ENHANCING SAFETY DURING THE GLOBAL NUCLEAR RENAISSANCE

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# RESEARCH ON TSUNAMI HAZARD FOR THE ATLANTIC AND GULF COASTS

U.S.NRC
United States Nuclear Regulatory Commission
*Protecting People and the Environment*

OFFICE OF NUCLEAR REGULATORY RESEARCH

## BACKGROUND

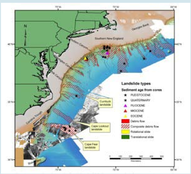
In response to the 2004 Indian Ocean Tsunami, the United States Nuclear Regulatory Commission (USNRC) initiated a long-term research program to improve understanding of tsunami hazard levels for nuclear power plants in the United States. To undertake this effort, the U.S. NRC organized a collaborative research project with the United States Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and other key researchers for the purpose of assessing tsunami hazards on the U.S. Atlantic and Gulf Coasts. This project represents the combined effort of a diverse group of marine geologists, geophysicists, geotechnical engineers, and hydrodynamic modelers.

The initial effort of this project consisted principally of collection, interpretation, and analysis of available offshore data and information. Necessarily, the analyses considered both seismic- and landslide-based tsunamigenic sources in both the near and the far fields. The incorporation of tsunamigenic landslides, an important category of sources that impact tsunami hazard levels for the Atlantic and Gulf Coasts over the long time periods of interest to the U.S. NRC, is a key difference between this program and previous tsunami hazard assessment programs, which are typically focused in the Pacific Ocean.

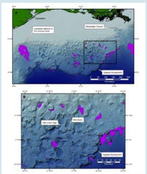
## COMPLETED WORK – PHASE 1

The initial phase of this work, undertaken by the USGS and now nearly complete, consisted of collection, interpretation, and analysis of available offshore data. Significant effort focused on characterizing offshore near-field landslides and analyzing their tsunamigenic potential and properties. The results of this work include an assessment and summary of the types, locations, sizes, and other key source parameters needed for tsunami modeling for a wide variety of sources. In some cases, mapped landslides were further investigated using geotechnical engineering-based analysis methods and the information was used in landslide-based tsunami initiation and propagation models to gain an understanding of the potential impact of mapped landslides off the continental shelf. This work provided important information needed to support later research objectives and meet the US NRC's long term research and regulatory goals. As a whole, the research performed to date has provided invaluable insights and information not previously available and can be considered the first, important step in and effort to determine tsunami hazard along the U.S. Atlantic and Gulf coasts.

Publically available NRC funded research report on potential sources affecting the US Atlantic and Gulf Coasts




Identification and classification of landslides off Atlantic Coast



Identification and classification of landslides off Gulf Coast

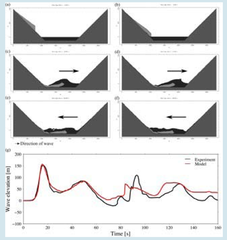
## CURRENT WORK – PHASE 2

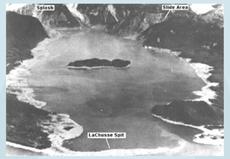
Phase 2 will be composed of two parts. The USGS will conduct field investigations in key locations of interest which currently lack sufficient existing data to perform a satisfactory assessment of sources. These data gaps were identified during Phase 1 of the research program.

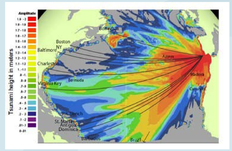
Simultaneously, NOAA's MOST tsunami generation and propagation model will be enhanced to include landslide-based initiation mechanisms. The enhanced MOST model will then be used to investigate the tsunamigenic sources identified and characterized in the research program to develop an estimation of deterministic tsunami hazard levels for the length of the Atlantic and Gulf Coasts.

This work by NOAA will include a validation effort based on the 1958 Lituya Bay Mega-tsunami and a comprehensive analysis of a potential Canary Islands landslide. While the scientific community does not endorse early studies showing a 25m high tsunami on the Atlantic coast as scientifically valid, some hazard does exist. To address this, the Canary Islands analysis study will consist of the most complete and robust assessment of the true potential of a failure of the La Palma Volcano.

The potential for probabilistic tsunami hazard assessment will also be explored in the final phases of the program.

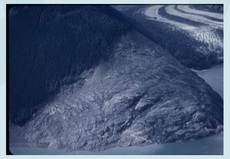



Modeling to understand source and effects of 1755 Lisbon earthquake and Tsunami

Example of head scarps from tsunamigenic landslides in the Hawaiian Islands similar to that hypothesized for Las Palmas Volcano in the Canary Islands



Laboratory testing, numerical modeling, and photographs of the Lituya Bay Megatsunami, which denuded the adjacent slopes to a height of 524m (1,720 ft). This case study will be used for validation of tsunamigenic landslide modeling tools

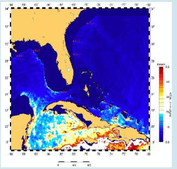
## TSUNAMIS ON THE ATLANTIC AND GULF COASTS?

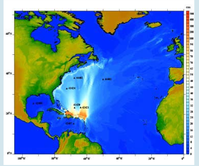
As with the source area for the 2004 Indian Ocean earthquake, where the recurrence interval for earthquakes of similar magnitude is greater than 1,000 years, many of the tsunamigenic fault zones in the Caribbean and Atlantic are characterized by low convergence rates. While these events have less impact on tsunami probability calculations for some applications (e.g., FEMA flood insurance rate maps), it is critical to account for these sources when defining the tsunami hazard at longer return periods used for design of nuclear power facilities.

The Atlantic and Gulf of Mexico coasts are highly vulnerable to tsunamis when they do occur because major population centers and industrial facilities are located near the shoreline at low-lying elevations, and often in estuaries. This is in comparison to the Pacific coast where tsunamis are more frequent but the coastline is more sparsely populated and most sections have much more topographic relief.

Following the Sumatra 2004 earthquake, a major concern was raised about a similar plate tectonic geometry existing in the Puerto Rico trench with a potential impact on the U.S. East Coast. The Puerto Rico trench is a curved subduction zone where, similar to the Sumatra trench, relative plate motion is strike slip with only a small component of subduction. Tsunami hazard due to thrust earthquakes was underestimated in the Sumatra trench because of the large component of strike slip.

Submarine landslides such as those that occur off the continental shelf have also historically generated destructive tsunamis, although the extent of damaging waves generated by landslides is generally more localized. Along coastlines proximal to catastrophic submarine landslides, tsunami run-up can be significant as exemplified by the 1929 Grand Banks tsunami (Newfoundland and Nova Scotia), which likely had a significant landslide-generated component and killed 32 people. Less is generally known about submarine landslides as tsunami triggers, in comparison to their earthquake counterparts.





Model results of two possible scenarios of ruptures in the Caribbean seismic zone

Early News report of 1929 "Grand Banks" earthquake and tsunami