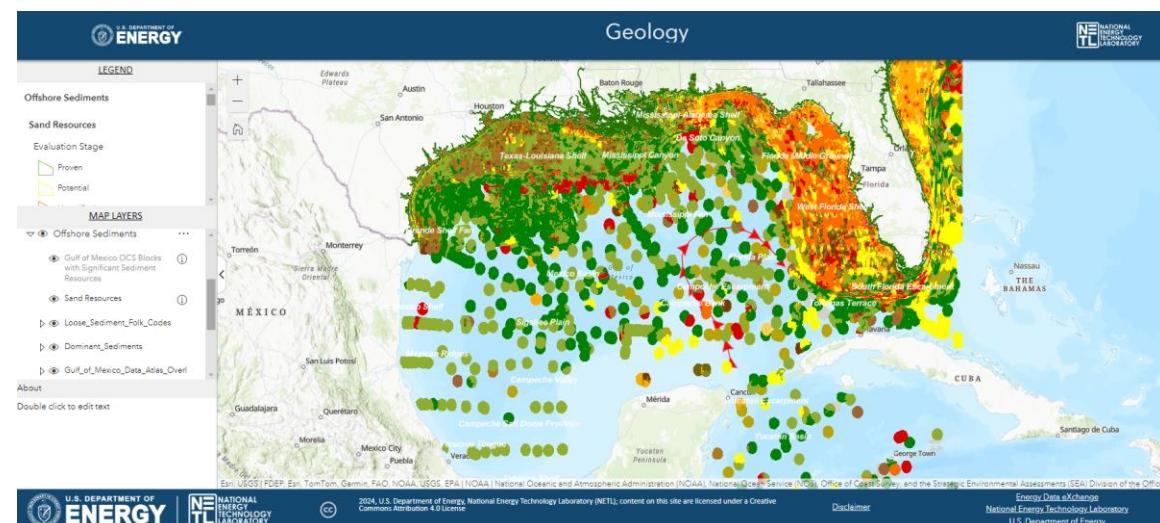
MAP LAYERS

- ▷ ⓘ 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

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Offshore Geologic Carbon Storage Data Collection and Data Gaps Analysis

30 June 2024

U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Office of Fossil Energy and Carbon Management

DOE/NETL-2024/4804

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>



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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				
	Pressure Communication with Reservoir				
Trap	Geological Trap Type and Certainty	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.	
	Trap Viability and Previously Demonstrated Integrity				
Faulting	Fault Presence, Depth, Spacing, Magnitude, Status (Active vs. Inactive)	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.	
	Fracture Type and Density				
	Fault Reactivation Likelihood with Increased Pressure				
	Fault Gouge and Cementation/Fault Seal Viability				
	Earthquake Prevalence and Likelihood				

Data Gaps Assessment by Region Using CS TVA Matrix



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				

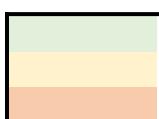
Reservoir Suitability					
Sub-Cat	Components	Gulf of Mexico	Atlantic	Pacific	Alaska
Reservoir Quality	Reservoir Porosity	Some aggregated well data and regional geologic interpolations for reservoir properties exist, primarily for the Gulf of Mexico.	A limited number of wells (~30) were drilled in the 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					
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



