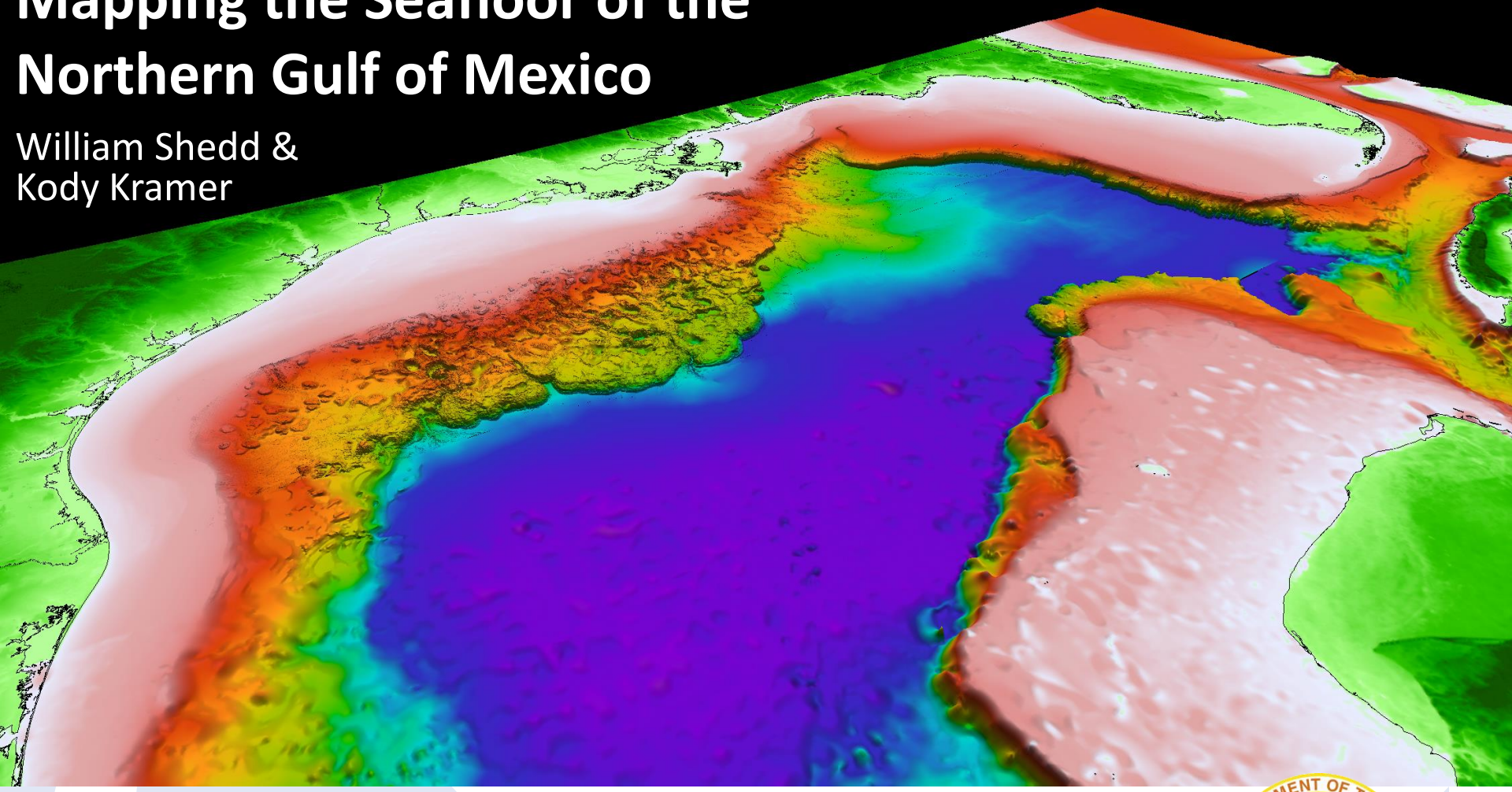
2017 Information Transfer Meeting

Mapping the Seafloor of the Northern Gulf of Mexico

William Shedd &
Kody Kramer



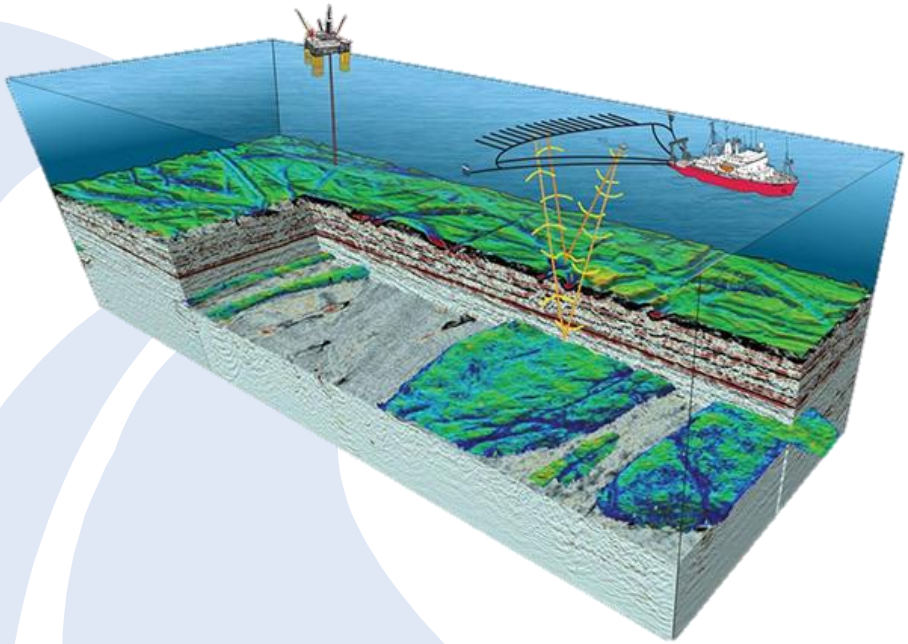
BOEM
Bureau of Ocean Energy Management

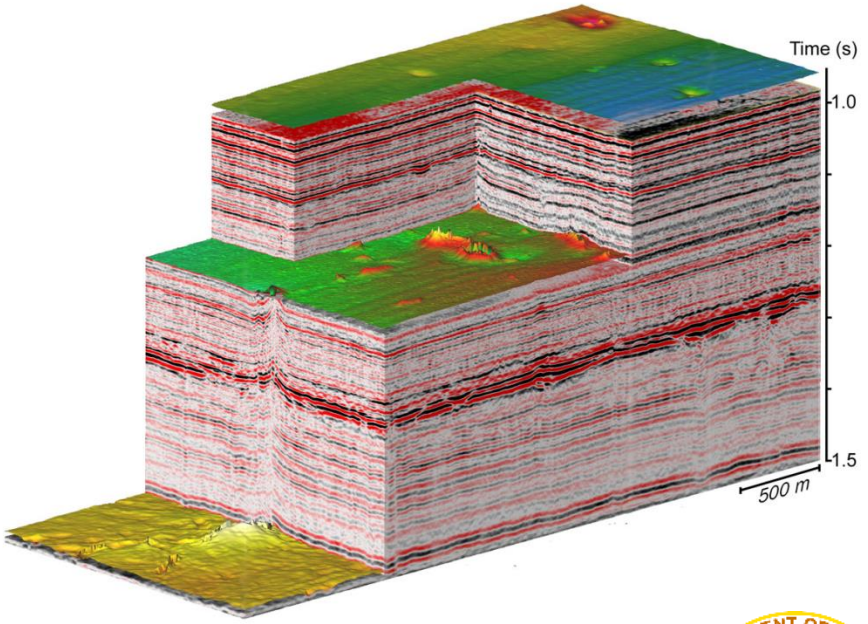
U.S. Department of the Interior
March 3, 1849

Seismic Surveys are Crucial to Mapping Geology

Seismic surveys are a method of exploration geophysics which uses reflected sound waves to create 2-D lines and 3-D cubes of the Earth's upper crust.

- **Offshore - airgun arrays are used as the acoustic source**
- **Onshore - explosives and vibroseis trucks are typical**
- **Signals recorded with hydrophones or geophones**

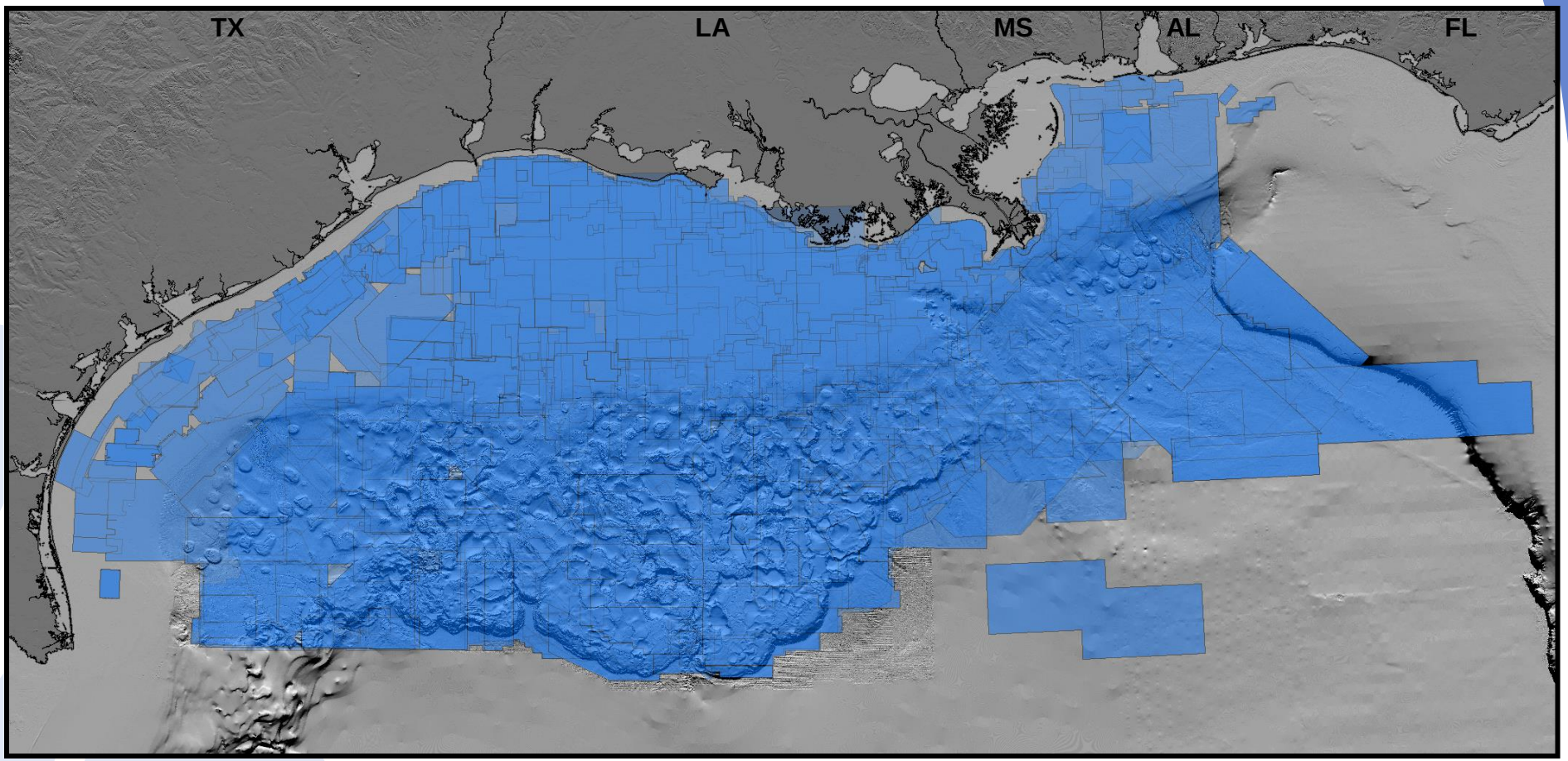




BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

BOEM's Gulf 3-D Seismic Survey Coverage

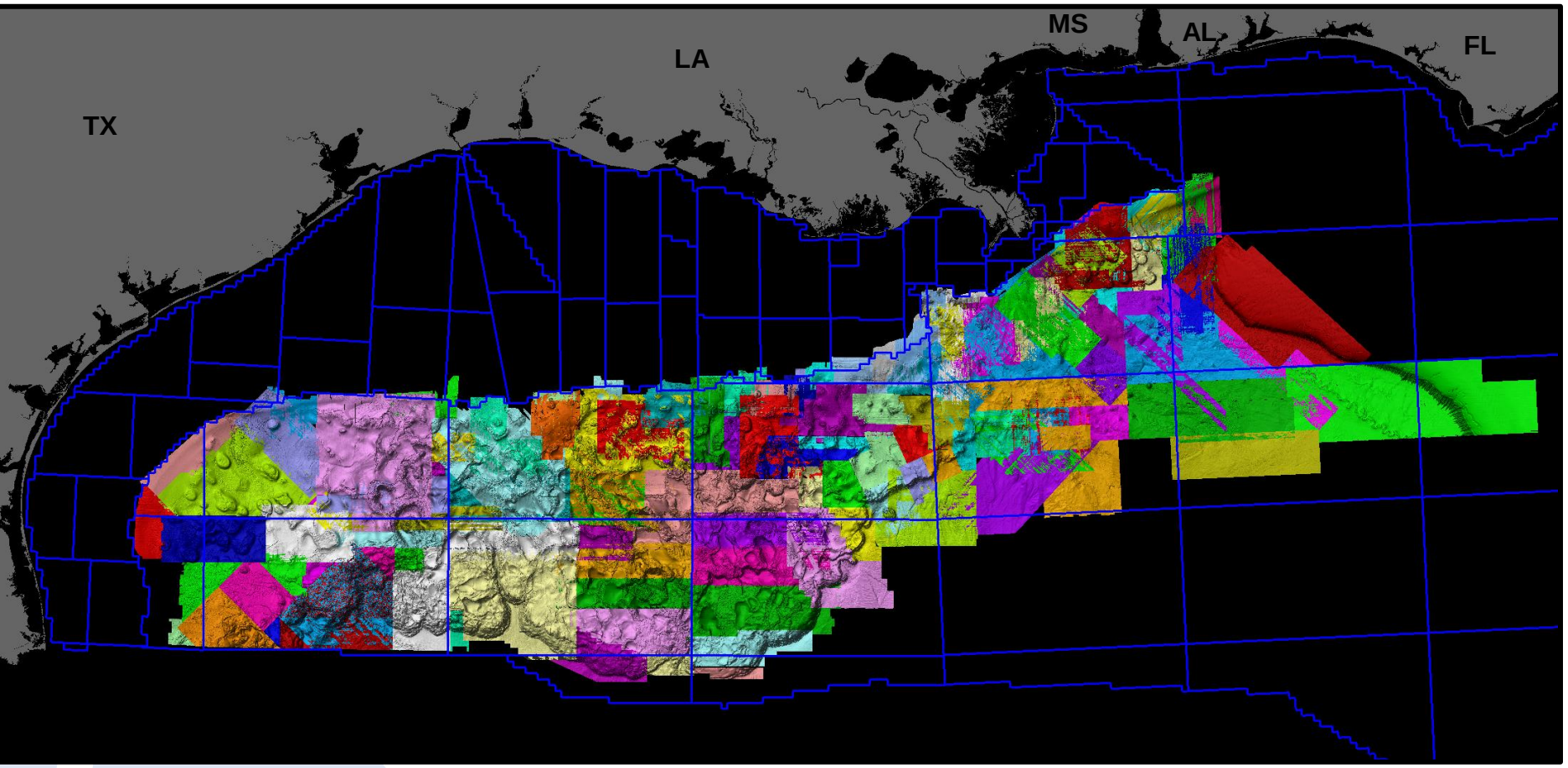


Database contains over 2,000 3-D surveys.
340,000 km^2 total offshore coverage.

