Investigation of Submarine Landslides along the New England Margin with Implications to Tsunami Hazards

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Co-PIs

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Project Description

Tsunami hazard assessment is critical for coastal communities, emergency services, and industry for a regional risk assessment and response management of catastrophic events, such as those that occurred in 1998 in Papua New Guinea and 2004 in the Indian Ocean. Along the northeastern United States coastline, tsunami hazard assessment is in its infancy due to the lack of historical tsunami record and the uncertainty regarding the return periods of potential large-scale events, such as a large transoceanic tsunami caused by a collapse of the Cumbre Vieja volcano in the Canary Islands, or a large co-seismic tsunami initiated in the Puerto Rican subduction zone. Moreover, considerable geologic and some historical (e.g., the 1929 Grand Bank landslide tsunami) evidence suggests that the most significant tsunami hazard in this region may arise from submarine mass movements triggered on the continental slope by moderate seismic activity; such tsunamigenic landslides can potentially cause concentrated coastal damage affecting specific communities.

A probabilistic geotechnical and tsunami impact analysis that estimates coastal hazard on the upper northeast coast of the United States was recently completed by PIs Baxter and Grilli (Grilli et al. 2009). This project was funded by FM Global, Inc., which is a large, Rhode Island based insurance company. The study involved a large number of slope stability analyses that investigated the role of earthquakes in the triggering of submarine landslides and the resulting tsunamis and runup caused by such failures. The resulting first-order estimate of the overall tsunami hazard in this region was found to be quite low at most locations as compared to the typical 100 year hurricane storm surge in the region (~5m). However, there were two locations along the coast of Long Island, NY and New Jersey that had an elevated tsunami hazard. The

locations along New Jersey (Figure 1) had the highest hazard, with an estimated peak inundation of approximately 4-m.

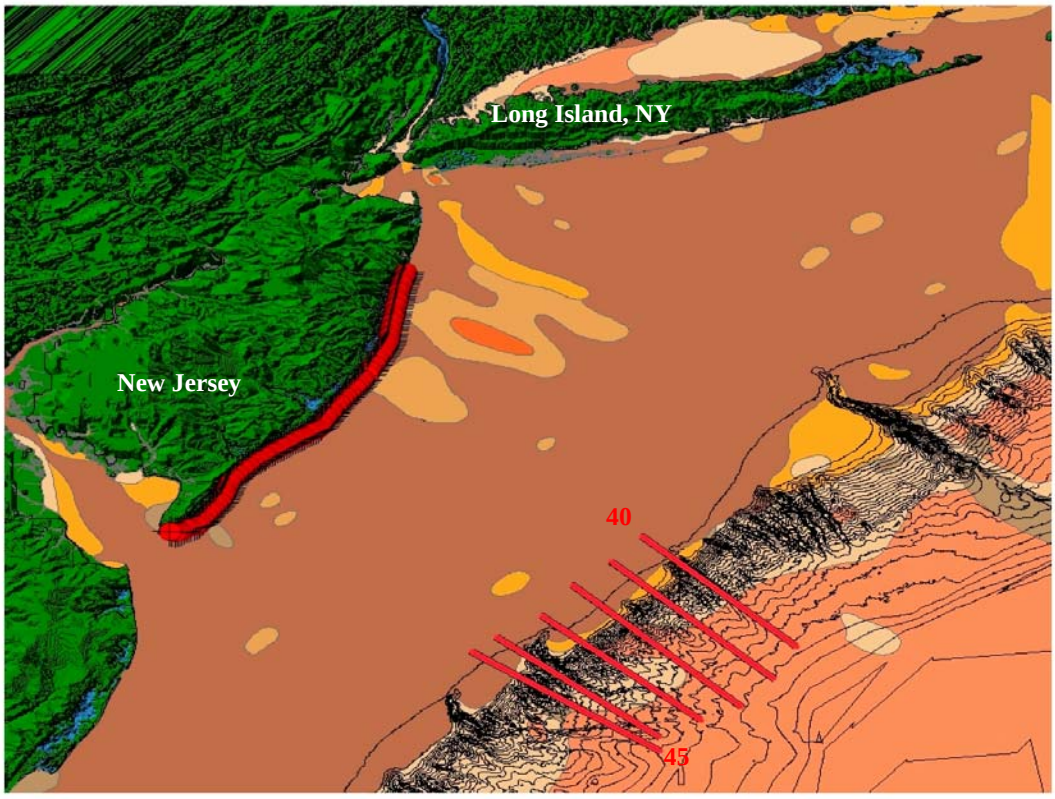

Figure 1. Transects along the New Jersey coastline in which submarine landslides pose an elevated tsunami hazard (up to 4-m of inundation for a 500-year tsunami event).

