

# Depositional Environments of Jeffreys Ledge, Western Gulf of Maine: Impacts of Glaciation, Sea-Level Fluctuations and Marine Processes Assessed Using High Resolution Multibeam Bathymetry, Subbottom Seismics, Videography, and Direct Sampling (OS31A-0975)

Larry Ward<sup>1</sup> ([larry.ward@unh.edu](mailto:larry.ward@unh.edu)), Paul Johnson<sup>1</sup> ([pjohnson@ccom.unh.edu](mailto:pjohnson@ccom.unh.edu)), Mashkoor Malik<sup>1,2</sup> ([Mashkoor.Malik@noaa.gov](mailto:Mashkoor.Malik@noaa.gov)), and Raymond Grizzle<sup>3</sup> ([ray.grizzle@unh.edu](mailto:ray.grizzle@unh.edu))



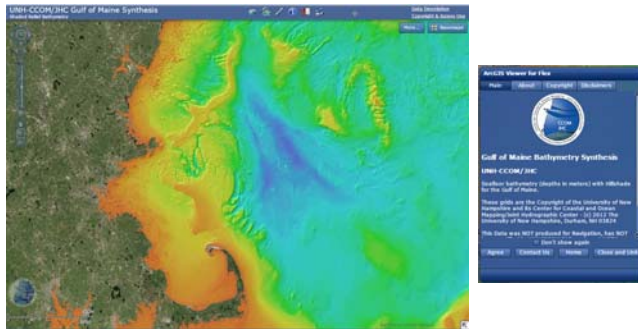
1. Center for Coastal and Ocean Mapping/Joint Hydrographic Center, School of Marine Science and Ocean Engineering, University of New Hampshire, Durham, NH 03824, USA
2. NOAA Office of Coast Survey, 1315 East West Highway, Silver Spring, MD 20910, USA
3. Jackson Estuarine Laboratory, School of Marine Science and Ocean Engineering, University of New Hampshire, Durham, NH 03824, USA



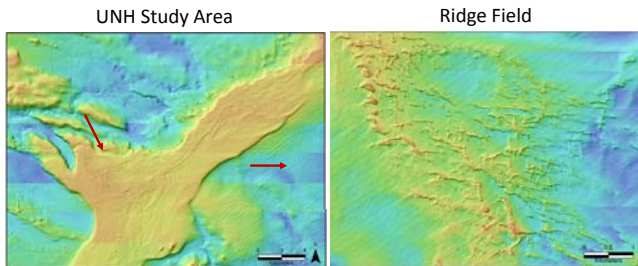
## Introduction

Jeffreys Ledge, located ~50 km off the coast of New Hampshire, USA, is a major physiographic feature in the western Gulf of Maine (WGOM), extending over 100 km along its axis, while generally only being 5 to 10 km in width (~20 km maximum). The feature rises over 200 m from nearby basins to depths less than 50 m on the ridge surface. A major study was undertaken at Jeffreys Ledge in order to assess the roles of glaciation, sea-level fluctuations, and marine processes on the development of the major depositional environments. The study focused on an ~500 sq km area that extended from the shallowest reaches to the deep adjacent basins (UNH Study Area shown below) utilizing high resolution multibeam echosounder bathymetry (synthesized and gridded at the highest possible resolution), videography and bottom sediment sampling for describing and classifying the bottom sediments, and subbottom seismics. Presented here are the following: a new high resolution bathymetric map (1); a bottom sediment classification developed for gravel environments (2); a surficial sediment map of the UNH study area (3), and description and examples of future work at Jeffreys Ledge (4).

## 1. WGOM Bathymetry Synthesis



Important to studies of marine environments, including the work presented here, is a detailed depiction of the bathymetry of the seafloor. Therefore, the UNH Center for Coastal and Ocean Mapping/Joint Hydrographic Center developed a synthesis of all of the high resolution multibeam bathymetric echosounder surveys (MBES) available in the Western Gulf of Maine (WGOM), as well as earlier, lower resolution surveys. The new bathymetric maps display the bathymetry at the highest resolution possible. In addition, the WGOM Bathymetry Synthesis (gridded at 8 m) and shown above is available online at the following site: [http://ccom.unh.edu/gis/flexviewers/GulfOfMaine\\_Regional\\_8m/](http://ccom.unh.edu/gis/flexviewers/GulfOfMaine_Regional_8m/).



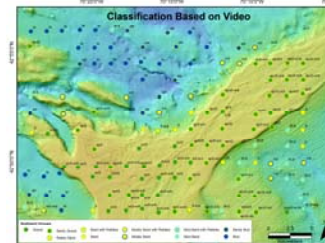
Two examples of the WGOM Bathymetry Synthesis are shown above. The figure on the left is located near the middle reach of Jeffreys Ledge and is gridded at 5 m. This area is the focus of the study presented here. Note the ridge field (unknown origin) on the upper left (arrow) and the iceberg scours (arrow) on the bottom right of the figure. The figure on the right shows the ridge field in higher resolution (gridded at 2 m).

## 2. Seafloor Sediment Classification

Classification of the bottom sediment on and in the vicinity of Jeffreys Ledge required two approaches. Where possible, the bottom was directly sampled for grain size. This was particularly successful in the muddy basins and sandier regions surrounding Jeffreys Ledge. However, much of the UNH Study Area located on Jeffreys Ledge was composed of gravels where direct sampling with standard box cores or grab samplers (Shipek) was impossible. Here a classification based on the video was developed.