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Surveys Incorporated into the New Map

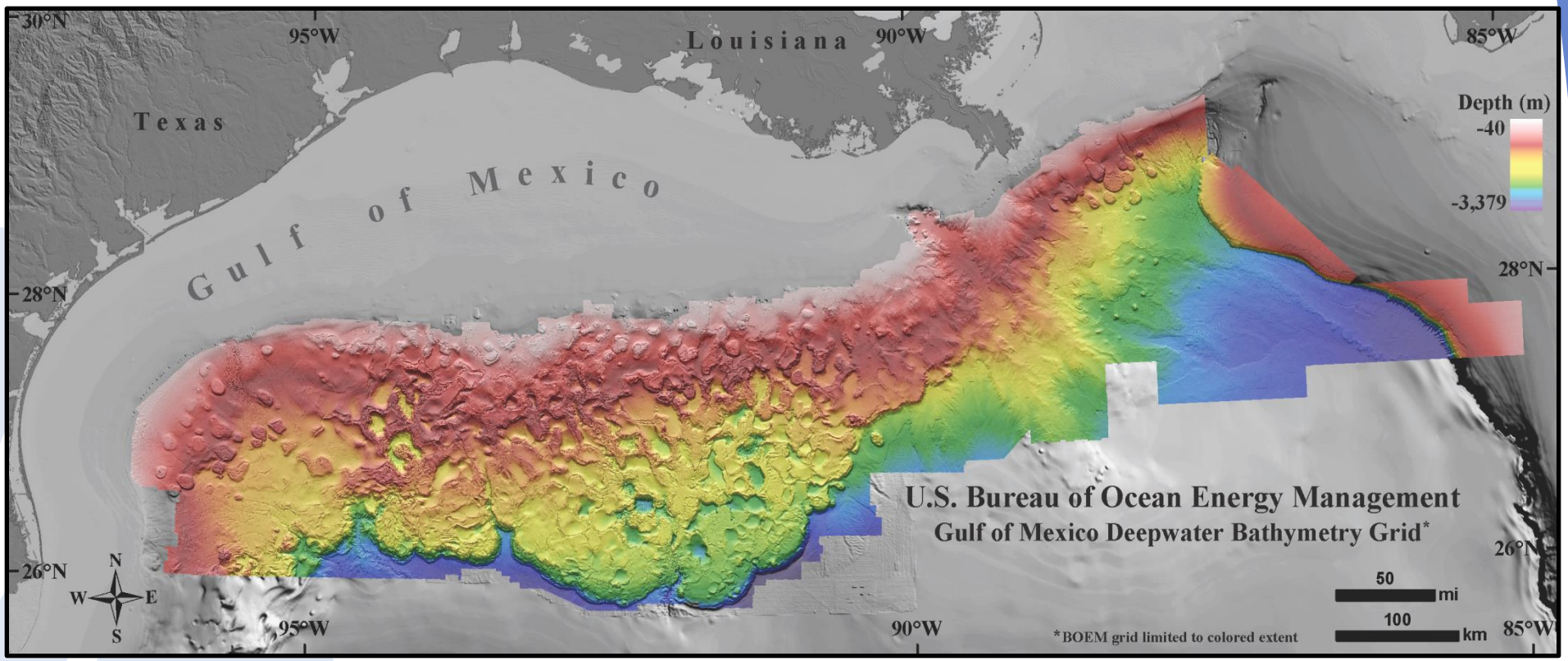


117 surveys used to compile the BOEM seafloor grid.
240,000 km^2 in deep water mapped.

100 m

BOEM
Bureau of Ocean Energy Management

BOEM's Deepwater GOM Bathymetry Map



Map can be downloaded from our BOEM website:

https://www.boem.gov/Gulf-of-Mexico-Deepwater-Bathymetry/

BOEM
Bureau of Ocean Energy Management

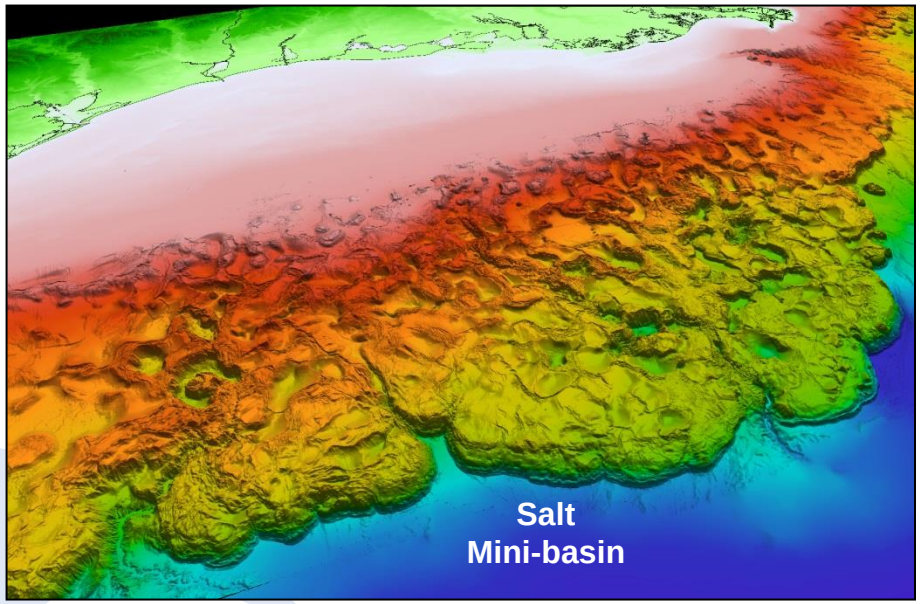
U.S. Department of the Interior
March 3, 1849

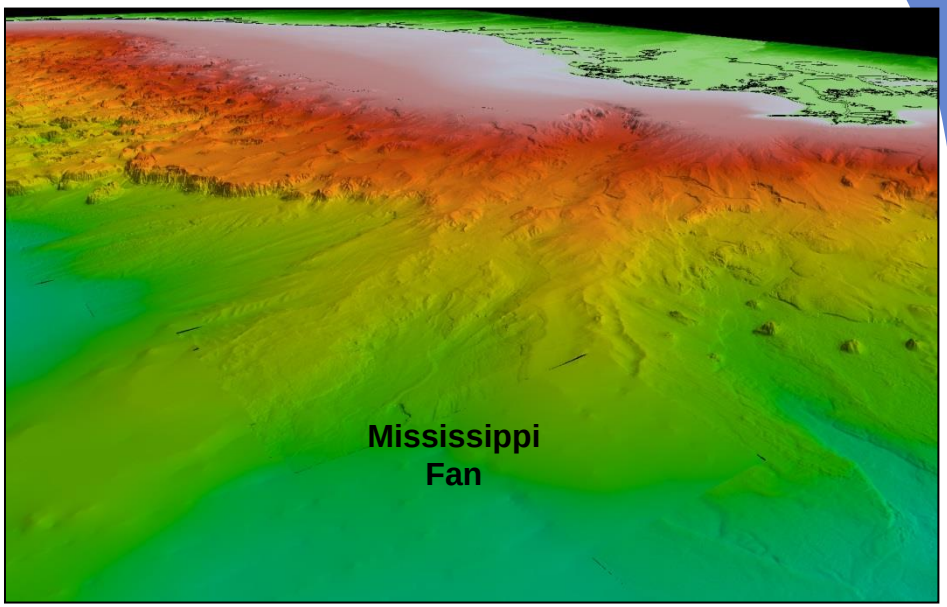
BOEM's Deepwater GOM Bathymetry Map

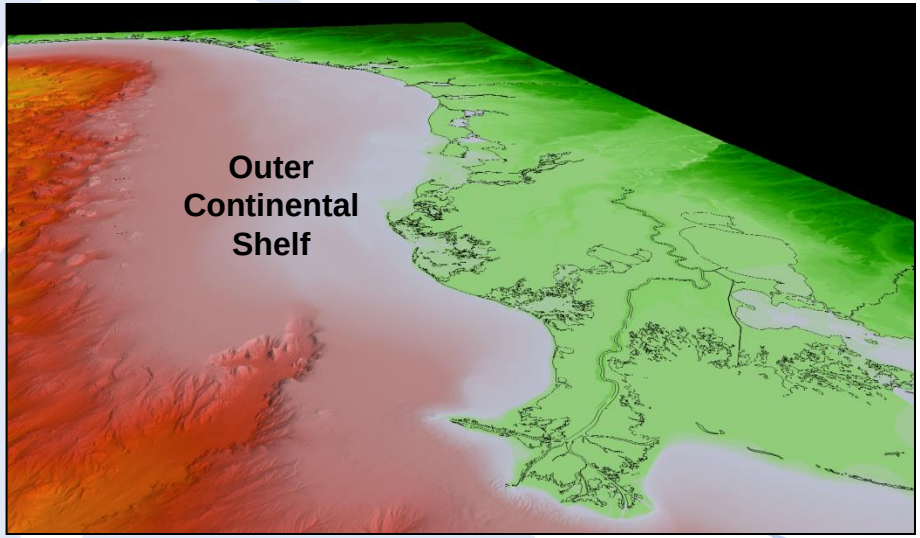
- Created by splicing together seafloor maps originally created for identifying potential natural hydrocarbon seeps
- 1.4 billion defined cells; 40x40 ft (12.2x12.2 m)
- Water depth 130-11,000 ft (40-3,350 m)
- Depth error ≈1.5 % of water depth when measured at 300 oil & gas wells
- Will provide exceptional value in scientific and academic communities because of its high resolution:
  - Marine biologists and ecologists (deepwater biota habitat modeling, dive planning)
  - Geoscientists (geomorphology and sedimentology)
  - Oceanographers (ocean-bottom current modeling, oil spill modeling)

