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EDITORIAL

Speaking Up For Science

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The Smithsonian Institution's National Museum of Natural History in Washington D.C. is planning to show a film, "A Privileged Planet" that promotes creationism in the form of "intelligent design." The film is based on the book by Guillermo Gonzalez and Jay Wesley Richards, both affiliated with the Discovery Institute, which advocates including "intelligent design" in U.S. public school science classes. By associating with the Discovery Institute, the Smithsonian Institution will associate science with creationism and damage its credibility. The film is slated for airing on 23 June, unless the Smithsonian comes to its senses.

Why is this important? Because the film promotes a long term strategy of the Discovery Institute (http://www.discovery.org/csc/) to replace "materialistic science" with "intelligent design." The film fosters the idea that science should include the supernatural. This is unacceptable. AGU's position is clear, creationism is not science and AGU opposes all efforts to promote creationism as science (The full text of the AGU position statement can be found at: http://www.agu.org/sci_soc/policy/positions/evolution.shtml).

After a 28 May article in the *New York Times*, the museum took a positive step and withdrew its cosponsorship and refunded the Discovery Institute's $16,000, on the grounds that it "determined that the content of the film is not consistent with the mission of the Smithsonian Institution's scientific research." But it still plans to show the film, and it is unlikely that disclaimers, explanations, or excuses will prevent proponents of "intelligent design" from claiming legitimacy from their association with the Smithsonian Institute. It is analogous to the way creationists used the opportunity afforded by the presentation of posters at AGU's Fall Meeting in 2003 (http://www.icr.org/research/misc/aguconference.html).

In the film, several scientists are interviewed, and their interviews are weaved into interviews with "intelligent design" advocates, who talk about an ultimate meaning for our universe. The film's point is to raise the idea that the universe was designed for intelligent beings like humans, and further, that it was designed for us to discover things about it. That is legitimate as a philosophical or religious viewpoint, but it is not science.

This is an opportunity for you to express your point of view to members of the Smithsonian Board of Regents (http://www.si.edu/about/people.htm). The film is also being offered to PBS stations. If you notice that your local station puts it on the schedule, you may also want to contact it. It is important for each of us as scientists to speak up in the defense of the integrity of science.

—FRED SPILHAUS, Executive Director

Integrative Acoustic Mapping Reveals Hudson River Sediment Processes and Habitats

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Rivers and estuaries around the world are the focus of human settlements and activities. Needs for clean water, ecosystem preservation, commercial navigation, industrial development, and recreational access compete for the use of estuaries, and management of these resources requires a detailed understanding of estuarine morphology and sediment dynamics.

This article presents an overview of the first estuary-wide study of a heavily used estuary, the Hudson River, based on high-resolution acoustic mapping of the river bottom. The integration of three high-resolution acoustic methods with extensive sampling reveals an unexpected complexity of bottom features and allows detailed classification of the benthic environment in terms of riverbed morphology, sediment type, and sedimentary processes.

This study demonstrates the benefits of comprehensive mapping of sedimentary environments for the management of ecosystems, monitoring and remediation of contaminated sites, development of the estuary for future transportation needs, and preservation of cultural artifacts.

Hudson River Benthic Mapping Project

The Hudson River is a classic example of a heavily used estuary. New York City, located at the mouth of the estuary, has been a main gateway for people and goods going to the U.S. Midwest since the 1820s.

Aiming to implement a science-based management policy for the estuary, the New York State Department of Environmental Conservation (NYSDEC) launched the Hudson River Estuary Benthic Mapping Project as part of its Hudson River Estuary Program. Through this project, the entire 240-km long estuary has been mapped from New York Harbor to Troy, New York (Figure 1). This is the first comprehensive mapping of an entire estuarine or river system in such detail.

The major goals of this mapping initiative were to provide a base map for benthic habitats, to identify areas of deposition and erosion for contaminant management, and to obtain the detailed information necessary for the regulation and permitting of construction.