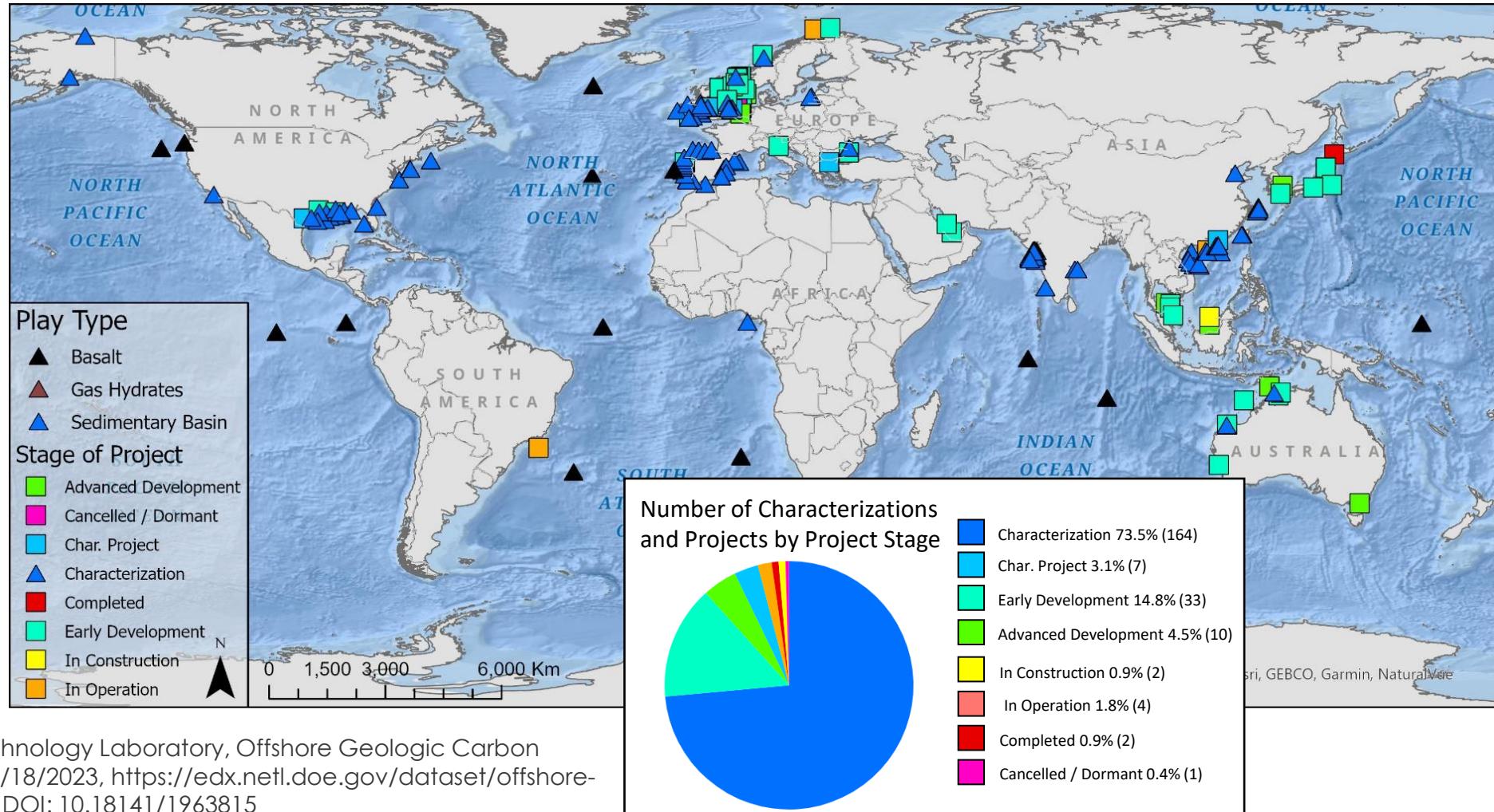
Updated Global Project Inventory

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