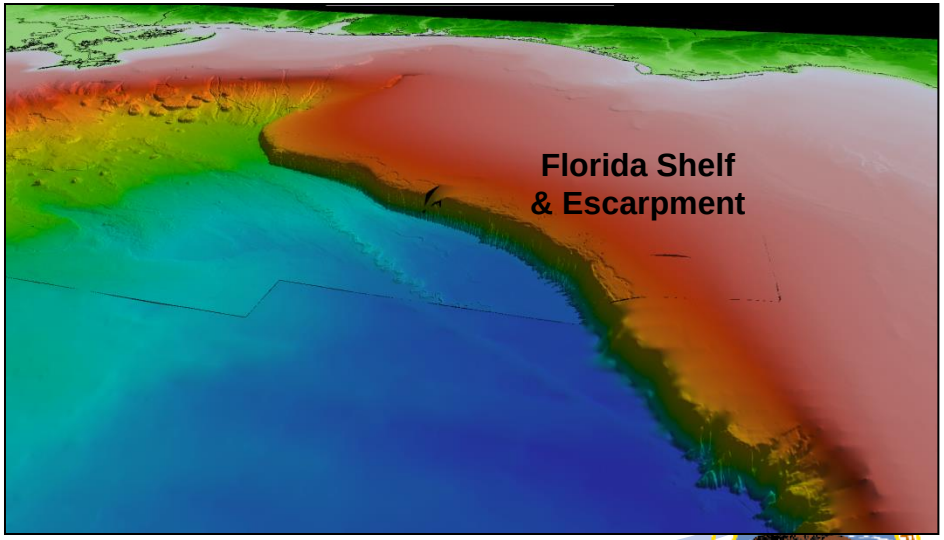
BOEM
Bureau of Ocean Energy Management

Main Gulf of Mexico Geological Provinces

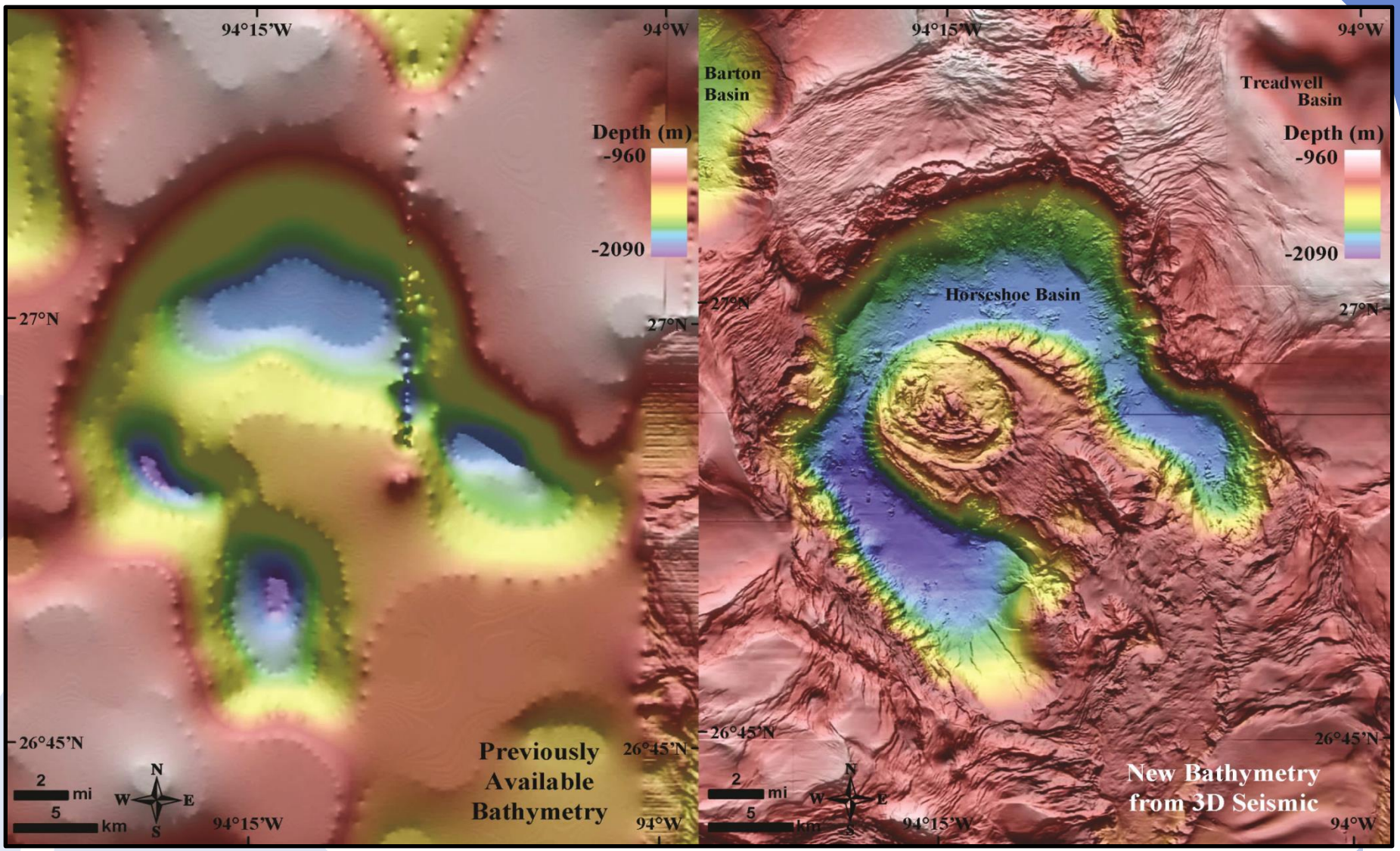






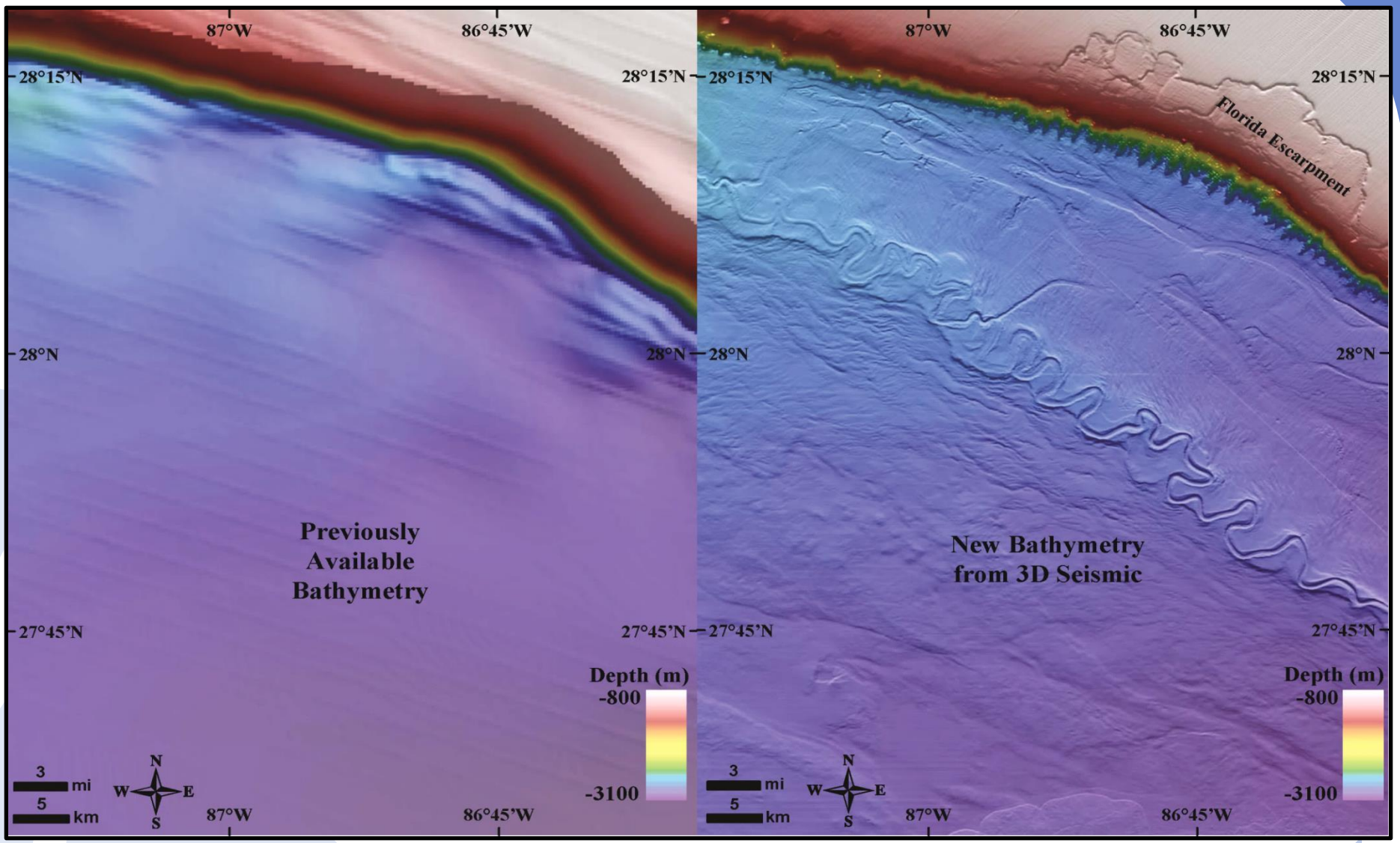


BOEM
Bureau of Ocean Energy Management



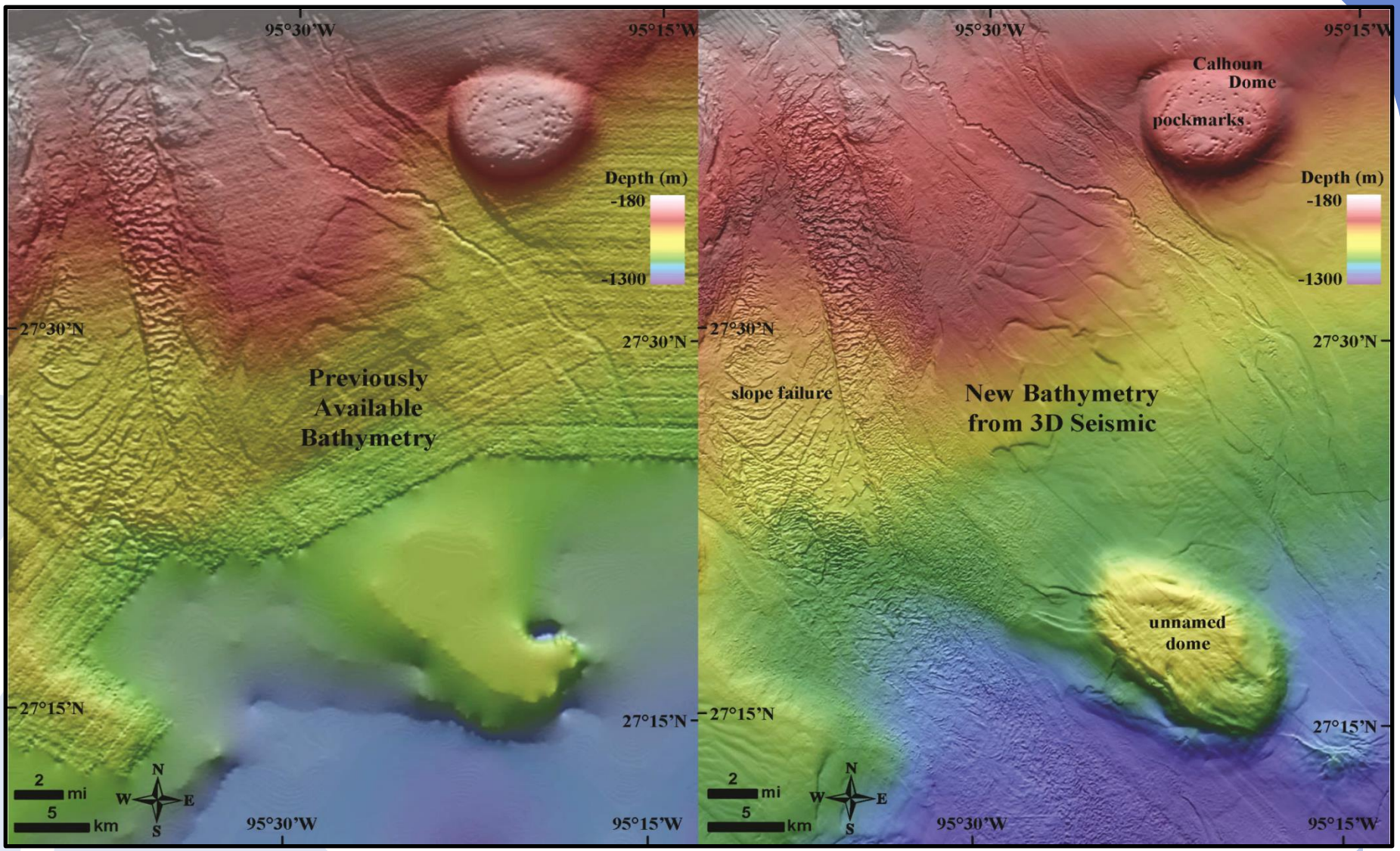
BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849



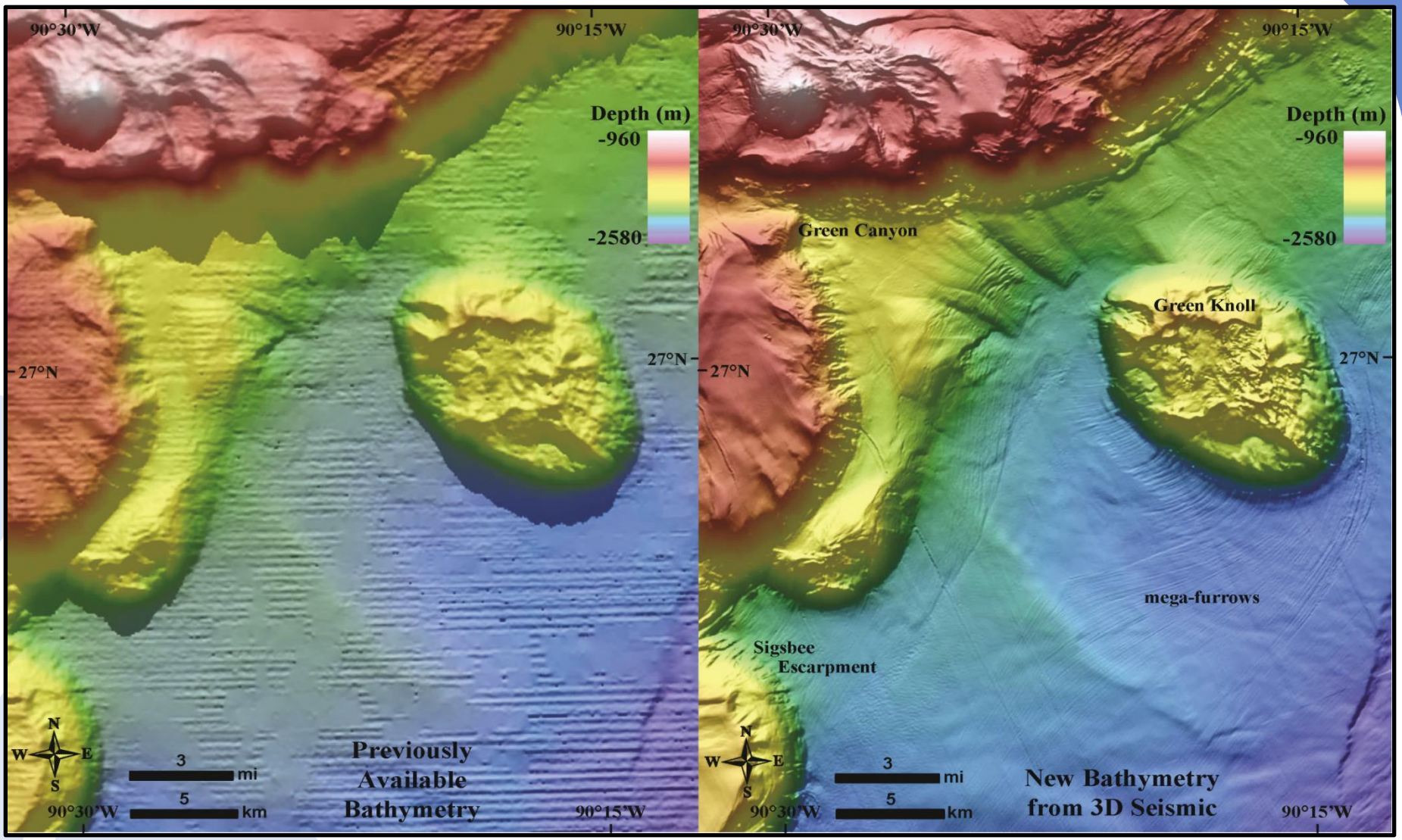
BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849



BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849



BOEM
Bureau of Ocean Energy Management

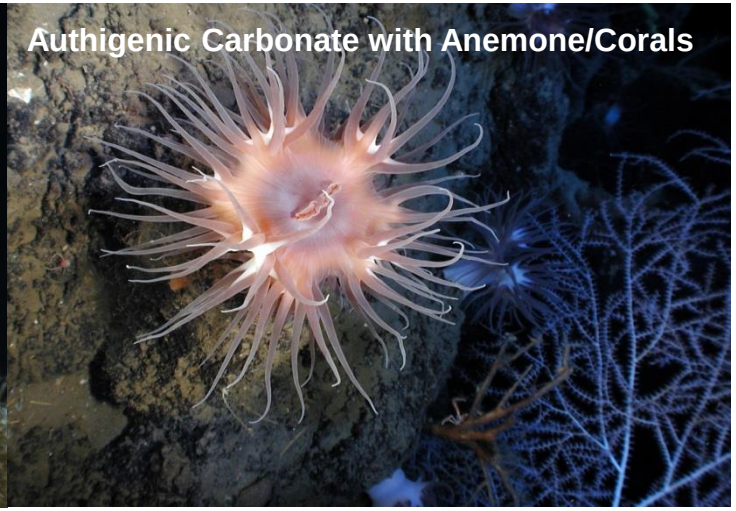
U.S. Department of the Interior
March 3, 1849

