

***Developing a Chronostratigraphy for Sediment Cores from Gilgo Beach Marsh, Long Island, NY***

**By E. Christa Farmer, J Bret Bennington, Courtney Melrose, Matthew Jensen, Amy Hoffmann,  
Tami Longjohn, and Luciana Noboa**

**Hofstra University Geology Department**

**9 April 2011**

**Long Island Geologists Eighteenth Conference**

**Introduction:**

Hurricane Frederic, which struck Alabama in 1979, left distinctive sediment deposits in Lake Shelby when the 4.8m storm surge overtopped the barrier beach. Studies of the sediment layers in the lake discovered a 9cm layer of white sand within the normally marshy lake sediments that was apparently left by Frederic. Radiocarbon dating of other sand layers implied that they were deposited by prehistoric storms, with a recurrence interval of Category 4-5 storms of around 600 years (Liu and Fearn 1993). This study launched the field now known as paleotempestology, in which past hurricane activity is inferred from geologic proxies.

Other locations along the Gulf Coast have yielded similar deposits. Western Lake, in western Florida, provides the best evidence for the impact of hurricanes on coastal lake sediments: a sediment core collected after the passage of Hurricane Opal in 1995 shows a 1.5cm sand layer that was not present in sediment cores collected before the hurricane strike. Deeper layers in several sediment cores indicate that hurricane strikes may have been stronger and more frequent between 1400 and 3400 radiocarbon years ago (Liu and Fearn 2000). Similar downcore patterns in the Lake Shelby sediments indicate that these shifts are truly due to changes in hurricane landfalls. Other evidence shows that the Bermuda High was located further north and east during the mid-Holocene (~6000 radiocarbon years ago). Liu and Fearn suggested that perhaps this drove tropical Atlantic hurricane systems northward along the Atlantic coast of North America rather than into the Gulf of Mexico. By ~3000 radiocarbon years ago, they suggest that the Jet Stream and Bermuda High had shifted south, directing hurricanes into the Gulf of Mexico rather than up the Atlantic coast (Liu and Fearn 2000).

Sediment cores from barrier beach island marshes on Long Island, New York have also been shown to have sand layers associated with hurricane overwash deposits. The patterns of hurricane landfalls they imply, however, are more similar in timing to the records from the Gulf Coast than they are opposite (Scileppi and Donnelly 2007). This calls into question the hypothesis advanced by Liu and Fearn (2000). Additional sediment records from the northeastern coast of North America are necessary to test the competing hypotheses governing long-term trends in the frequency and intensity of tropical Atlantic hurricanes.

Intending to expand the reconstruction of historic and prehistoric hurricane landfall events to locations further East on Long Island, six sediment cores were collected in the summer of 2010 from Gilgo Beach, NY (see Figure 1). Initial studies of these cores have focused on establishing

timelines for the ages of the sedimentary layers that were revealed in the cores. The primary tool used so far to accomplish this is measuring concentrations of trace metals in the various layers. Several studies have indicated that trace metal concentrations (particularly Cu, Pb, and Zn) have been shown to increase dramatically in sediments deposited after the Industrial Revolution. The timing of this increase has been given as the mid 1800s in the Northeastern U.S. (Scileppi and Donnelly 2007), around 1900 in Rhode Island (Bricker 1993), and around 1940 in Maryland (Marcus, Nielsen et al. 1993).

### **Methods:**

Of the six cores collected, we chose two with the most dramatic layering for trace metal analysis. Samples of approximately 5-10g were removed from ten selected depths (marking transitions between different facies) with a plastic spatula to reduce contamination. These samples were washed through a 150micron seive with deionized water, and the coarse fraction was dried and archived. The fine fraction was dried and approximately 0.5g was sent to ALS Minerals in Reno, NV for inductively coupled plasma-atomic emission spectrometry (ICP-AES) analysis of Cu, Pb, and Zn concentrations. The samples were digested with perchloric, nitric, hydrofluoric and hydrochloric acids and the residue topped up with dilute hydrochloric acid. ICP-AES results were corrected for spectral interelement interferences. Duplicate and standard tolerance was measured at 10%.

### **Results:**

One of the sediment fine fraction samples, at 0.3g, was too small to provide a measurement. The other nine samples returned values of 27-101ppm for Zn, 9-112ppm for Pb, and 9-48ppm for Cu. When plotted against depth in each core, these values suggest that Cu and Pb levels remained low (below 20ppm for Cu and below 50ppm for Pb) at depths below about 20-30cm in both cores (see Figure 2). Zn levels however, do not show a discernable pattern with depth.

