Submarine, Hurricane-Initiated Shelf Failure Morphodynamics, Mississippi River Delta Front, North-Central Gulf of Mexico, USA

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Abstract

Seafloor sediment instability along the Mississippi River Delta Front (MRDF) has gained renewed attention since the landfall of Hurricanes Ivan (2004) and Katrina (2005). Traditional root causes for MRDF shelf failure were accelerated by sea-state conditions associated with these severe tropical cyclones. These conditions are characterized by excessive wave heights, wave periods and wave-induced turbulence in the bottom boundary layer and throughout the water column.

To evaluate morphologic seafloor change through time, an investigation of 46 marine geohazard surveys spanning a 40-year time period was carried out over four test areas in the South Pass, Main Pass and Viosca Knoll Protraction Areas. These survey results, based on comparisons of bathymetry, side-scan sonar, sub-bottom profile and high-resolution 2D seismic data (where available), reveal substantial changes in seafloor bathymetry and the immediate subsurface sediment profile. We hypothesize these changes as the end result of cyclic wave-seafloor interaction, seafloor scour and failure, and the re-initiation of antecedent seafloor slides and subsequent sediment re-deposition. These findings demonstrate the complex, cross-cutting depositional history within the MRDF study area and its implication on GOM oil and gas infrastructure, mainly among fixed production platforms and pipelines.

Changes in seafloor morphology were then compared to observed and hindcast metocean conditions for five major hurricanes (Category 3+ on the Saffir-Simpson Scale) that traversed over or near the MRDF from 1965-2005. A series of numerical wave models, calibrated to the observed response from recent storms, were performed in MIKE 21 modeling software to depict prior storm conditions for which no direct observations could be made. These results were then integrated with key lithologic and geotechnical parameters from multiple databases within the four test areas. The integration of these parameters, along with known seafloor morphology change through time, helps quantify the risk of and seafloor response to future hurricane-induced seafloor failure.