Publications of Bathymetry Map to Date

- Originally published in AGU's Eos online magazine
- Within days, covered by online National Geographic, Smithsonian, Forbes, Gizmodo, ESRI, Daily Mail, Hydro International among others
- Eos Magazine, August print version, lead article
- Oil and Gas Journal, upcoming September print version, lead article
- National Geographic, TV episode of "Drain the Ocean", production in October, to be aired mid 2018

BOEM Mapping of Natural Seeps

- Since 1998, BOEM has used 3D seismic data to map seafloor amplitude anomalies that are indicators of natural hydrocarbon seepage and other geologic features
- After numerous manned submersible dives, unmanned ROV and AUV deployments, and camera sled tows, it was apparent that these sites were indeed seep sites



BOEM
Bureau of Ocean Energy Management

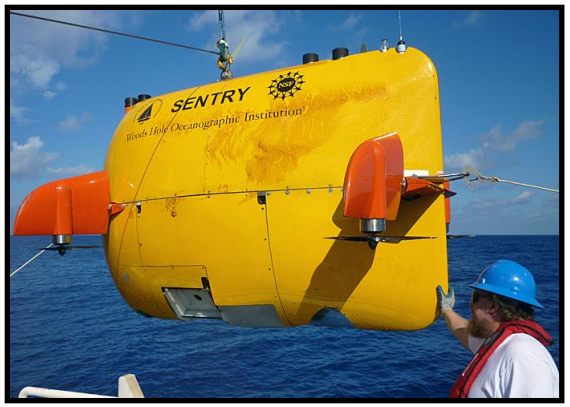
Photos courtesy of Ian MacDonald

U.S. Department of the Interior
March 3, 1849

Groundtruthing Natural Seep Sites

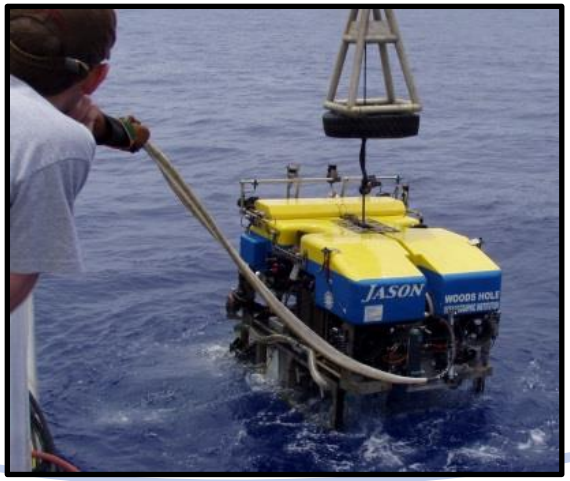
Camera Sled

"Sentry" AUV



"Alvin" Submersible

"Jason" ROV



BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Three types of seep-related anomalies:

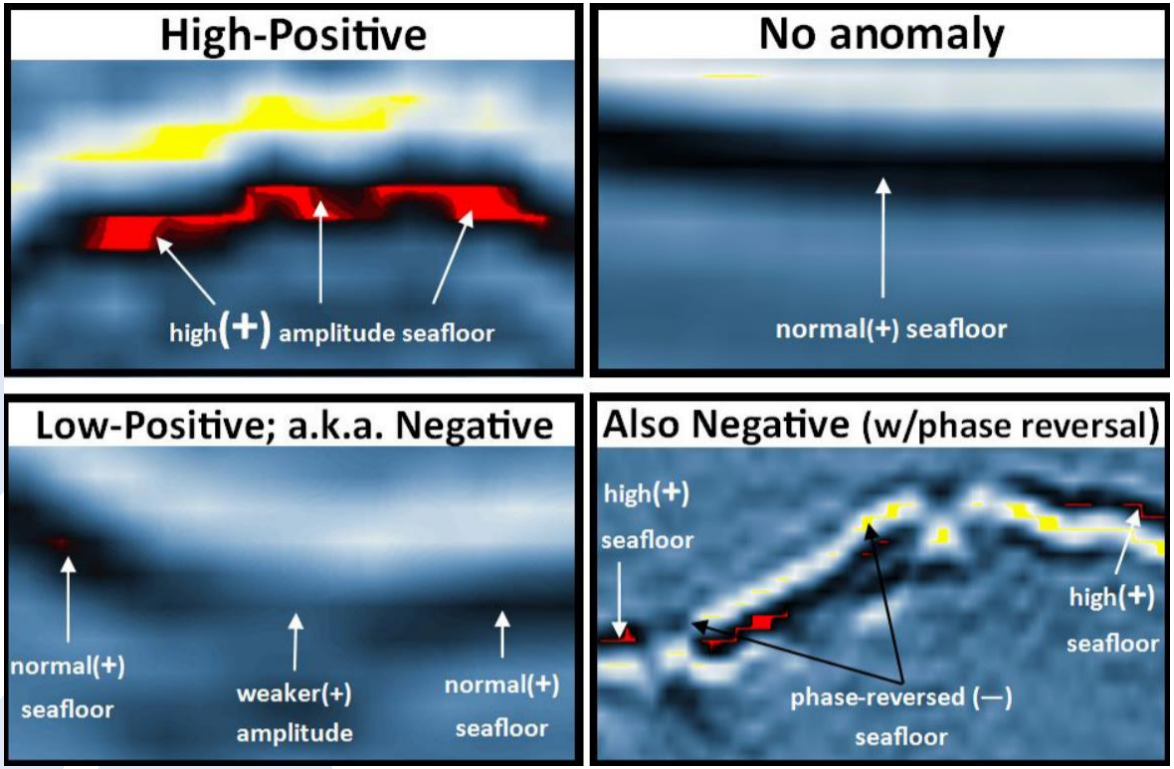


Image from BOEM website

High Positive

– interpreted to be from authigenic carbonates formed at slow to moderate seeps by bacteria in the sediment

Low Positive/Negative

– interpreted to be high-flux vent sites and mud volcanoes, oil and gas expulsion accompanied by sediment and brine

Pockmarks

– circular to oval depressions on the seafloor interpreted to be rapid, one-time expulsion of gas only

BOEM
Bureau of Ocean Energy Management

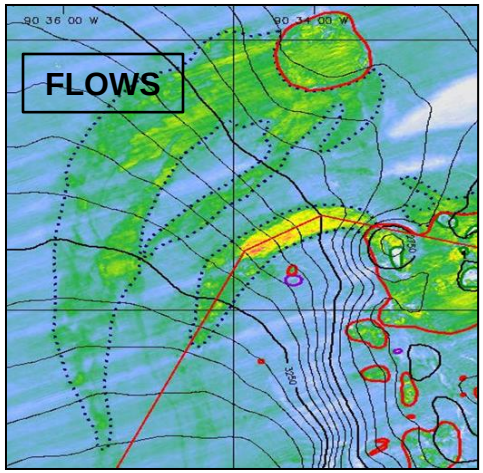
U.S. Department of the Interior
March 3, 1849

≈3,000 non-seep-related anomalies:

- sediment flows out of high flux vent sites

- exposures of salt

- turbidite fans and channels



- slumps at the base of over-steepened salt flanks

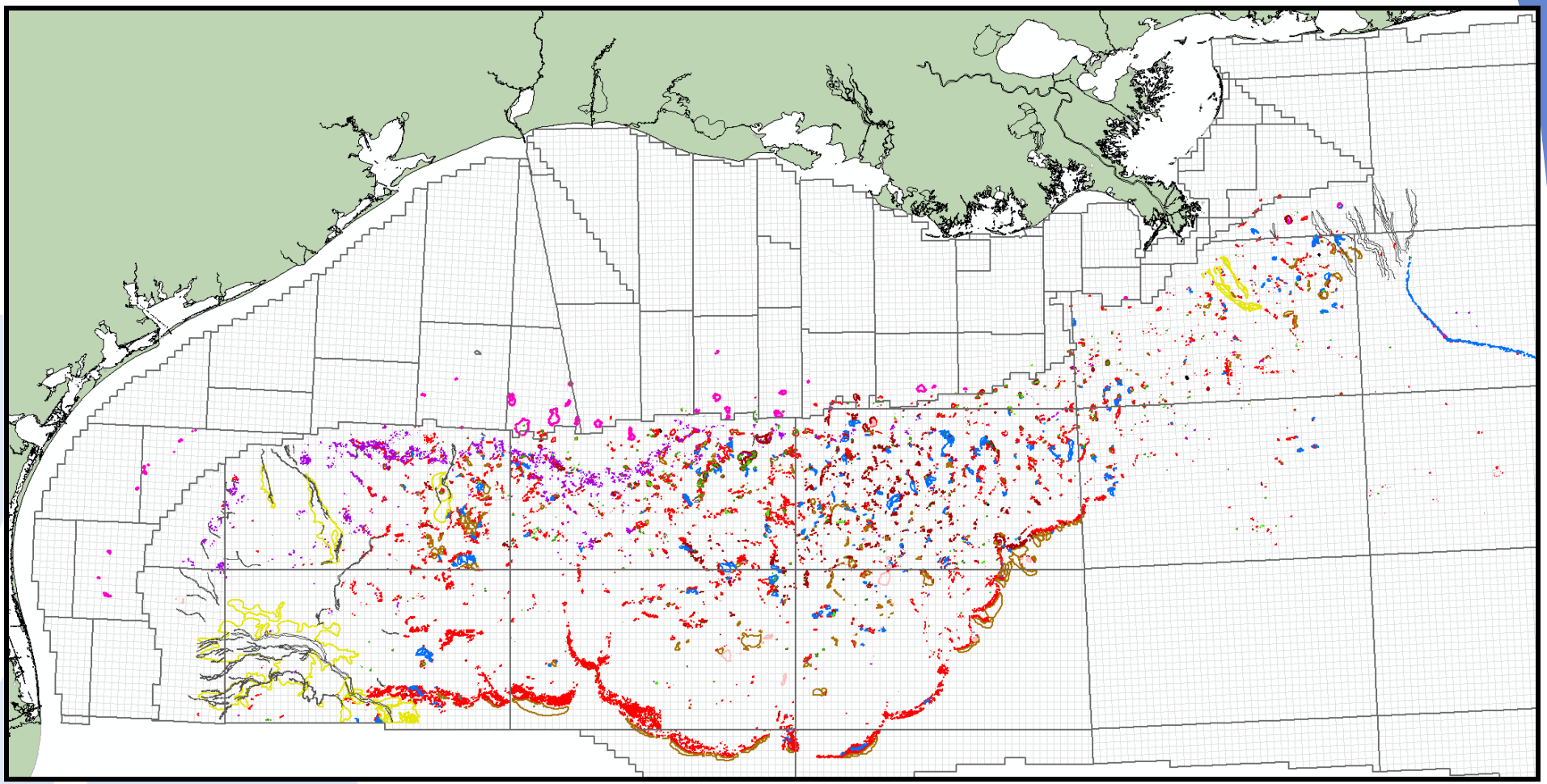
- Cretaceous carbonate outcrops on the face of the Florida Escarpment

Downloadable shapefiles of all anomalies at BOEM website:
https://www.boem.gov/Seismic-Water-Bottom-Anomalies-Map-Gallery/

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Seismic Amplitude Anomaly Distribution

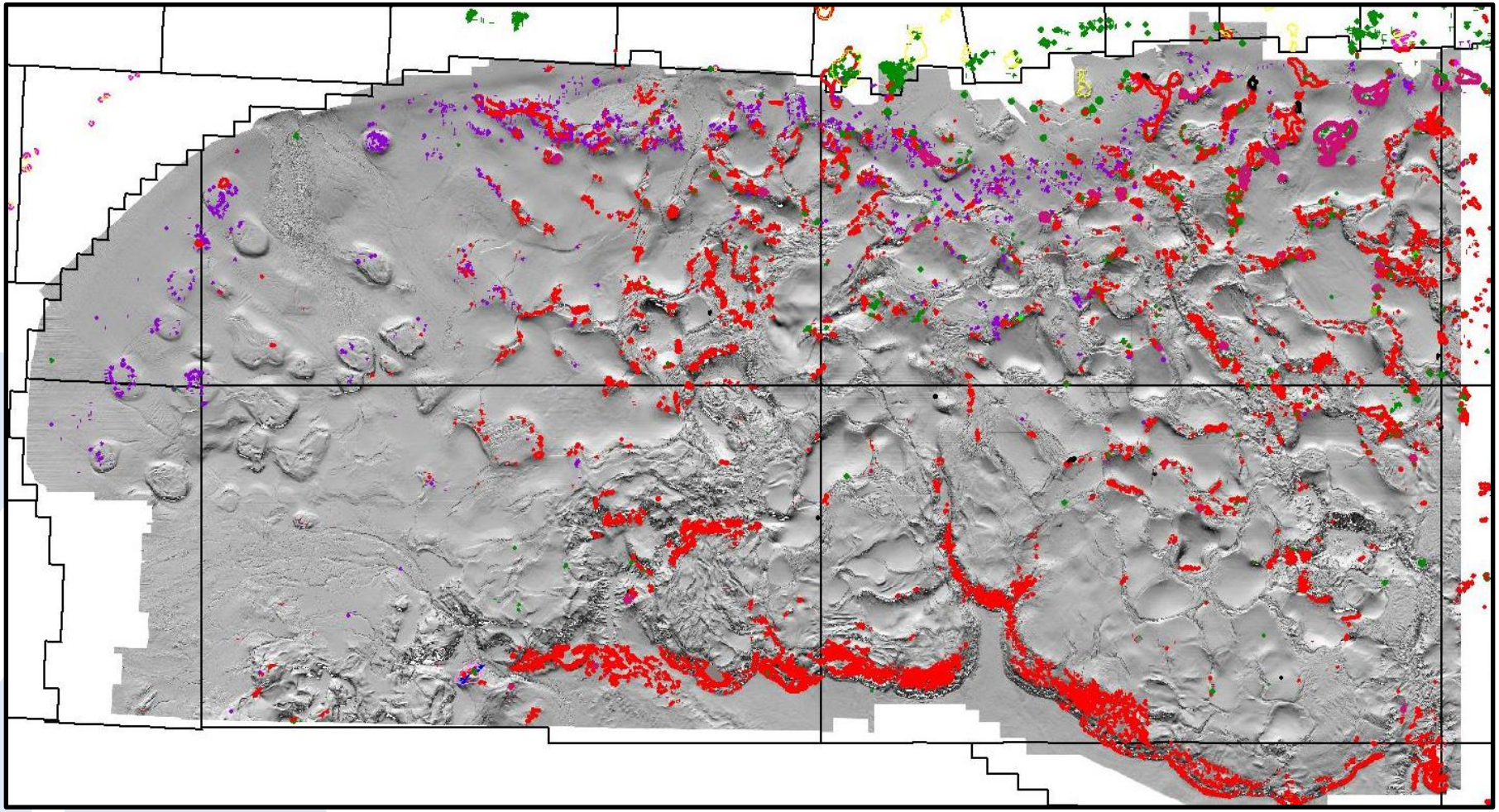


35,000 amplitude anomalies as of January 2017.
20 different classifications.

