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STUDY TITLE: Impacts of Recent Hurricane Activity on Historic Shipwrecks in the Gulf of Mexico Outer Continental Shelf

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BACKGROUND: Within a four week period in the second half of 2005, the Gulf of Mexico (GOM) was significantly impacted by two major hurricanes, Katrina and Rita. The massive forces associated with these storms left a wide path of destruction and devastation not only in the coastal areas where they made landfall, but also on and beneath the waters of the GOM. The magnitude of this damage raised questions within the archeological arm of the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) regarding the potential environmental effects to shipwrecks lying on or embedded in the seabed when storms of such magnitude pass overhead. In response to the destructive forces of these two Category 5 hurricanes, BOEMRE allocated over $1.5 million through their Environmental Studies Program to conduct research on the impacts of these storms on natural and cultural resources. In January 2007, BOEMRE contracted PBS&J of Austin, Texas to assess the impacts of recent hurricane activity on selected historic shipwrecks in the GOM.

OBJECTIVES: (1) to conduct remote sensing surveys in order to document the macro-scale post-storm condition of the sites; (2) to compare and contrast pre- and post-storm remote-sensing data from each site; (3) to carry out diver investigations of selected sites

to document areas which had changed during the period between pre- and post-storm surveys; (4) to collect sedimentary samples in order to characterize the substrate; (5) to estimate peak storm conditions on the seafloor at each site based on wave-current interaction models; and (6) to conduct archival and historical research of the primary study sites to fill gaps in their histories.

DESCRIPTION: Ten wrecks were selected for investigation based on their proximity to the hurricane paths and on the availability of pre-storm archeological data. Each wreck was subjected to a magnetometer and side-scan sonar survey at 30 m transects during a remote-sensing cruise from May 8-11, 2007. The remote-sensing data were analyzed and compared to pre-storm sonar data in order to identify potential hurricane impacts. As a result, four of the wrecks were selected for further investigation during the dive cruise from October 1-10, 2007. Divers recorded visual observations, measurements, underwater photographs (when possible), DIDSON acoustic camera imagery, in the case of *New York*, a complete site map. Box cores of the localized sediment were collected in a diver-operated stainless steel collection device, separated into levels based on stratigraphy, and analyzed for particle size in the lab. The samples were measured for textural percentages using the hydrometer method.

Wave-current interaction models were run at each of the four primary study sites in order to qualitatively assess whether hydrodynamics induced by Hurricanes Katrina and Rita could have caused damage to study shipwrecks. Model input data relied on hindcast environmental conditions during each hurricane, and the physical parameters of each wreck. The resulting wave model used stream function wave theory, was fully nonlinear, and was mathematically valid in deep water.

An archival research trip was conducted from January 21 – February 1, 2008. Repositories visited include the Mariners' Museum in Newport News, Virginia, the Library of Congress, and the National Archives branches in Washington, D.C. and College Park, Maryland. Additional research was conducted through phone and email correspondence with The Smithsonian Museum of American History, the Naval Historical Center, the U.S. Coast Guard Historian's Office, Lloyd's of London, and the Special Collections of the New York Public Library. Several newspaper archives were also searched for any published accounts of the various vessels' wrecking events.

Two archeologists conducted a research trip to New Iberia, Louisiana, from December 1-5, 2008. Over 500 items were documented from the artifact assemblage of *New York*, which has been recovered during periodic site excavations by the salvage group *Gentlemen of Fortune.*

SIGNIFICANT CONCLUSIONS: The damage caused by hurricanes Katrina and Rita to the primary study wrecks was substantially less than anticipated based on the level of damage reported for artificial reef vessels in waters offshore of Florida. Exploring the reasons for this observation has led to formulation of a hypothesis that the level of damage to a shipwreck (or artificial reef vessel) is relatively high after the first one or two hurricane passages, and is progressively less following later storms. The preservation of articulated wooden hull and an *in situ* artifact assemblage on *New York*

has demonstrated the potential for burial to provide a high degree of protection from hurricane damage to many more historic wood-hulled vessels in the GOM. Finally, studies of storm damage to petroleum infrastructure demonstrate that hurricanes have the potential to cause indirect damage to shipwrecks that is anthropogenic in nature. This conclusion has potential implications for the regulation of petroleum industry activities and the management of submerged cultural resources in the GOM.

STUDY RESULTS: Six of the ten wrecks surveyed exhibited no discernible impacts from hurricane activity. Damage at *Castine* was inconclusive, though there was evidence that storm currents swept loose artifacts and debris off of the deck and onto the surrounding seafloor. Site 323 was more severely impacted by hurricane forces; a 20 ft-x-30 ft rupture was opened in the lower hull near the stern, and the starboard rudder had been removed. The hull breakage was exacerbated by the Beaumont Formation of Pleistocene sediments lying directly underneath the wreck. *Gulf Tide* also exhibited increased amounts of sediment burial compared to pre-storm sonar data; however, determination of any additional impacts was inconclusive. The vessel is broken into two sections and appears to have been salvaged shortly after its sinking. *New York* received no negative impacts from Hurricane Rita, and was instead returned to a state of protective equilibrium by redeposition of sediments that had been removed by site excavation prior to passage of the storm. These excavations have resulted in the most significant adverse affects to the site, including removal of archeologically important artifacts and acceleration of erosive chemical, physical, and biological processes.

The wave-current interaction model results indicate strong bottom currents at each wreck site during peak storm conditions. Each site experienced a severe back and forth surge of current velocities ranging from 5.6-7.6 mph in the direction of wave propagation, followed by current velocities of 1.6-2.9 mph in the opposite direction only a few seconds later. The estimated period of this repeating surge cycle ranged from 14.0-16.4 seconds. The wind gusts required to generate equivalent forces on the 4 primary study wrecks would range from 158-215 mph in the direction of wave propagation followed by winds of 44-82 mph in the opposite direction, equivalent to a Category V hurricane on the Saffir-Simpson Scale. The force transferred by wave action to the seafloor becomes greatly magnified as the wave heights build and as the water depth decreases.

A total of 538 items within 154 artifact lots were documented during the artifact cataloging process. Artifact classes include ship-related mechanical items; galley items such as ceramic dinnerware, silverware, and beverage bottles; and personal effects.

STUDY PRODUCT: PBS&J 2011. Impacts of Recent Hurricane Activity on Historic Shipwrecks in the Gulf of Mexico Outer Continental Shelf. A final report for the U.S. Dept of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEMRE 2011-003. 205 pp.