To obtain a high-resolution characterization of the river bottom, a combination of multibeam bathymetry, side-scan sonar, and sub-bottom profiling was applied (Figure 2). A 300-kHz Simrad EM3000 multibeam system provided high-resolution bathymetry (< 1 m horizontal and 0.1 m vertical accuracy). To characterize the sediment surface, an EdgeTech DF-1000 dual-frequency side-scan sonar system (100 and 384 kHz) was used. Simultaneously with the side-scan sonar, an EdgeTech SB-424 Chirp sub-bottom profiler with a sweep of 4–16 kHz was towed to gather information about the sub-bottom sediment structure. All data were collected with differential GPS (DGPS) positions.

To ground-truth the different acoustic data, 410 sediment cores and 600 grab samples were

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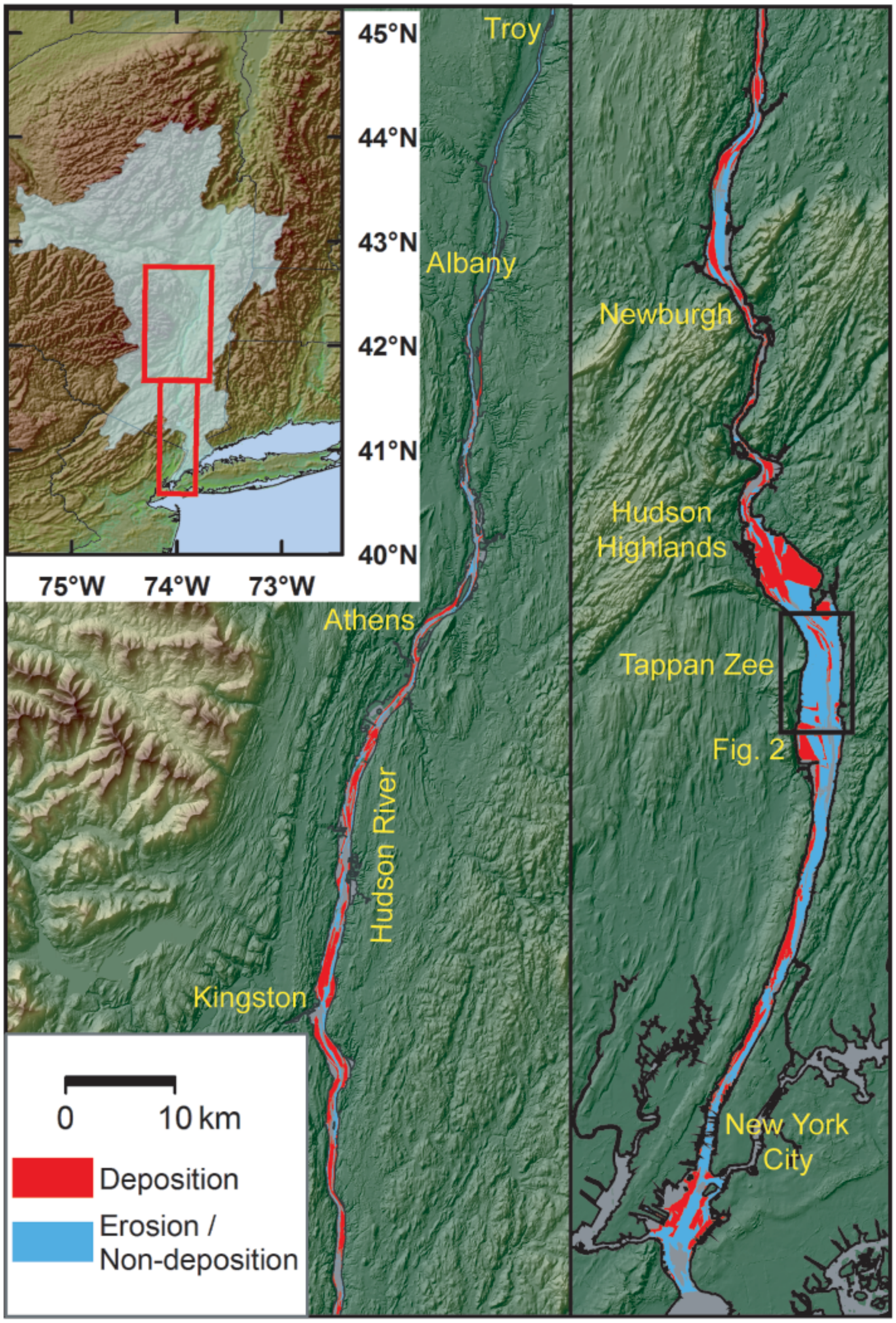