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Seeps and Bathymetry in the Western Gulf



Red – potential hardgrounds & seeps **Green – potential mud volcanoes and vents** **Purple - pockmarks**

Note that most seeps are located over and along flanks of the bathymetric highs, which are supported by the underlying salt.

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

High Positive and Low Positive Amplitude Anomalies

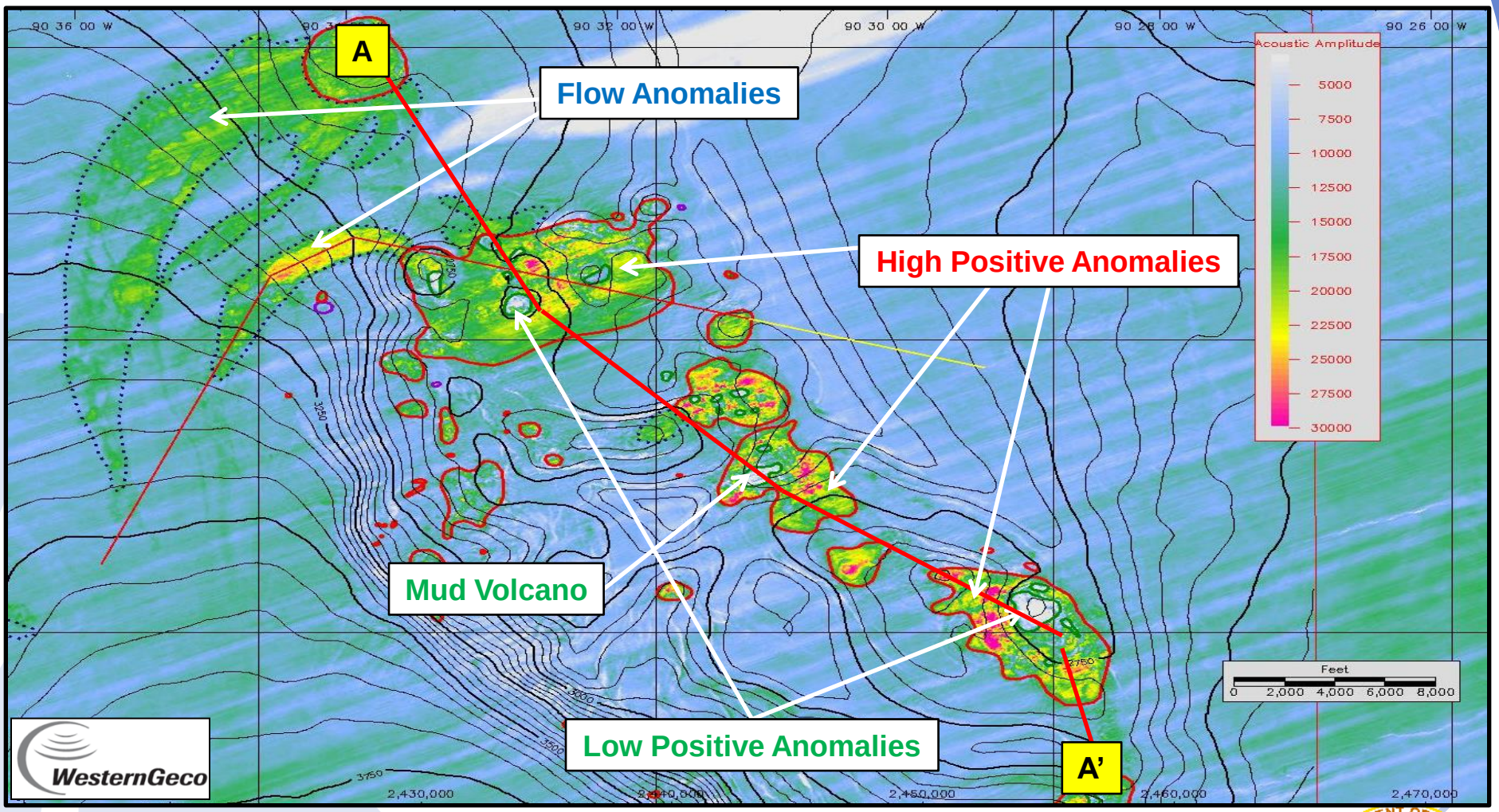


Image from BOEM website

This area visited several times and all features are confirmed

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Seismic Traverse A - A’

High and Low Positive Amplitude Anomalies

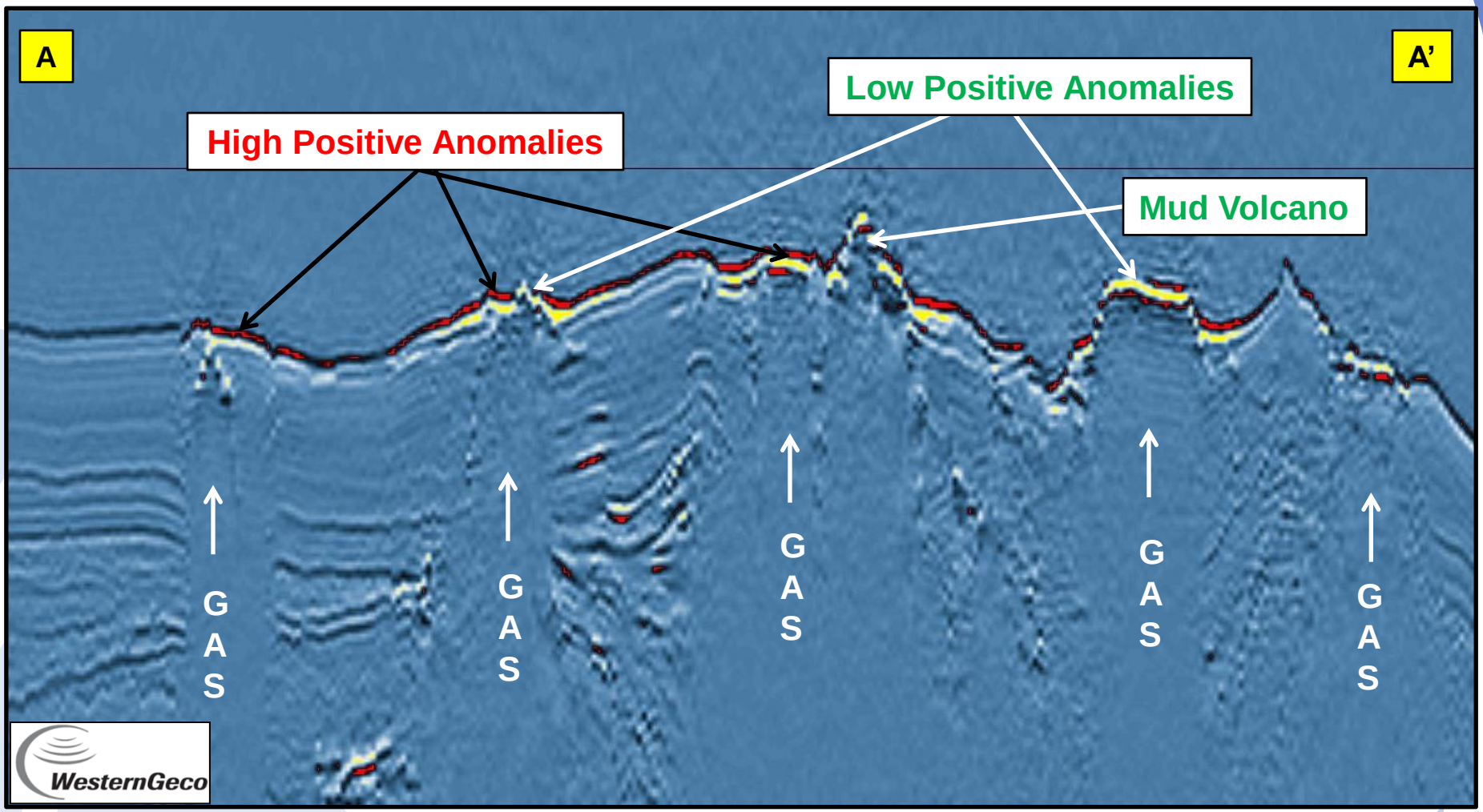
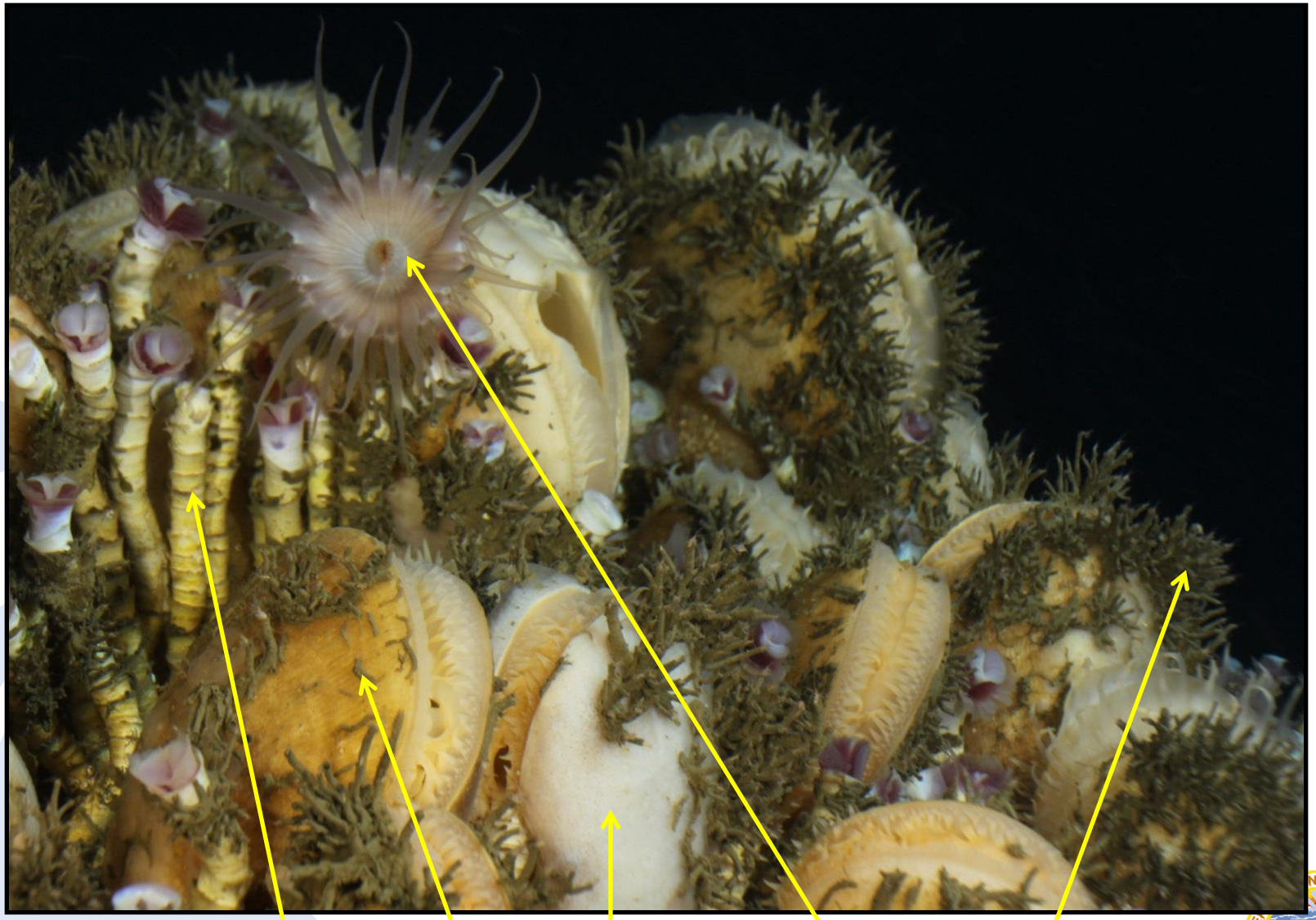


Image from BOEM website

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Diverse, High Density Chemosynthetic Community

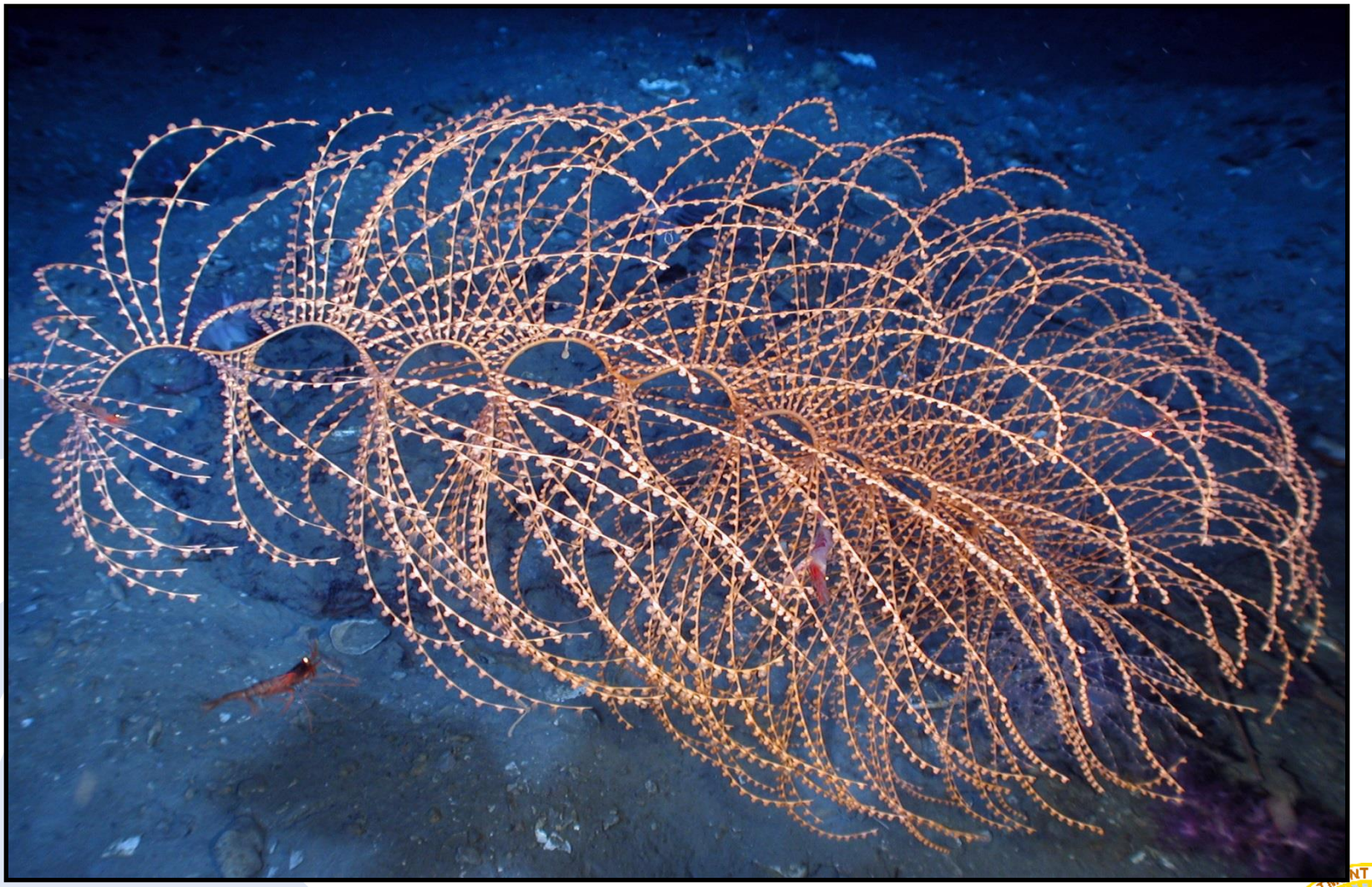


Tubeworms, clams, gas hydrate, sea anemones, pogonoferans, all found on authigenic carbonate (high positive anomalies)