### Video Classification

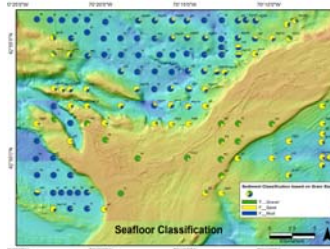
Seafloor Classification	Gravel or Cobble or Separately Sized	% of Frames With Pebbles	% of Frames With Cobbles
Muddy Gravel	> 50%	< 50%	< 50%
Muddy Gravel with Cobble	> 50%	30-50%	< 50%
Muddy Gravel with Cobble and Boulder	> 50%	30-50%	30-50%
Gravel	> 50%	> 50%	< 50%
Muddy and Cobble Gravel	> 50%	> 50%	30-50%
Muddy Cobble and Boulder Gravel	> 50%	> 50%	> 50%
Separated Gravel	> 50%	< 50%	< 50%
Gravel with Cobble	> 50%	30-50%	< 50%
Muddy Gravel with Cobble and Boulder	> 50%	30-50%	30-50%
Muddy and Cobble Gravel	> 50%	> 50%	< 50%
Muddy Cobble and Boulder Gravel	> 50%	> 50%	> 50%



The descriptive classification for the bottom sediment adapted for this study is primarily based on visual inspection of the video and an estimation of grain size (with the aid of lasers; see images below). At each station, a portion of the video transect that typically extended ~25 to ~50 m in length was isolated for analysis. Bottom sediment viewed in each frame was first described as mud-sand or gravel. If the gravel size clasts were largely in contact, the bottom was classified as a gravel with the appropriate modifiers (see Table 1). If the gravel clasts were separated by sand or granule material, then the seafloor was classified as a sandy gravel with the appropriate modifiers. Examples of the video classification are given below.



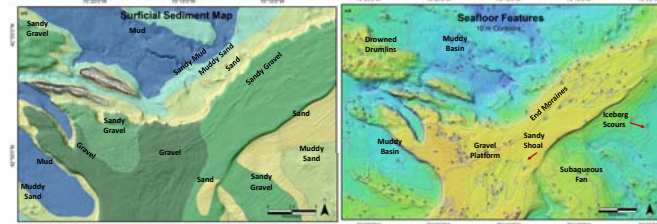
### Direct Sampling



Bottom samples were collected and analyzed for grain size at 124 stations where the sediment size of the seafloor allowed box coring or grab sampling. Subsequently, the samples were classified based on standard procedures (after Folk, R.L. 1980. *Petrology of Sedimentary Rocks*. Hemphill Publishing Company, Austin, TX. 182 pp.). Shown in the left figure are the Gravel/Sand/Mud Ratio and the Sediment Classification.

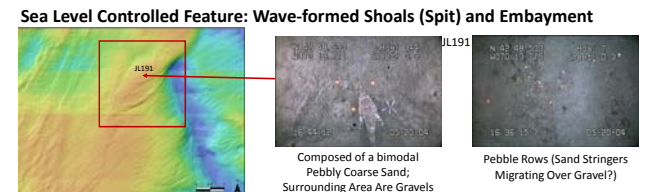
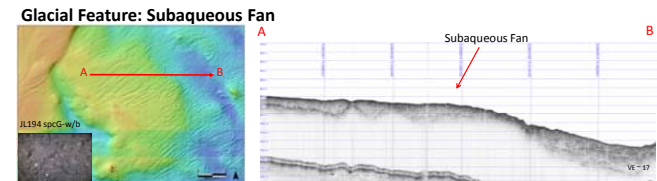
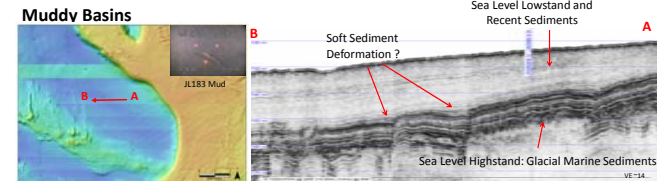
## 3. Major Depositional Environments and Features

The bottom sediment classifications (using both video for the gravel and direct sampling for the sand and mud fractions), coupled with the high resolution multibeam bathymetry, were used to develop the surficial sediment map and the features map of the study area. Note on the Surficial Sediment Map that the contoured area has not been mapped.



## 4. Future Work

Presently, efforts are focused on defining and interpreting the major morphologic and sedimentologic features of Jeffreys Ledge. Of special interest are features that are related to the glacial history, as well as those modified or formed by marine processes. Below are examples of a Muddy Basin and a Subaqueous Fan (?) along with associated subbottom seismic profiles and bottom images. Also shown is a sand body that was likely formed by wave processes during the sea level lowstand.



## 5. Acknowledgements

The study was funded by UNH/NOAA Atlantic Marine Aquaculture Center (AMAC), the UNH/NOAA Northeast Consortium (NEC), and the UNH/NOAA Joint Hydrographic Center (Award NA10NOS4000073). Bottom sediment sampling was done using fishing vessels captained by P. Kendall, C. Mavrikis, and J. Driscoll. Science Applications International Corporation (SAIC) conducted the bathymetry survey of the UNH study area.