Fig. 1. An overview map of the Hudson River Estuary and its watershed (outlined in gray in the inset). This study surveyed the estuary between New York City and Troy, New York. Red indicates areas interpreted as depositional, and blue marks erosional or non-depositional areas.

collected that then were analyzed for grain size composition and physical properties. A limited number of the samples were gamma-counted for presence of cesium-137 (^{137}Cs) and beryllium-7 (^{7}Be) to identify modern sediments deposited. The anthropogenic radionuclide ^{137}Cs, which is derived from global fallout, indicates sedimentation after 1950 whereas the short-living ^{7}Be (half-life 53.2 days) indicates sedimentation during the last year.

Mapping Sediment Processes

On the basis of grain size analyses and backscatter data, the distribution of different sediment types such as mud (silt and clay), sand, and gravel throughout the estuary was mapped (Figure 2). However, in mud-dominated sections of the river, significant variations in backscatter intensity are not controlled by variations in grain size but, based on sub-bottom and bathymetry data, are due to variations in fine-scale surface roughness associated with depositional and erosional processes [*Nitsche et al.,* 2004].

The sub-bottom data permit further classification of the surface processes. Truncated reflections indicate erosion, while recent mud deposits often appear as a layer of low reflectivity draped on the river bottom in the sub-bottom profiles. The high-resolution data also show evidence of a dynamic sedimentary regime such as sediment wave fields, scour pools, and debris flows. Combining this information, interpretive maps were produced that distinguish three classes of sedimentary environments: depositional, erosional/non-depositional, and dynamic where sediment bed forms dominate [*Nitsche et al.,* 2004].

Applications

This integrative analysis of multiple complementary data sets provides powerful insights into the dynamics of the estuarine system that would have been unidentifiable with any single method. This detailed information is valuable for a range of applications.