A parallel study of tsunami hazards along the U.S. east coast is being conducted by scientists from the United States Geological Survey on behalf of the Nuclear Regulatory Commission. A significant portion of this work has involved detailed characterization of the number, size and frequency of large submarine landslides in this region (Chaytor et al. 2009). This work has been conducted mostly using existing bathymetric and seismic data, although new multibeam mapping of the region will be conducted in the summer 2009 (see Figure 2).

What is missing from these complementary research projects at URI and USGS is high quality sediment samples for dating of existing failures and evaluation of the shear strength of the slopes for stability analyses. This information is critical to provide proper "ground truth" for the assumptions made in both the current stability of the slopes and the recurrence of large failures. **Therefore, we propose to conduct a 7-day cruise to obtain gravity cores at two locations off the coast of Rhode Island and New Jersey where we have identified submarine landslides with a possible link to seismically induced tsunamis.**

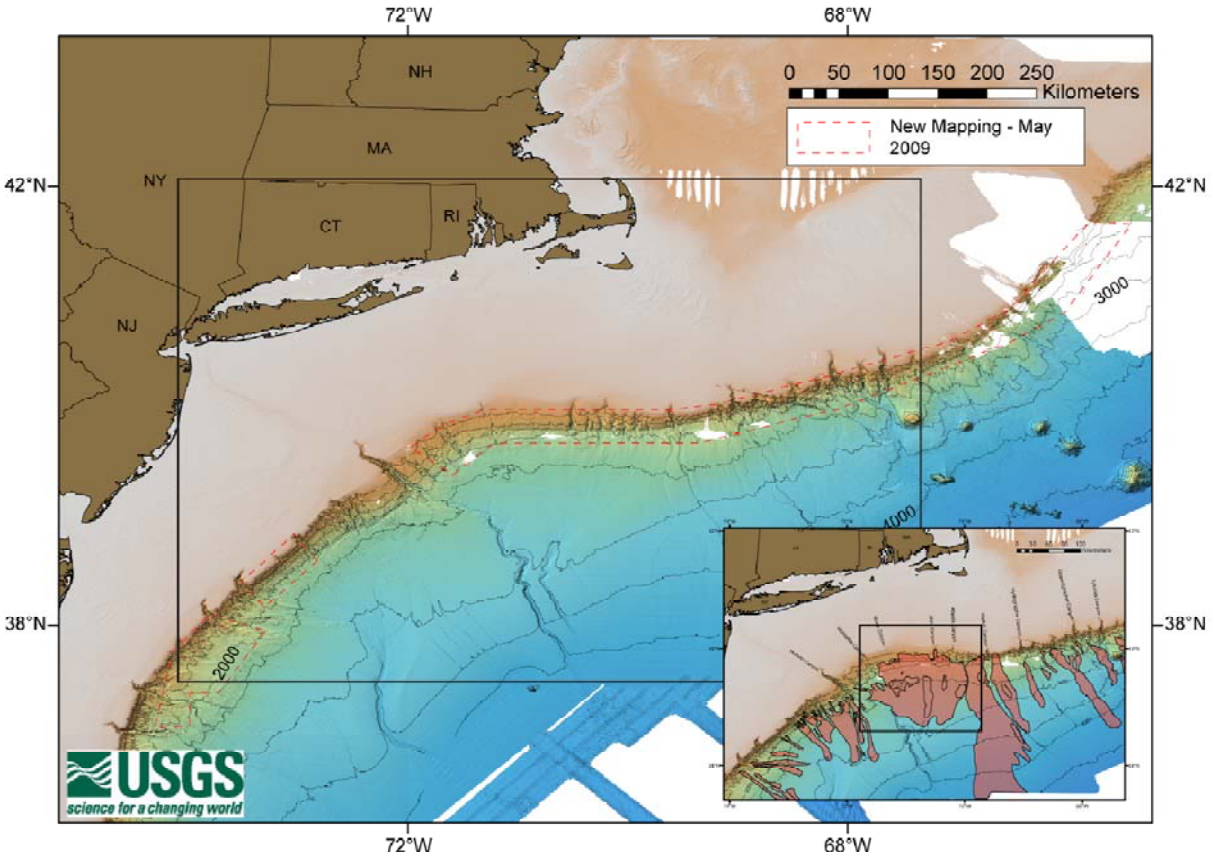

Figure 2. Area of interest for current USGS study. Detail in the inset shows the location of mapped landslides in the Southern New England slope/rise region as well as the location of major canyons.