### **Discussion:**

Surveys of the literature indicate the levels of trace metal concentrations one might expect in a marsh near suburban areas such as Long Island: Sanger et al. (1999) measured trace metal concentrations in South Carolina creeks with various levels of development. The measurements from a relatively undisturbed forested watershed ranged from 4.7-25.5ppm for Cu, 9.8-27.5ppm for Pb, and 24.3-98.5ppm for Zn. For a suburban watershed (defined as >45% urban/suburban land cover with human population density >5 but <20 individuals per ha), the measurements ranged from 27.7-46.4ppm for Cu, 23.6-37.1ppm for Pb, and 89.4-132.9ppm for Zn. For an industrial watershed (defined as >45% urban/suburban land cover which drained known industrial facilities), measurements ranged from 13.8-88.3ppm for Cu, 17.9-109.9ppm

for Pb, and 51.7-211.0ppm for Zn. In general, these measurements taken from Table 4 of Sanger et al. (1999) show that increasing development, from forested to suburban to industrial uses, increases the trace metal content of the marsh sediments (Sanger, Holland et al. 1999).

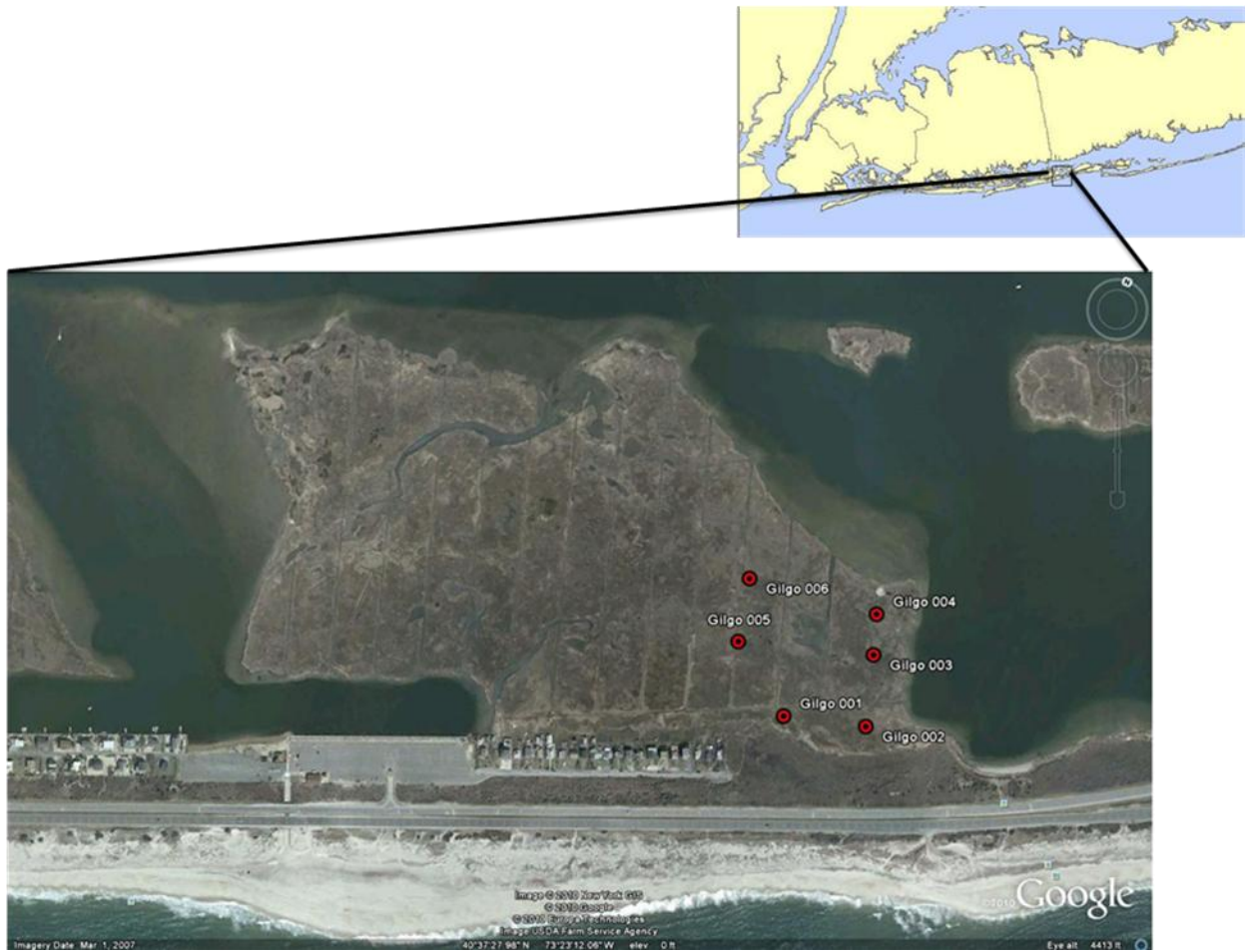
The concentrations of Cu and Pb in Gilgo 002B and 003A below 25cm depth can be characterized as relatively low levels (below 20ppm and 50ppm, respectively) that seem typical of an undisturbed watershed in the Sanger et al. (1999) study. Above 25cm, the concentrations of Cu and Pb in Gilgo 2B could not be measured due to small sample size. Above 25cm in Gilgo003A, however, Cu and Pb concentrations rise to levels above 20ppm and 50ppm, respectively, which are more consistent with those of an industrial watershed in the Sanger et al. (1999) study.