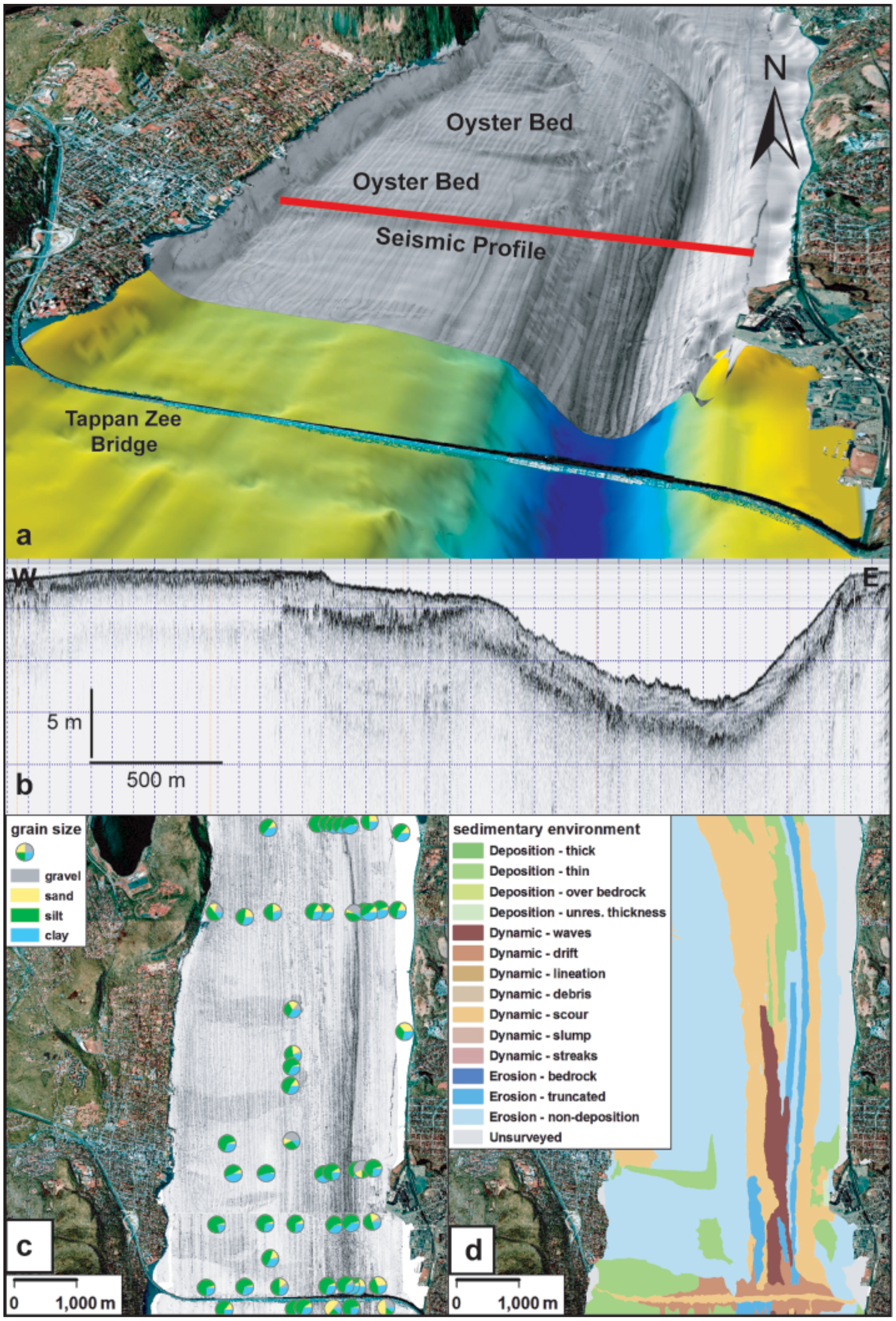

Fig. 2. Examples of data and interpretation from the Tappan Zee area (Figure 1): (a) perspective image showing bathymetry (color) and superimposed side-scan sonar data (gray), (b) sub-bottom data along the red line, (c) side-scan sonar with superimposed sample sites and grain size composition, and (d) interpreted sedimentary environments.

Prior efforts to understand the concentration and distribution of contaminants in the Hudson River Estuary have relied on sediment cores [e.g., *Bopp et al.*, 1998]. Although these basin-wide contaminant studies provide a detailed picture of present and historical contaminant concentrations, the spatial resolution of these sampling studies has been, by necessity, relatively coarse. Detailed information on the location and extent of depositional areas provided by the geophysical data significantly improves the spatial coverage obtained by individual cores, and allows for a more accurate estimate of sediment budgets and contaminant distribution. Combining the spatial information from acoustic surveys with constraints on deposition rates based on radionuclide analyses, *McHugh et al.* [2004] estimated that about 50 x 10^3 tons/yr of sediment are being deposited in a 30-km section of the river in the Hudson Highlands.

Parts of the Hudson River Estuary are dredged regularly for commercial transportation. Detailed knowledge of contaminant distributions and sediment dynamics are essential to managing dredging efforts. The ^{137}Cs and ^{7}Be analyses of sediment cores from dredged areas indicate these regions act as a focus for rapid deposition of organic-rich, fine-grained mud at rates of several centimeters per year, an order of magnitude greater than outside these areas. The NYSDEC is using the process-based sedimentary classification for its decision-making for permitting dredging, pipelines, and cable routes.

The high-resolution and spatially continuous coverage of the acoustic data revealed many potentially important cultural features on the river bottom, including shipwrecks with ages ranging from modern to revolutionary times. As a result, the U.S. National Oceanic and Atmospheric Administration (NOAA) and NYSDEC are developing a method for systematically evaluating these cultural resources. The process-based interpretation of sedimentary environments provides an important tool in this assessment. For example, clearly exposed artifacts in depositional areas are likely to be modern while partially buried features may be much older. In erosional or dynamic environments, recent and older artifacts will be exposed, but the older artifacts may have accumulated considerable sediment drifts (Figure 3).

The sedimentary environments also provide a new framework for the study and management of estuarine communities. Side-scan images reveal a series of ancient oyster beds in the Tappan Zee section of the Hudson River Estuary (Figure 2a) that flourished during the Medieval Warm Period and collapsed during the Little Ice Age [*Carbotte et al.*, 2004].