Education and Outreach

There will be significant participation in this cruise by both undergraduate and graduate ocean engineering students. This has been done successfully on at least two previous RIEP cruises (e.g. John King's SAMP cruise in 2008 and Kate Moran's PIES cruise in 2007). Feedback from the students on both cruises was extremely positive and highlights the importance of hands-on educational experiences in the training of future ocean engineers and scientists.

Relationship of Proposed Effort to Other Funded Research

As mentioned previously, the proposed cruise builds on two-years of funded research from a private insurance company (FM Global, Inc.) and an on-going study at the U.S. Geological Survey. Neither of these projects have funds available to obtain sediment samples from the study area, therefore the RI Endeavor program provides a unique opportunity to leverage the efforts of these two research groups.

Proposed Schedule and Shipboard Details

Ship time is requested for 7-days in September or October 2009. This includes approximately 36 hours for transit (12 hours to the first site, 12 hours to the second site, and 18 hours return trip). Gravity cores will be taken at locations on the continental slope and rise off the coast of Rhode Island (39° 45' N, 70° 56' W) and New Jersey (38° 53' N, 72° 32' W). Figure 3 shows proposed core locations for the Rhode Island site. Water depths at the proposed coring locations will range from 500 to 2500 m. The ocean engineering department's Large-Diameter Gravity Corer will be used, which can obtain 10 cm diameter, 3 m long samples in soft sediments. This system was used successfully on the Endeavor in 2007 by Kate Moran in the same study area. This request is for a total of seven days of ship time at a day rate of $20,000 per day for a total request of $140,000.