The Cu and Pb concentrations suggest that perhaps the start of the industrialization of the Long Island area is evidenced in the Gilgo 003A sediments at around 25cm depth. This suggests that deeper sediments were deposited prior to the industrial period, which in this area corresponds to either the mid-1800s or 1900 as previously discussed.

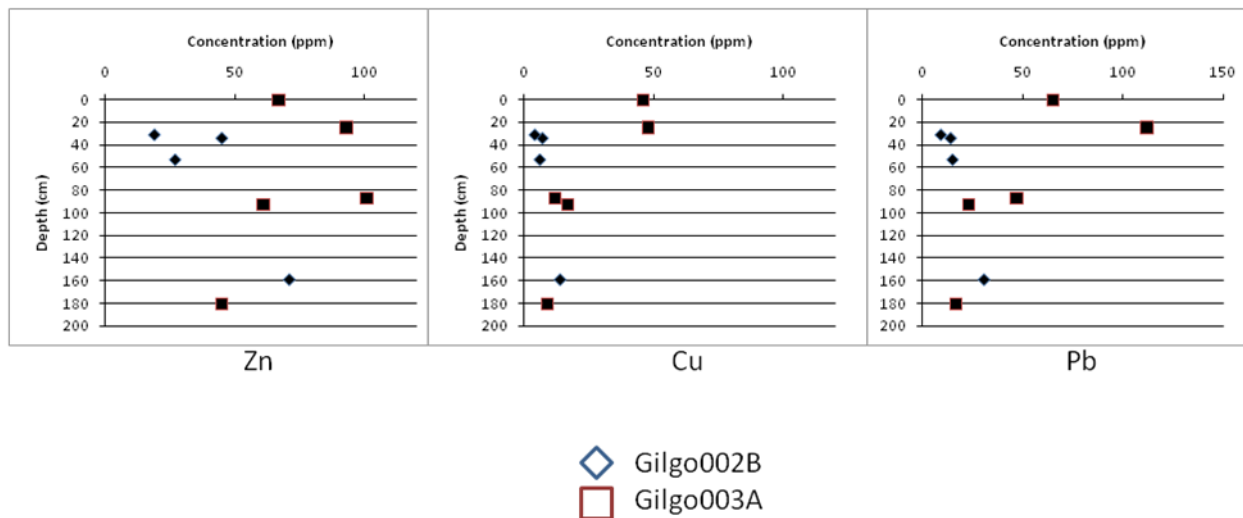
One remaining question that complicates this interpretation is why the Zn levels do not show the same pattern as the Cu and Pb. Zn concentrations are also relatively low in the deepest two samples in Gilgo 003A, but rise to relatively high levels (above 100ppm) at 87cm depth. Perhaps additional trace metal measurements can clarify whether the sample at 87cm was contaminated. We also plan to collect pollen data from these samples to establish the timing of the increase in agricultural activity in this area as expressed in the sediments with increased pollen counts from weed species.

