High resolution bio-geological study at Woolsey Mound (MC 118, Northern Gulf of Mexico)

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Research Framework

1: Lithological characterization (Mosaic SSS, Photos, samples)
   - Multibeam Data from AUV (Hugin 3000)
   - Morphobathymetry Map
   - Principal Geological Features
   - Mosaic SSS
   - Principal Surface Types
   - Sediment Distribution Map (GIS)
   - Identification of micro and macro benthic fauna
   - Benthic Fauna Distribution Map (GIS)
   - Digitized with ArcGIS Quantification Study Biological Diversity Statistical Analysis
   - Photomosaics
   - Possible Oil Spill Impact
   - Benthic Habitat Mapping

2: Benthic fauna characterization (HQ images, photo-mosaics, samples)
   - SideScan Sonar Data from NR-1
   - Images and Videos from JSL, DSC, Jason, Alvin
   - Photomosaics

3: Benthic Habitat Mapping

4: Possible Oil Spill Impact (photos, samples)
Acoustic Data
2005 C&C AUV Multibeam reprocessed

Woolsey Mound
Acoustic Data - Side Scan Sonar -

**Side Scan Sonar 2007 Survey (NR-1)**

SSS instrument collects the **backscattered energy returning from the seafloor**

(Seafloor features and backscatter anomalies to identify hardgrounds)

**Backscatter**

It's a measure of the sound’s intensity that is scattered back toward the transmitter by acoustic reflection and scattering, both at the sediment-water's interface and from within the sediment.
Ground truthing Data (Video and still Images)

**Cruise JSL 2002:**
Total video approximately 10 hours

**Cruise JSL 2006:**
Total video approximately 15 hours

**Camera Cruise Deep-See 2006:**
Total video approximately 15 hours

**Cruises Station Service Device 2009/2010:**
Total video approximately 4 hours

**Lophelia II Cruise Jason II 2010:**
Total video approximately 17 hours

**Alvin Cruise 2010:**
Total video approximately 7 hours
Habitat Mapping

Habitat is the place where an organism lives (Odum 1971)

Spatially recognizable areas where physical, chemical, and biological environment is distinctly different from surrounding environment (Valentine et al., 2005)

Applications

- **Environmental** (assessment of the health of ecosystems, preservation, monitoring)
- **Economic** (assess resources exploitation)
- **Legal** (define areas of fishing)

Hierarchical Classification

Importance of Observation Scale

**Macro-Microhabitat**

Mississippi Mineral Resources Institute
Seafloor Morphology Features Map
(Multibeam Data)

Geologic Features at Woolsey Mound

Pockmarks (multibeam, seismic)

Authigenic carbonate (video, backscatter, seismic)

Master faults (seismic, multibeam)

Gas hydrates outcropping and in the shallow subseafloor (video, cores)

Carbonate-Hydrate Complex Mound
NR-1 SSS Mosaic - West part of Woolsey Mound

20 cm resolution

NW Crater

20 cm resolution
NR-1 SSS Backscatter Mosaic - West part of Woolsey Mound

Distribution of backscatter values

3D Backscatter SSS Image

BS Scale (dB)

Mississippi Mineral Resources Institute
Substrate types: Side Scan Sonar + Video/images

Type A (Hemipelagic mud)

Type B (Hemipelagic mud with shells/clams coverage < 50%)

Type C (Mud with shells coverage > 50%)

Type D (Carbonate slab/rock)
Sediments Distribution Map

**Type A:**
- A1: Hemipelagic mud with burrows
- A2: Hemipelagic mud with white patch/bacterial mats.

**Type B:**
Hemipelagic mud with shells/clams with <50% of coverage

**Type C:**
Area with >50% coverage
- C1: Rubble Carbonate
- C2: Rubble Coral
- C3: Bed Clams

**Type D:**
- D1: Authigenic carbonate (rock, block, slab)
- D2: Authigenic carbonate pavement
- D3: Gas Hydrates Outcrops

![Map showing distribution of sediment types](image)

Legend:
- Type A: 83.18%
- Type B: 14.32%
- Type C: 2.19%
- Type D: 0.03%
Micro-Macro benthic Fauna at Woolsey Mound

20 taxa belonging to the following Phyla:

Gammaproteobacteria, Anellida, Mollusca, Arthropoda, Echinodermata, Cnidaria.

Beggiatoa sp. (NS, NWC, SWC)

Acesta sp. (NWC, SWC)

Bathymodiolus childressi (SWC)

Calyptogena ponderosa (NS, NWC, SWC)

Vesycomia sp. (SWC)

Gastropod ind. (NWC, SWC)

NS Northern Sector NWC Northwest Crater SWC Southwest Crater
Micro-Macro-benthic Fauna at Woolsey Mound

20 taxa belonging to the following Phyla:
Gammaproteobacteria, Anellida, Mollusca, Arthropoda, Echinodermata, Cnidaria.

Bathynomus giganteus (SWC)
Chaceon sp. (NS, NWC, SWC)
Munida sp. (NWC, SWC)

Echinide ind. (NWC, SWC)
Asteroschema sp. (NWC, SWC)
Holothuria (NWC, SWC)
Asteroidea ind., (NS, NWC, SWC)

Chrysogorgia sp. (NWC, SWC)
Madrepora oculata (NWC, SWC)
Desmophillum sp. (NWC, SWC)
Paramuricea sp. (NWC, SWC)
Benthic Fauna Distribution Map

Northern Sector:
Low Biological Diversity

Northwest Crater:
Medium Biological Diversity

Southwest Crater:
High Biological Diversity
Underwater Photo-mosaic Technique

Compilation of a series of overlapping photographs into a single large image

Very High Resolution image and extremely precise position

100% seafloor coverage

2 photo-mosaics at the Southwest Crater have been done, where we have found a Deep-sea Coral Community (Madrepora oculata field)
Photo-mosaics T1 and X (MC118 Southwest crater)

Photo-mosaic T1
Area: 24,78 m²
Depth: 882 m
65 still images

Location area (SW Crater)

Photo-mosaic X
Area: 52,465 m²
Depth: 882 m
75 still images

The University of Mississippi
Madrepora oculata has been found so far in only three sites in the Gulf of Mexico (MC 118, MC 885, AV 047).