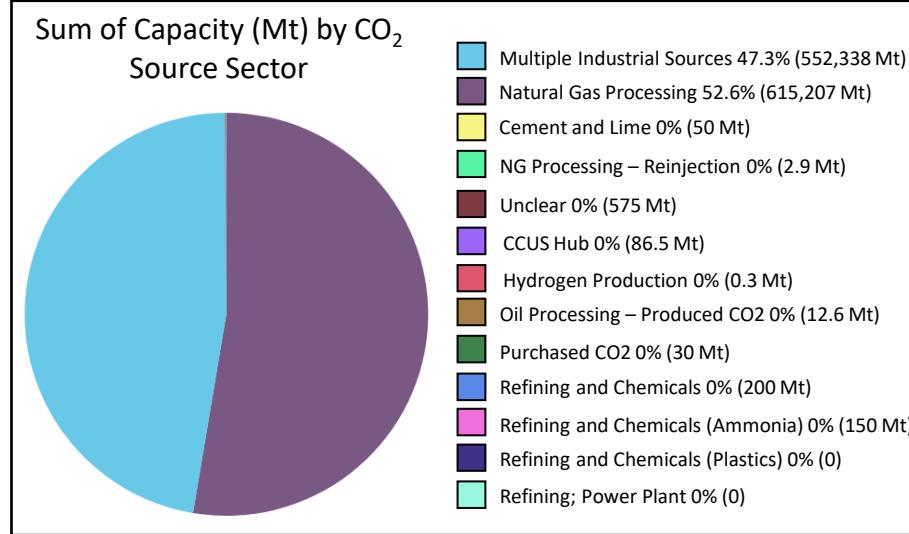
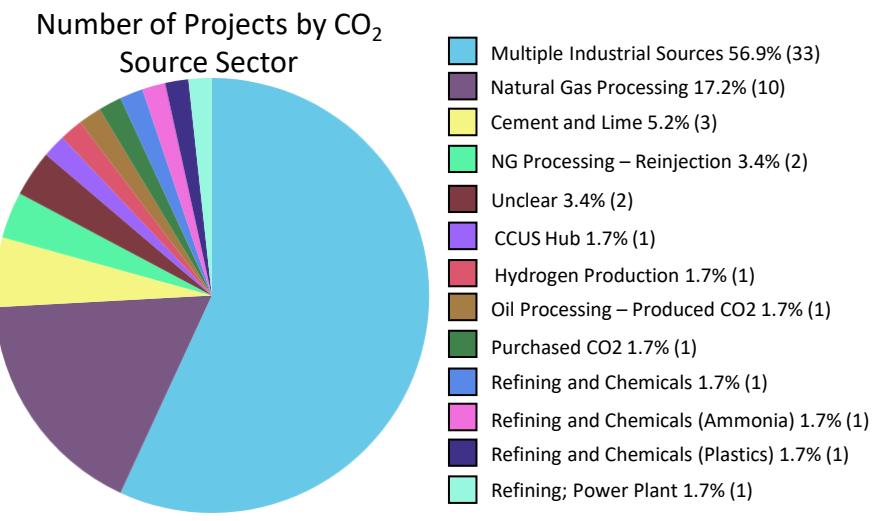
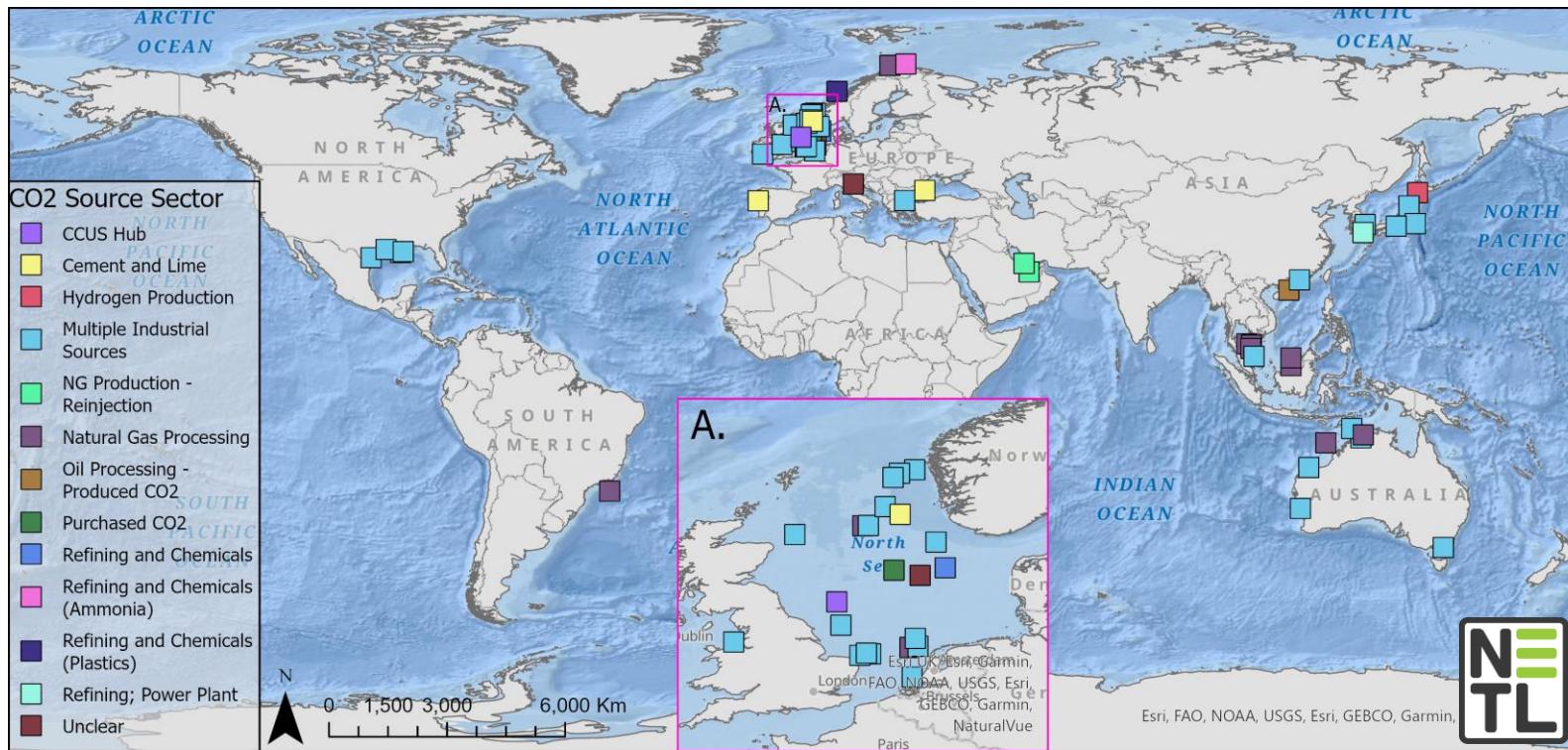