Photo courtesy of Ian MacDonald

BOEM
Bureau of Ocean Energy Management

“Fireworks Coral”



Corals require hard substrate as well and are also protected

BOEM
Bureau of Ocean Energy Management

Photo courtesy of Ian MacDonald

Bubble Plumes Emanating from Hydrate Mound

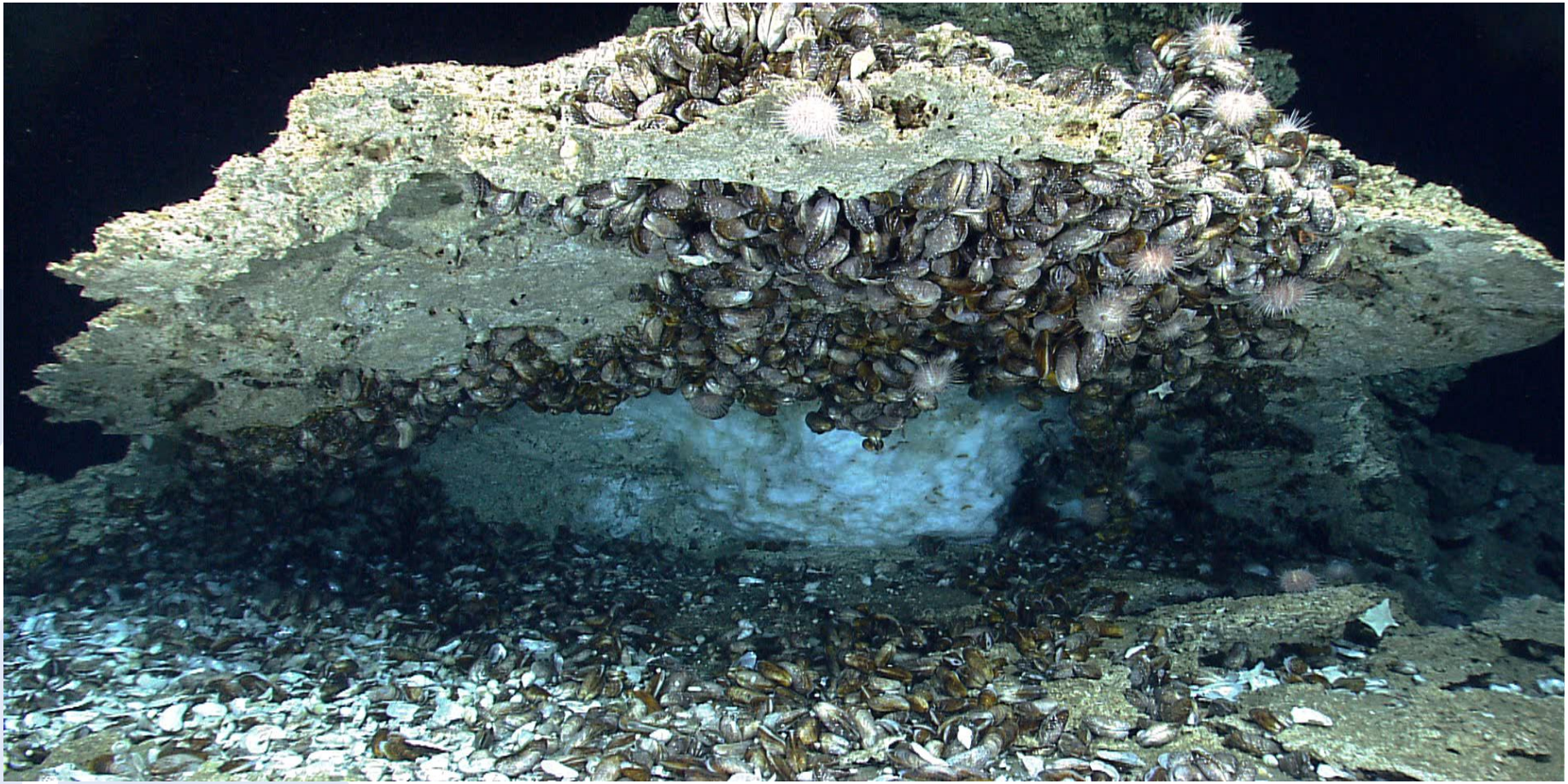
Surface mounds of gas hydrate are common in the GOM in association with carbonates and are always surrounded by abundant benthic organisms

BOEM
Bureau of Ocean Energy Management

Photo courtesy of Greg Boland, BOEM

U.S. Department of the Interior
March 3, 1849

Overhanging Ledge of Carbonate with Hydrate and Numerous Mussels



Surface mounds of gas hydrate are common in the GOM in association with carbonates and are always surrounded by abundant benthic organisms

Photo courtesy of Okeanos Explorer, NOAA

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Fish are Common at Deepwater Seep Sites

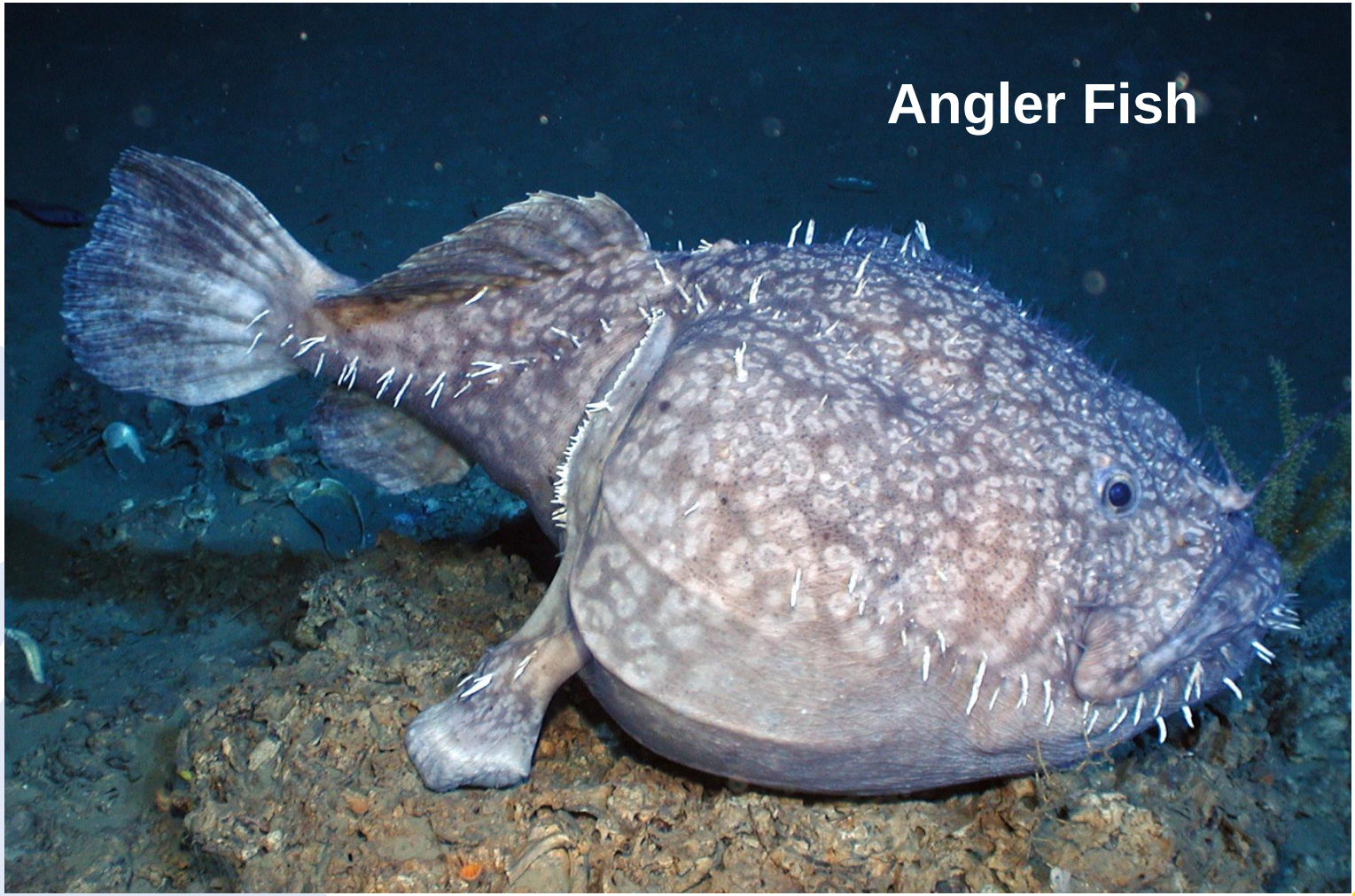


Photo courtesy of Ian MacDonald

BOEM
Bureau of Ocean Energy Management

Seafloor Amplitude Map

Pockmarks and High Positive Amplitude Anomalies

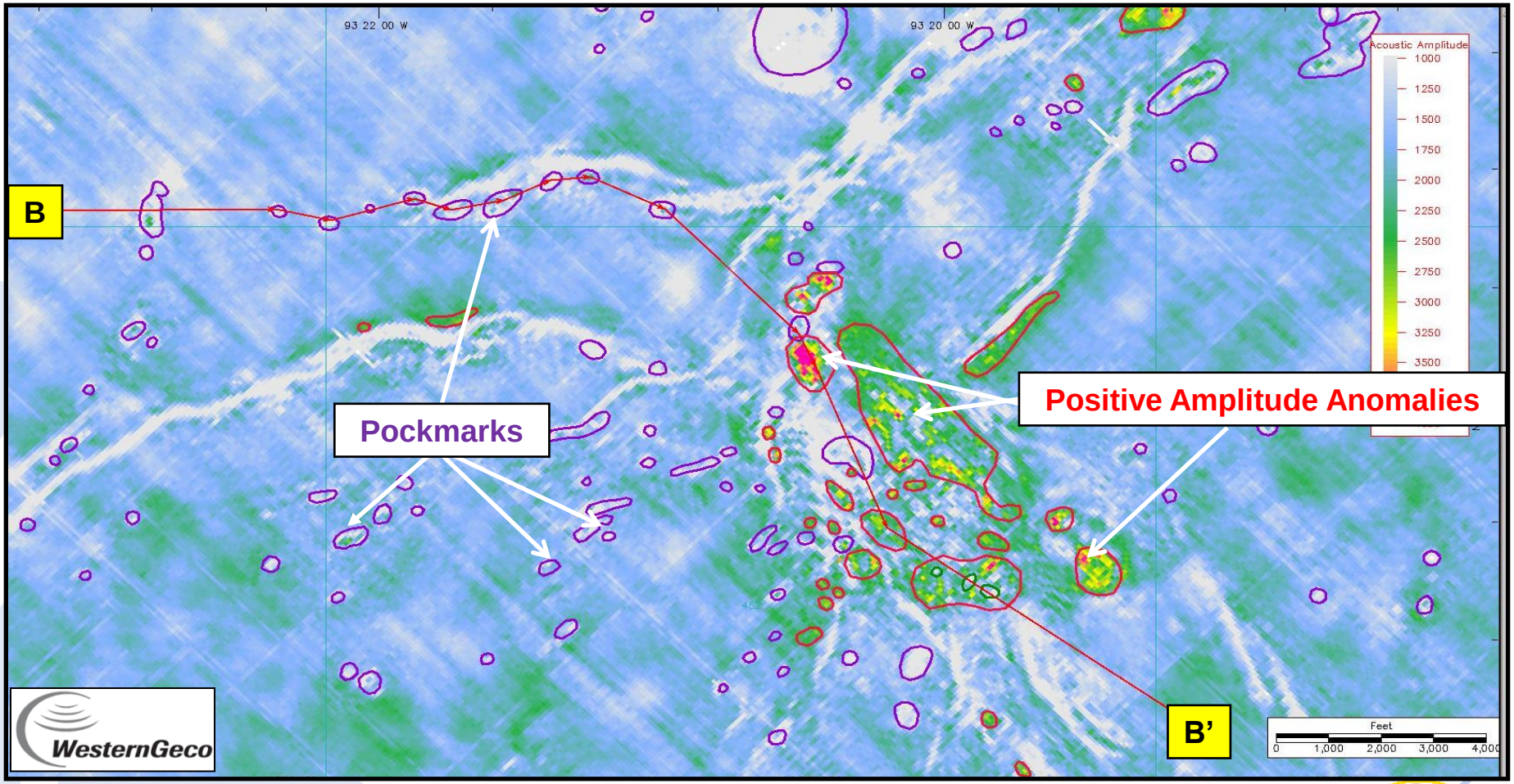


Image from BOEM website

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Seismic Traverse B - B’