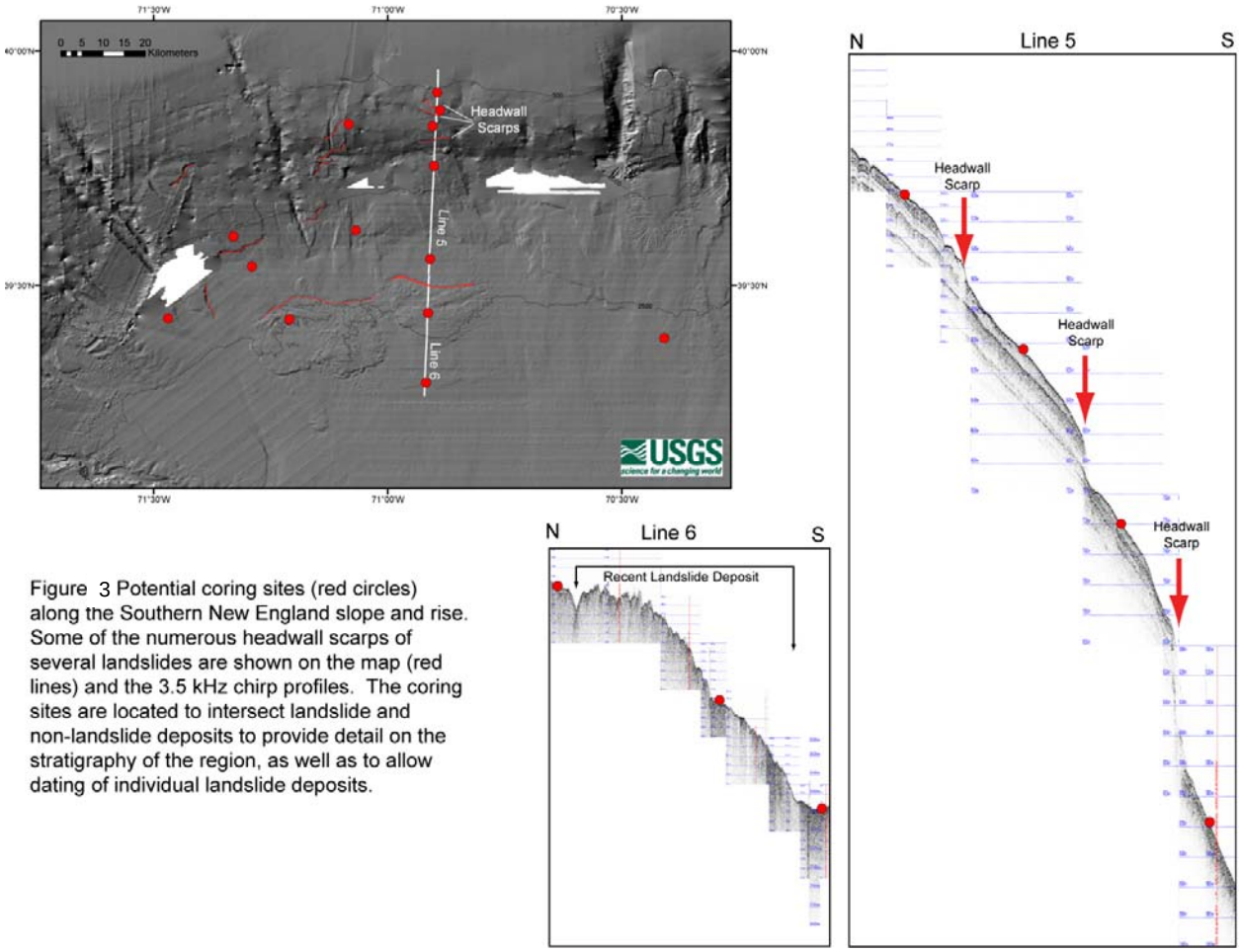

Figure 3 Potential coring sites (red circles) along the Southern New England slope and rise. Some of the numerous headwall scarps of several landslides are shown on the map (red lines) and the 3.5 kHz chirp profiles. The coring sites are located to intersect landslide and non-landslide deposits to provide detail on the stratigraphy of the region, as well as to allow dating of individual landslide deposits.

Shipboard Participants

Chris Baxter (Chief Scientist), URI
Jason Chaytor (Co-Chief Scientist), USGS
Stephan Grilli, URI
Uri ten Brink, USGS
Oliver Taylor (Ph.D. student), and other ocean engineering students, URI

Curriculum Vitae for Christopher D. P. Baxter, Ph.D., P. E.

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Education

B.S. Tufts University (Civil Engineering), 1990.
M.S. Purdue University (Civil Engineering), 1994.
Ph.D. Virginia Tech (Civil Engineering), 1999.

Experience

Associate Professor, Departments of Ocean/Civil and Environmental Engineering, University of Rhode Island, 2000-present.
Research Fellow, Norwegian Geotechnical Institute/International Center for Geohazards, Oslo, 2007.
Post-doctoral Fellow/Laboratory Manager, Marine Geomechanics Laboratory, Department of Ocean Engineering, University of Rhode Island, 1999-2000.
Instructor, Department of Civil Engineering, Virginia Tech, 1998-1999.
Research Assistant, Department of Civil Engineering, Virginia Tech, 1994-1999.
Research Assistant, Department of Civil Engineering, Purdue University, 1992-1994.
Geotechnical Engineer, GZA GeoEnvironmental, Inc., Trumbull, CT, 1990-1992.

Relevant Publications for the RIEP Proposal

Grilli, S.J., Taylor, O.-D., Baxter, C.D.P., and Maretzki, S. (2009). Probabilistic Approach for Determining Submarine Landslide Tsunami Hazard along the Upper East Coast of the United States, *Marine Geology* (accepted for publication).

El Bettah, M., S.T. Grilli, C.D.P. Baxter, K. Bollinger, M. Krafczyk and C. Janssen (2008). A microfluidics study of the triggering of underwater landslides by earthquakes. *In Proc. 18th Offshore and Polar Engng. Conf. (ISOPE08, Vancouver, Canada, July 2008)*, 8 pps.

Bradshaw, A.S. Baxter, C.D.P. Taylor, O., and Grilli, S.T. (2007). Role of Basal Resistance on the Initial Acceleration of Tsunamigenic Landslides, *3rd International Conference on Submarine Mass Movements and Their Consequences*, Santorini, Italy, 387-394.

Maretzki, S., Grilli, S., and Baxter, (2007). Probabilistic SMF Tsunami Hazard Assessment for the upper East Coast of the United States, *3rd International Conference on Submarine Mass Movements and Their Consequences*, Santorini, Italy, pp. 377-385.

Silva, A.J., Baxter, C.D.P., LaRosa, P.T., and Bryant, W.R. (2004). Investigation of Mass Wasting on the Continental Slope and Rise, *Marine Geology*, 203 (3-4), 355-366.

Baxter, C.D.P, King, J.W., Silva, A.J., and Bryant, W.R. (2003). Investigation of the Age of Submarine Slope Failures in the Gulf of Mexico, *Proceedings of the International Society of Offshore and Polar Engineers Conference*, June, Honolulu.