Meta-Analysis Example

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

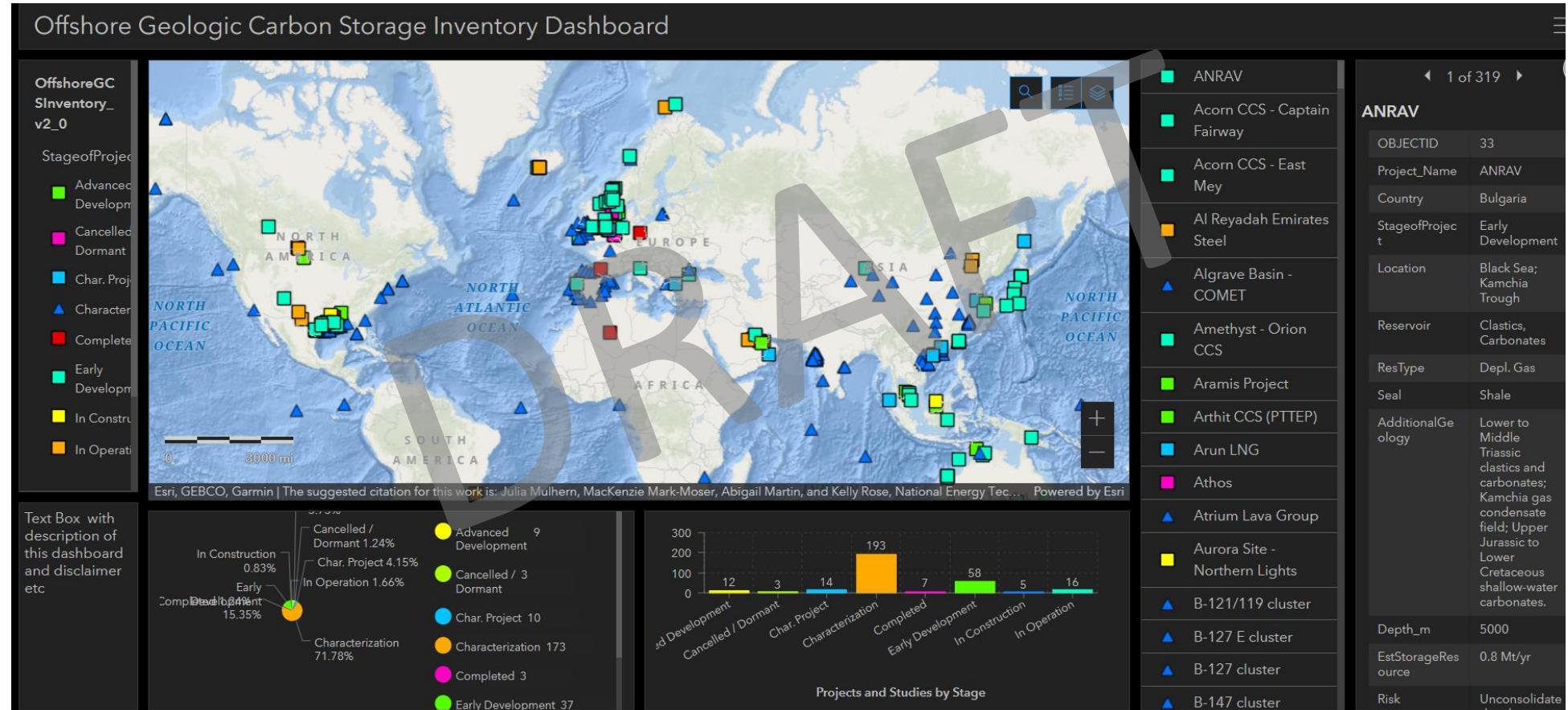


Upcoming Interactive Dashboard for Inventory

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

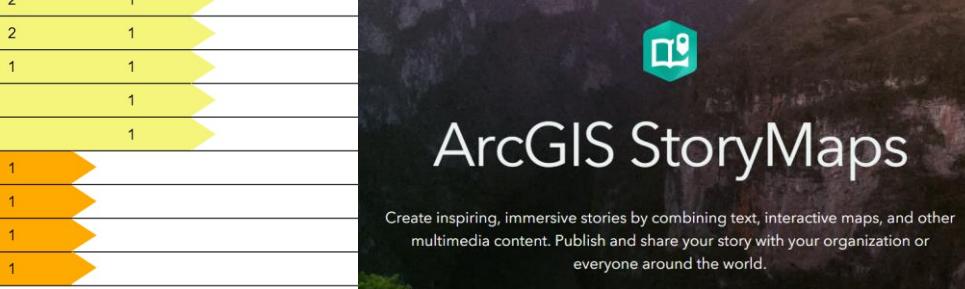
Scoping Review of Global Offshore Geologic Carbon Storage Activities
5 December 2023

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



NETL	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					



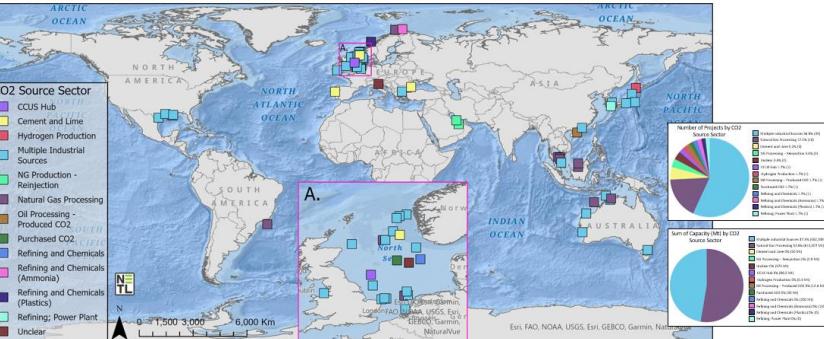
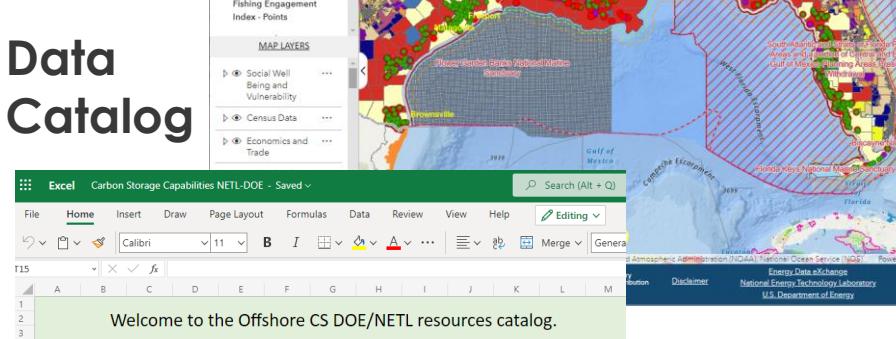
ArcGIS StoryMaps
Create inspiring, immersive stories by combining text, interactive maps, and other multimedia content. Publish and share your story with your organization or everyone around the world.

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)
<ul style="list-style-type: none"> Compilation of key data resources on information supporting offshore CCS including geologic setting, infrastructure, policy Comprehensive, up-to-date review of international CCS efforts 	<ul style="list-style-type: none"> Update and integrate available data into U.S. Offshore CCS evaluations Compile and release U.S. offshore CCS catalog and inventory 	<ul style="list-style-type: none"> 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 	<p>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</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;"> <p>Inventory</p>  <p>Global Offshore GCS Projects by CO2 Emission Source Sector</p> <p>CO2 Source Sector Legend:</p> <ul style="list-style-type: none"> CCUS Hub Cement and Lime Hydrogen Production Multiple Industrial Sources Oil Production Rejection Natural Gas Processing Oil Processing - Produced CO2 Purchased CO2 Refining and Chemicals Refining and Chemicals (Ammonia) Refining and Chemicals (Plastics) Refining: Power Plant Unclear </div> <div style="text-align: center;"> <p>Data Catalog</p>  <p>Excel Carbon Storage Capabilities NETL-DOE – Saved</p> <p>Welcome to the Offshore CS DOE/NETL resources catalog.</p> </div> </div>



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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