Photo-mosaic A
Area: 39,477 m²
Depth: 880 m
70 still images

Photo-mosaic A (Atwater Valley 047)

Area: 39,477 m²
Depth: 880 m
70 still images

Madrepora oculata has been found so far in only three sites in the Gulf of Mexico (MC 118, MC 885, AV 047).
Photo-mosaics GIS statistical analysis (ArcGIS)

Mosaic T1

Mosaic X

Mosaic A

Legend
- Anemones T1
- Golden Crab T1
- Galaxias Crab T1
- Fishes T1
- Perimeter T1
- Marker T1
- Clamsbed T1

Vector Elements

Polygons: No-Mobile Fauna and Substrate Types
Points: Mobile Fauna

MC 118

AV 047
Data sets integration

Video/image data
Biological data
Acoustic data
Geological data
Samples
Photo-mosaics

Identification of different habitats

Benthic Habitat Map
Benthic Habitat Map at Woolsey Mound

Deep Sea Coral Community: Northwest Crater and Southwest Crater

Madrepora oculata
Chryssogorgia sp.
Paramuricea sp.

Pogonophora field: peripheral areas of the craters

Deep Sea Bedrock: NWC, SWC

Soft coral and golden crabs
Golden crabs
Gastropods with bacteria on dark sediment
MC 118 Habitat Model: An ideal W-E profile across the SW Crater

Legend
- Methane plume
- Authigenic carbonate slabs and pavements
- Zoarcid fish
- Ophiucre
- Ice worm
- Oloturie
- Tube worms - Pogonophora
- Upward Hydrocarbon gases
- Deep water corals
- Crab
- Starfish
- Rest of shells
- Infaunal and epifaunal molluscs
- Fractures and cracks
- Gas Hydrates
- Fractures, Faults and Fractures
- CH$_4$ oxidizing & SO$_4^{2-}$ reduction Bacteria produce H$_2$S
- Thermogenic Oil and Gas
- Bacterial mats

Preliminary habitat model based on the integration of all data sets
Deepwater Horizon Disaster

Deep-water Coral study sites “Lophelia II” Cruise
Oct 14- Nov 4-2010, BOEMRE / NOAA

Estimation of the Oil Plume: 2 km wide; 35 km long; 1.100 m underwater
Corals produce mucus in stressed environment
Oil Spill impact at Mississippi Canyon 338

Soft corals and brittle stars covered by brown material

Jason II, Lophelia II Cruise (Oct, 2010)
Results to date

This study defines the bio geo-lithological complexity of the Woolsey Mound;

From the photo and video analysis, it has been possible to classify 4 main classes and 8 sub-classes of substrates at Woolsey Mound;

The definition of the different substrate types (Sediment Distribution Map) shows a positive trend from North to South;

The identification of the general biology (missing aspect in the previous study of the area) shows the same positive trend corresponding with the lithological trend;

The photo-mosaics study has been used to realize the characterization of the Deep-Sea Coral Community;

Benthic Habitat Mapping and Habitat Model through the integration of acoustic, geological and videos/images data;

Possible Oil Spill impact at MC 118;

Identification of other significant areas within the mound that have not been studied and that would be interesting to investigate in the future.
Moving forward

Preliminary Observations:

- According to the Habitat Map, Woolsey Mound could be considered as a “mature” stage of the Cold Seep Succession (Biocenosis of deep sea corals) even if the earlier stages’ characteristics are present in parts of the mound, showing a positive diversity trend from north to south. The corals are at least hundreds of years old which means the seepage essentially “stopped” then.

- The seismic dataset shows salt driven tectonics still active. The master faults from the salt body intersect the seafloor. The identification of a very dense pattern of minor faults all around the mound implies that the migration of gas and fluid hydrocarbons could be still going on.

- Gas hydrates outcrop and extend into the sediments. The gas hydrates formation/dissociation could play a crucial role to the seepage.

We are developing a new approach to characterize cold seep areas (BIO-SEISMIC) trying to match known fauna sites with the sub-seafloor geophysical features. This approach has been presented to the AAPG-ICE October 2011 in Milan.
Thanks for your attention

Acknowledgements

BOEM - NOAA - DOE
Questions:

• How the seepage is ruled by the gas hydrates formation/dissociation?

• Do we have “three” different fluid regimes within the mound?

• Which are the mechanisms that govern such small scale differences?

Knowing more about what is on the seafloor (biology), more about the sub-seafloor (seismic), we need to investigate the gap in between them improving the geochemistry (of the gas hydrates) that is the missing link to our new approach.
General setting in the Northern Gulf of Mexico

Cold Seep Environment at MC118
During the past year we acquired new data including:

- **Jumbo Piston Cores (January 2011);**
- **AUV Side Scan Sonar (April 2011 Navy Cruise, resolution 10 cm);**
- **Data from the BBLA (April and October 2011);**
- **OBS data (April 2011);**
- **Data from the ROVARD (July 2011);**