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Education:

2001-2006 Ph.D. Geological Oceanography, Oregon State University, Corvallis, OR
1997-2000 B. App. Sci. (Honours-First Class) Geology, Queensland University of Technology, Brisbane, Australia

Employment and Professional Experience:

- Postdoctoral Scholar, Woods Hole Oceanographic Institution, 2006-present
- Research Assistant, College of Oceanic & Atmospheric Sciences, Oregon State University, 2001-2006
- Instructor, Geoscience Department, Oregon State University, 2006
- Geologist-Technical Assistant, Oil Company of Australia, Brisbane, Australia 1999-2001

Research Cruises:

2008 - *Chief Scientist*, R/V Seward Johnson, Gravity coring of landslides and seismites around Puerto Rico and the U.S. Virgin Island
- R/V Oceanus, WHOI AUV 'Sentry' science payload test cruise
2007 - NOAA Ship Nancy Foster, High-resolution multibeam mapping of Mona Passage, offshore western Puerto Rico
2005 - F/V Velero IV, High-resolution multibeam mapping offshore southern California
- R/V Thomas G. Thompson, NOAA NWFSC Advanced Technologies Cruise II, multibeam mapping of shallow banks off the west coast of the United States
2004 - R/V Thomas Thompson/CSSF ROPOS, NOAA NWFSC Advanced Technologies Cruise, California Borderland
- *Co-chief scientist*, F/V Velero/DELTA submersible, NURP Active Tectonics of the Peninsular Ranges-Transverse Ranges Intersection, California Borderland
- R/V Atlantis/DSRV ALVIN, NOAA OE Gulf of Alaska Seamounts Expedition
2003 - F/V Velero/DELTA submerisble, NURP Active Tectonics of the Peninsular Ranges-Transverse Ranges Intersection, California Borderland
2002 - R/V Roger Revelle, Paleoseismic Investigation of the Northern San Andreas Fault, Northern & Central California Margin
2001 - F/V Auriga, NOAA OE Lewis & Clark Legacy, Astoria Canyon Mapping

Selected Recent Publications:

Chaytor, J. D., ten Brink, U. S., Solow, A. R., and Andrews, B. D., Size distribution of submarine landslides along the U.S. Atlantic Margin and its implications to tsunami hazards. Marine Geology, 10.1016/j.margeo.2008.08.007, *in press*.

Twichell, D. C., Chaytor, J. D., ten Brink, U. S., and Buczkowski, B., Geologic Controls on the Distribution of Submarine Landslides along the US Atlantic Continental Margin. Marine Geology, *doi:10.1016/j.margeo.2009.01.00.*

Geist, E. L., Lynett, P. J., and Chaytor, J. D., Hydrodynamic Modeling of Tsunamis from the Currituck Landslide. Marine Geology, *doi:10.1016/j.margeo.2008.09.005*.

Chaytor, J. D., Goldfinger, C., Meiner, M. A., Huftile, G. J., Romsos, C. G., and Legg, M. R., 2008, Measuring vertical tectonic motion at the intersection of the Santa Cruz-Catalina Ridge and Northern Channel Islands Platform, California Continental Borderland, using submerged paleoshorelines, Geological Society of America Bulletin, 120, 1053-1071.

Goldfinger, C., Grijalva, K., Burgmann, R., Morey, A.E., Johnson, J.E., Nelson, C.H., Gutierrez-Pastor, J., Karabanov, E., Chaytor, J.D., Patton, J., and Gracia, E., 2008, Late Holocene Rupture of the Northern San Andreas Fault and Possible Stress Linkage to the Cascadia Subduction Zone, Bulletin of the Seismological Society of America, 98, 861-889.

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Chaytor, J.D., R.A. Keller, R.A. Duncan, and R.P. Dziak, 2007, Seamount morphology in the Bowie and Cobb hotspot trails, Gulf of Alaska. Geochem. Geophys. Geosys. 8(9), doi:10.1029/2007GC001712.

Chaytor, J. D., Twichell, D. C., ten Brink, U. S., Buczkowski, B. D., and Andrews, B. D. 2007. Revisiting submarine mass movements along the U.S. Atlantic continental margin: Implications for tsunami hazards, in: Sakellariou, D. and Lykousis, V. (eds.) Submarine Mass Movements and Their Consequences, Springer, New York, p. 395-403.

Goldfinger, C, Morey, A. E., Nelson, C. H., Pastor, J. G., Johnson, J. E., Karabanov, E. Chaytor, J., Ericsson, A., and Shipboard Scientific Party. 2007. Rupture lengths and temporal history of significant Earthquakes on the offshore and north coast segments of the Northern San Andreas Fault based on turbidite stratigraphy. Earth and Planetary Science Letters, 254, 9-27.

Legg, M. R., Goldfinger, C., Kamerling, M. J., Chaytor, J. D., and Einstein, D. E., 2007, Morphology, structure and evolution of California Continental Borderland restraining bends, in Cunningham, W. D. and Mann, P. (eds.), Tectonics of Strike-slip Restraining and Releasing Bends, Geological Society, London, Special Publications, 290, 143-168.