Pockmarks and High Positive Amplitude Anomalies

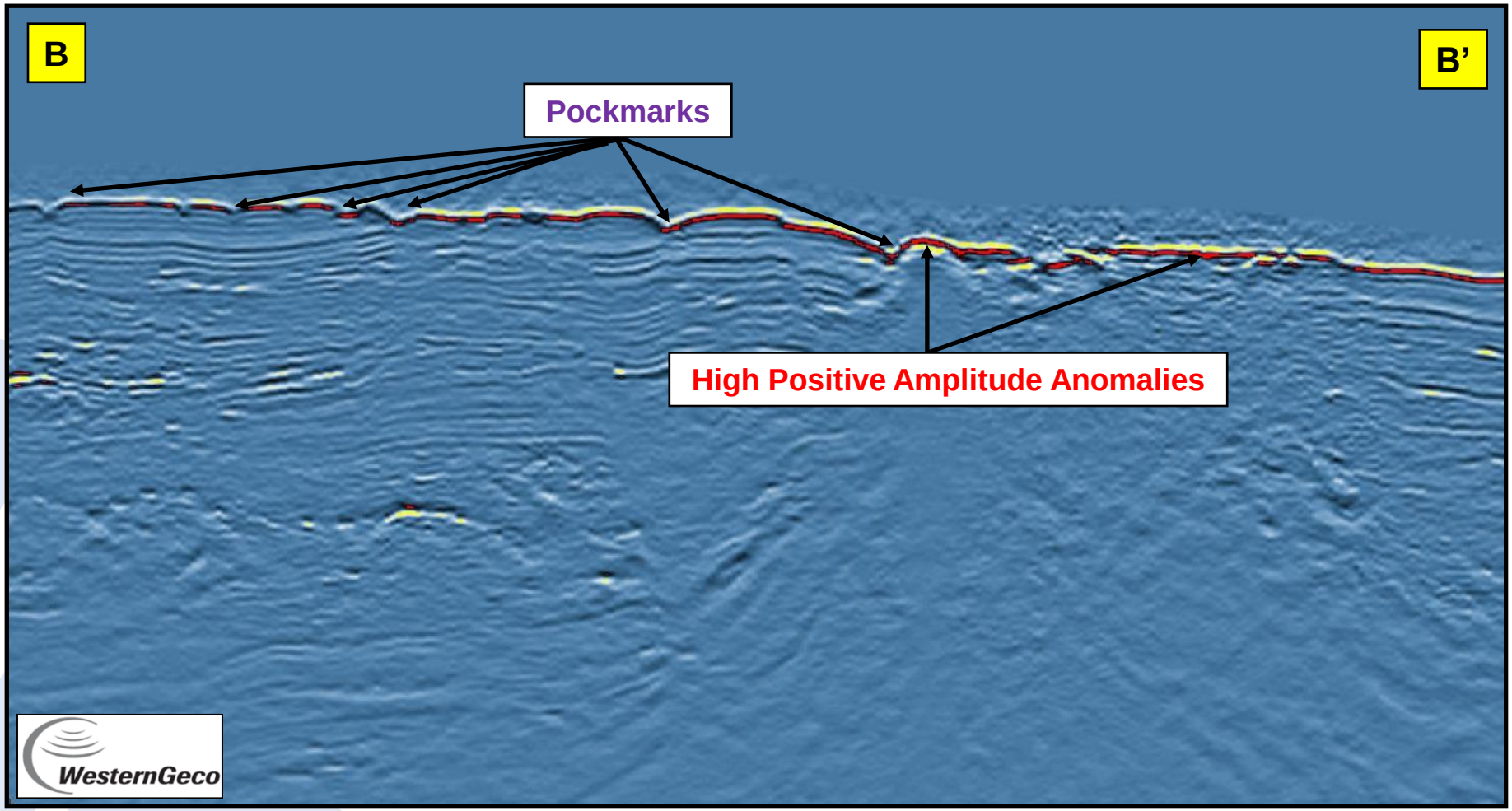


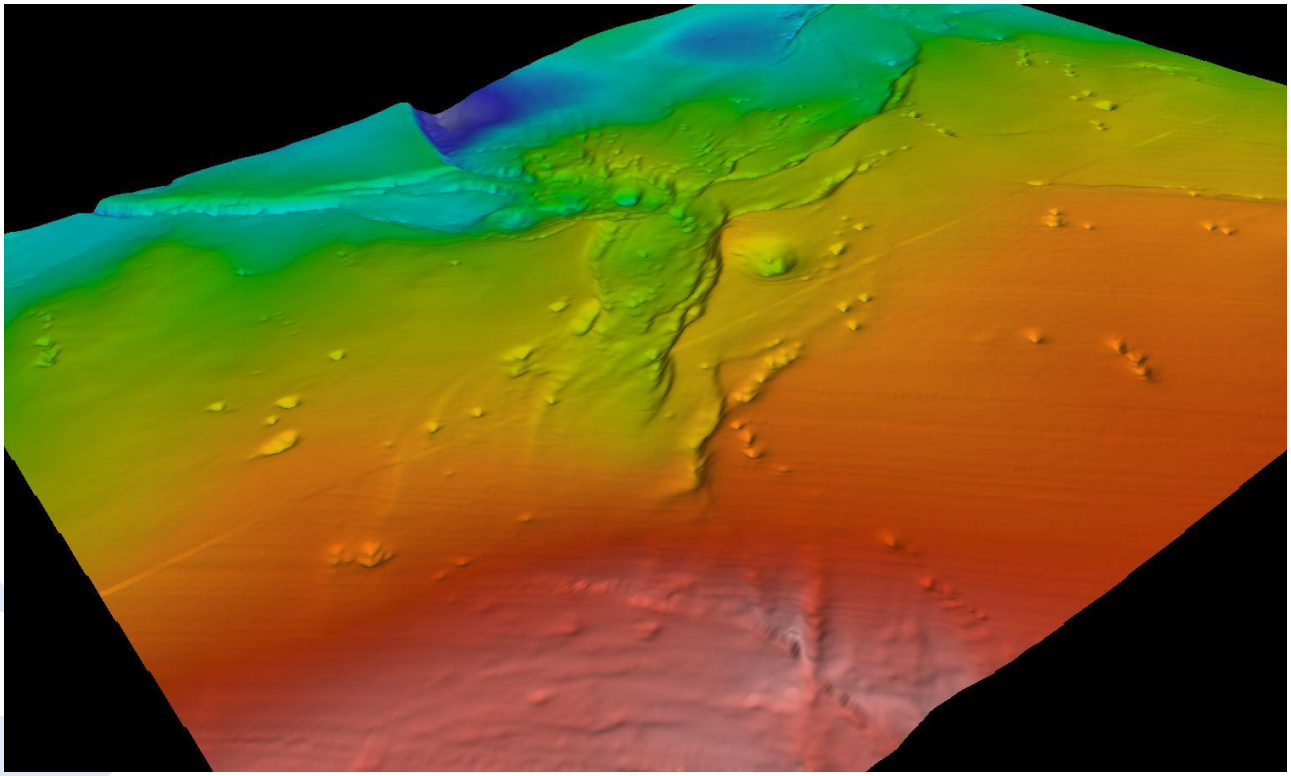
Image from BOEM Website

Pockmarks probably form when gas is expelled forcefully, without accompanying fluidized sediments and/or brine

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Video: Seafloor Pockmarks



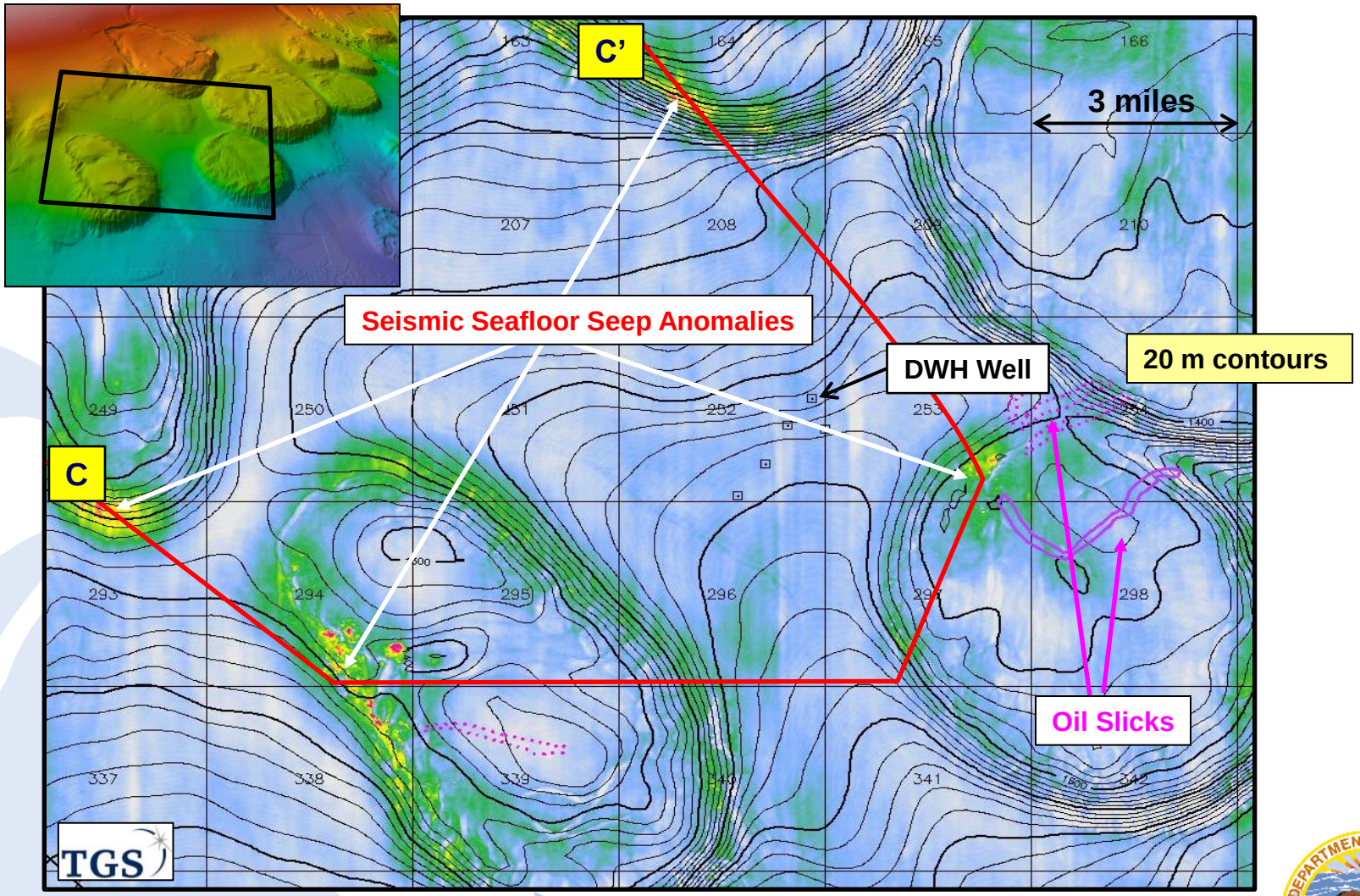
Island of Manhattan for scale reference

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Depth Bathymetry Map with Acoustic Amplitude Underlay

Natural Seeps in the Vicinity of Deepwater Horizon



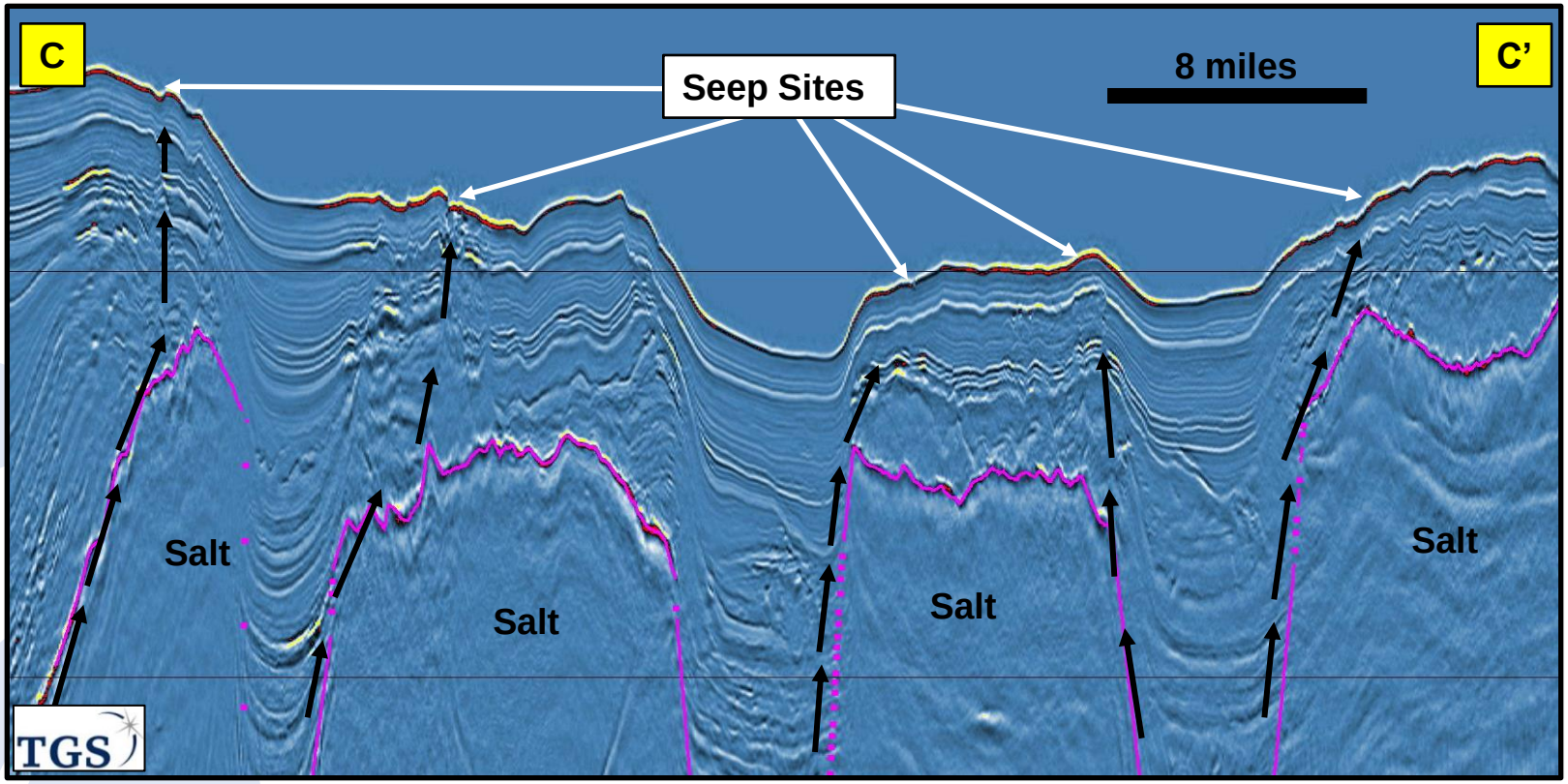
Modified from ERMA website

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Seismic Traverse C - C’