### **Conclusions:**

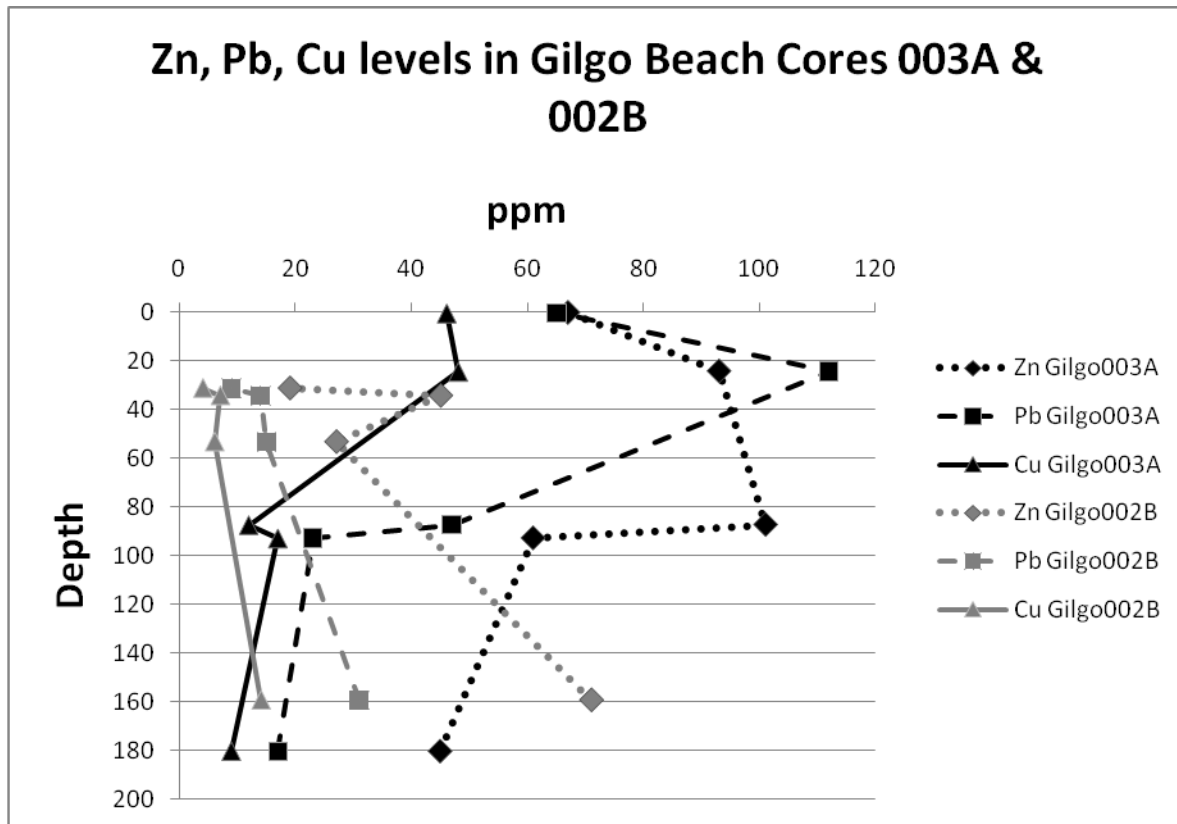
Cu and Pb concentrations in a sediment core from Gilgo Beach marsh on Long Island, NY, suggest that the top 25cm may represent modern sedimentary facies, while sediments below 25cm depth may represent sediments deposited before the onset of industrialization in the area (between the mid-1800s and 1900). Zn concentrations and results from a neighboring sediment core do not corroborate these conclusions, but perhaps additional sampling for trace metal concentrations and pollen data will confirm this chronology for the sediment core. Once the chronology of these sediment cores is established, analysis of their grain size data may provide a history of hurricane activity in the area that can corroborate one of the competing hypotheses about hurricane activity in the Atlantic basin as a whole.



**Figure 1:** Sediment core locations in Gilgo Beach marsh, Long Island.



**Figure 2:** Trace metal concentrations in sediment samples taken from various depths in Gilgo Beach cores 002B and 003A, plotted by element (Zn, Cu, and Pb).



**Figure 3:** Trace metal concentrations measured at various depths in Gilgo Marsh sediment cores 002B and 003A, plotted by core.

## References:

- Bricker, S. B. (1993). "The History Of Cu, Pb, And Zn Inputs To Narragansett Bay, Rhode-Island As Recorded By Salt-Marsh Sediments." *Estuaries* **16**(3B): 589-607.
- Liu, K. B. and M. L. Fearn (1993). "Lake-Sediment Record of Late Holocene Hurricane Activities from Coastal Alabama." *Geology* **21**(9): 793-796.
- Liu, K. B. and M. L. Fearn (2000). "Reconstruction of prehistoric landfall frequencies of catastrophic hurricanes in northwestern Florida from lake sediment records." *Quaternary Research* **54**(2): 238-245.
- Marcus, W. A., C. C. Nielsen and J. C. Cornwell (1993). "Sediment Budget-Based Estimates of Trace-Metal Inputs to a Chesapeake Estuary." *Environmental Geology* **22**(1): 1-9.
- Sanger, D. M., A. E. Holland and G. I. Scott (1999). "Tidal creek and salt marsh sediments in South Carolina coastal estuaries: I. Distribution of trace metals." *Archives of Environmental Contamination and Toxicology* **37**(4): 445-457.
- Scileppi, E. and J. P. Donnelly (2007). "Sedimentary evidence of hurricane strikes in western Long Island, New York." *Geochemistry Geophysics Geosystems* **8**: Q06011.