Oil & Gas Migration Pathways Along Flank of Salt



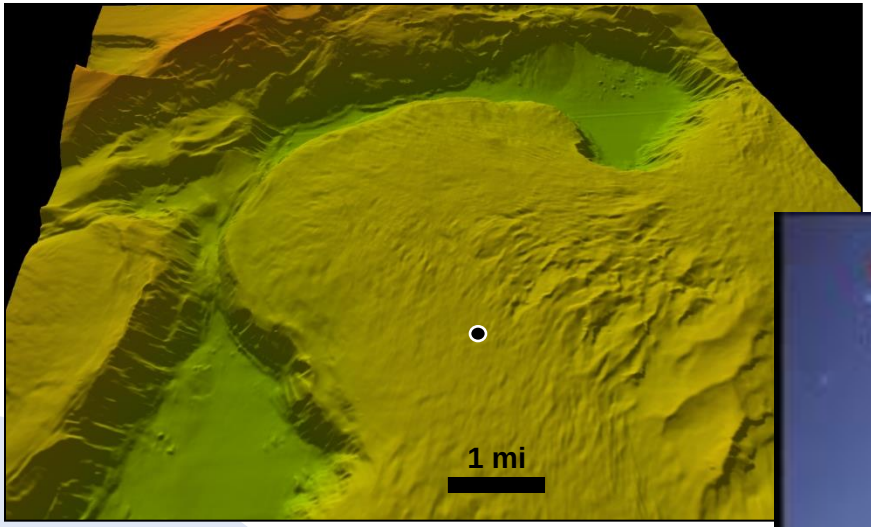
Modified from ERMA website

Seismic line showing relationship between probable seep sites and underlying salt bodies controlling migration pathways

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

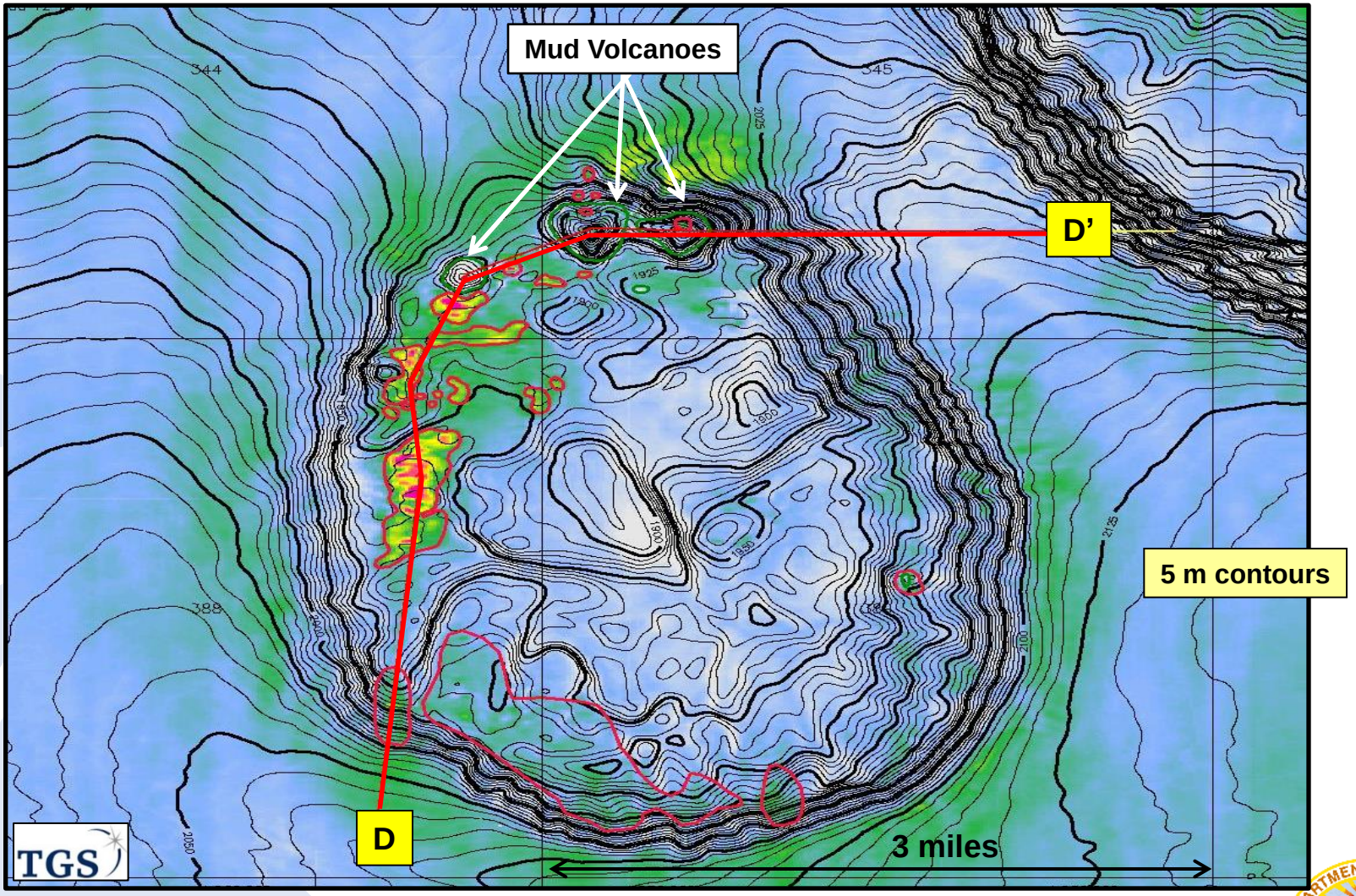
Natural Oil Seep Above a Salt Canopy



BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849

Mud Volcanoes in Mississippi Canyon 345

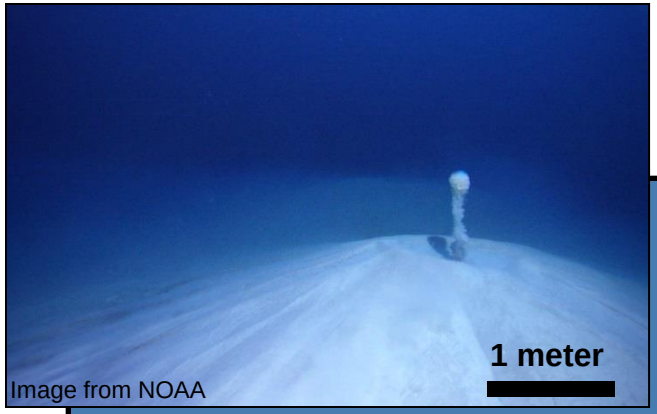


Modified from Gordon Research Conference

BOEM
Bureau of Ocean Energy Management

Seismic Traverse D – D’

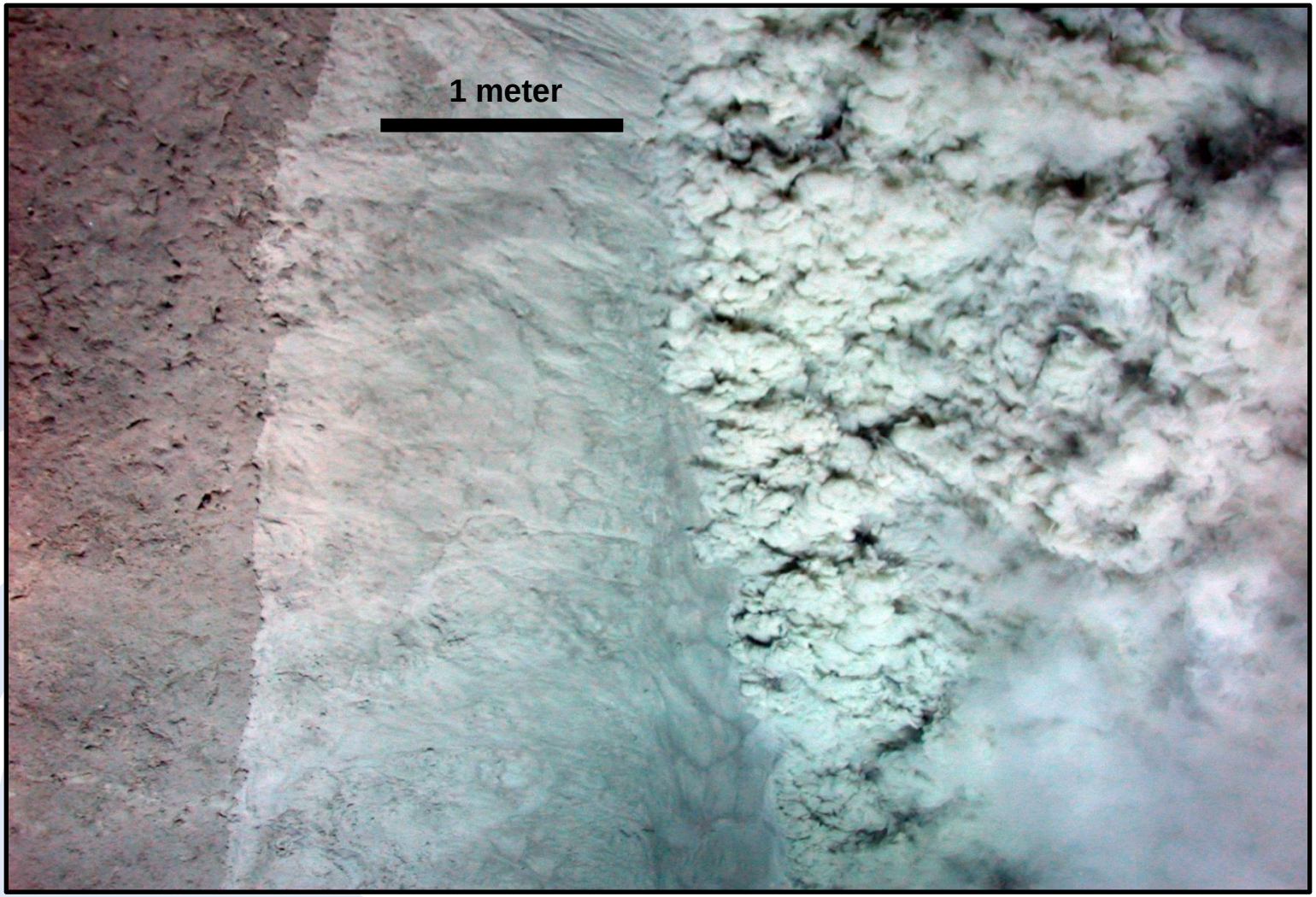
Formation of Mud Volcanoes



BOEM
Bureau of Ocean Energy Management

Modified from Gordon Research Conference

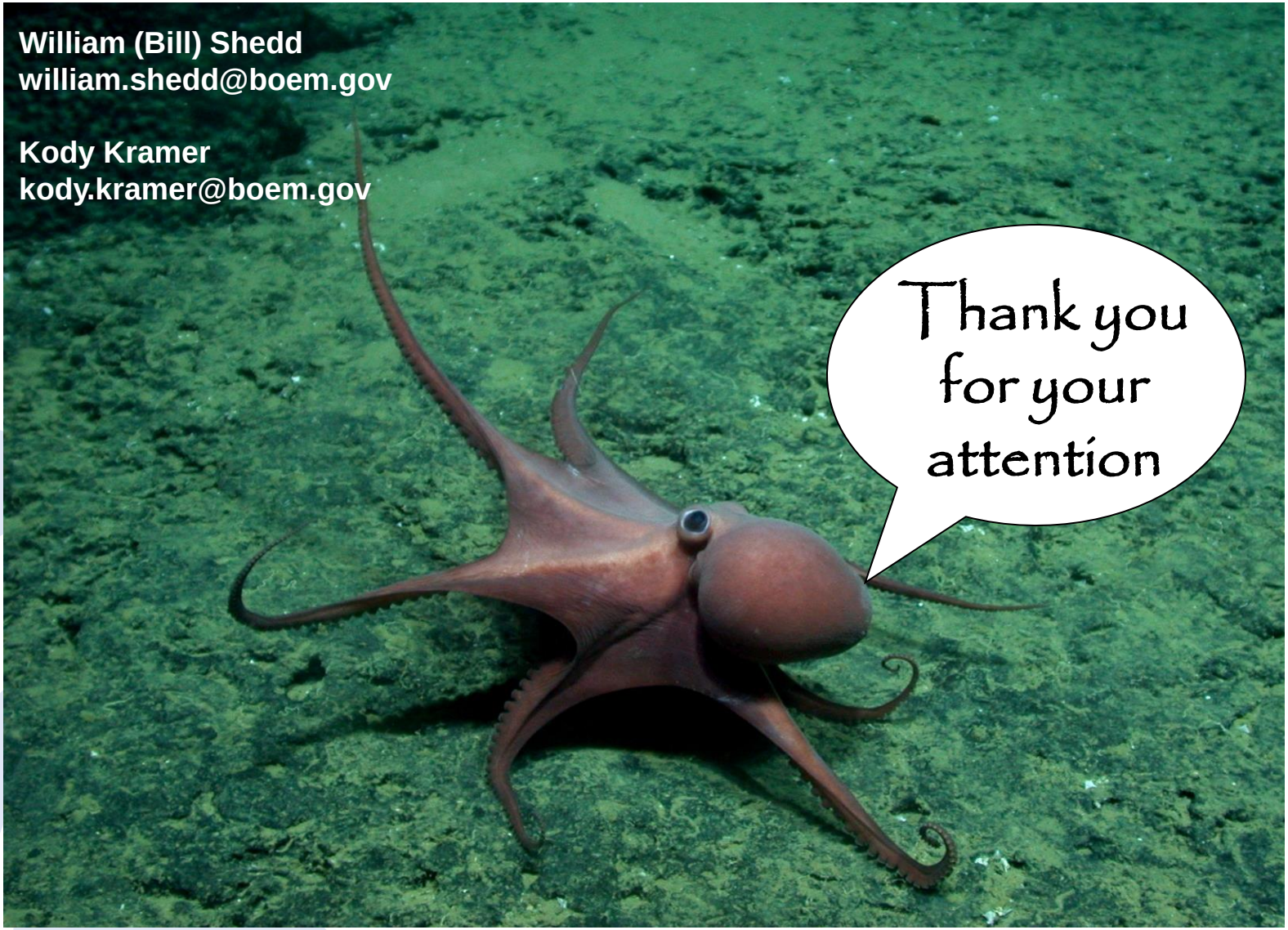
Crater of a Mud Volcano



BOEM
Bureau of Ocean Energy Management

Photo courtesy of NOAA

U.S. Department of the Interior
March 3, 1849



William (Bill) Shedd
william.shedd@boem.gov

Kody Kramer
kody.kramer@boem.gov

BOEM
Bureau of Ocean Energy Management

U.S. Department of the Interior
March 3, 1849