Efforts are ongoing to link the physical environments revealed by the bottom mapping with information on fish and benthic communities. Initial biological studies near Kingston, New York, and in the Tappan Zee analyzed the relationship between different environmental parameters and benthic communities. It was found that integrative descriptors such as process-related sedimentary environments and morphology are more successful in predicting distinct benthic communities than single parameters such as grain size or depth alone (D. L. Strayer et al., Combining geophysical and biological information to define benthic habitats in the Hudson River, submitted to *Freshwater Biology*, 2005).

Future Prospects

The importance of shallow-water areas as benthic habitats and sites of significant contaminant storage has led to an increased interest in benthic mapping. Recent developments in mapping technology including improved multibeam systems with wider swaths and higher resolution, faster multipulse side-scan systems, and advances in positioning make surveying in shallower waters more feasible economically.

The Hudson River Benthic Mapping Project has demonstrated that integrated, high-resolution mapping results in a detailed understanding of bottom processes and provides information essential for many aspects of managing shallow water environments.

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We thank the skippers of the *Riverkeeper*, the R/V *Walford*, and the R/V *Prichard*, J. Ardai for

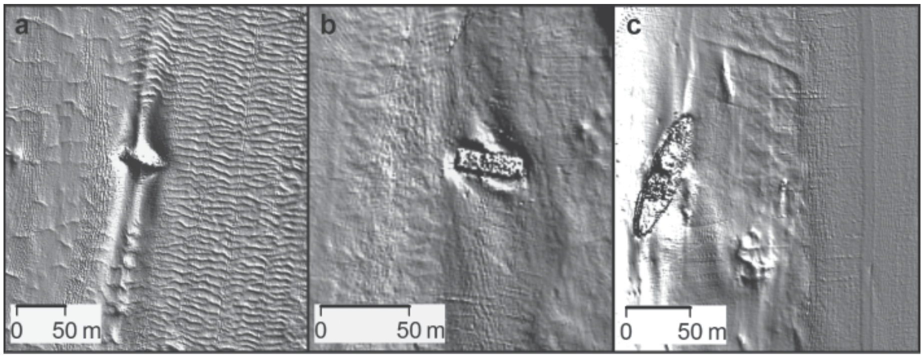

Fig. 3. Sun-illuminated multibeam bathymetry (illuminated from NE) showing (a) a probably older shipwreck (unknown age) with deep scours and long sediment drifts, (b) a shipwreck with minor scours, and (c) a more modern (20th century) shipwreck with small sediment drifts.

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New Tools for Analyzing Time Series Relationships and Trends

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Geophysical studies are plagued by short and noisy time series. These time series are typically nonstationary, contain various long-period quasi-periodic components, and have rather low signal-to-noise ratios and/or poor spatial sampling. Classic examples of these time series are tide gauge records, which are influenced by ocean and atmospheric circulation patterns, twentieth-century warming, and other long-term variability.

Remarkable progress recently has been made in the statistical analysis of time series. *Ghil et al.* [2002] presented a general review of several advanced statistical methods with a solid theoretical foundation. This present article highlights several new approaches that are easy to use and that may be of general interest.

Extracting trends from data is a key element of many geophysical studies; however, when the best fit is clearly not linear, it can be difficult to evaluate appropriate errors for the trend. Here, a method is suggested of finding a data-adaptive nonlinear trend and its error at any point along the trend. The method has significant advantages over, e.g., low-pass filtering or fitting by polynomial functions in that as the fit is data adaptive, no preconceived functions are forced on the data; the errors associated with the trend are then usually much smaller than individual measurement errors.

Fourier or wavelet techniques are often used in time series analysis extracting periodic signals. However, a difficulty for many users has been how to relate the wavelet spectrum they compute with another spectrum from a different series, in order to examine causality and phase relations expected in an a priori mechanism.

Grinsted et al. [2004] present two new techniques that advance the wavelet approach popularized by *Torrence and Compo* [1998]. Often, it is not simply the wavelet spectrum of a time series that is of interest, but rather the similarity it has with the spectrum from another, putatively related series. Two suitable methods to examine the relationship between two spectra are the cross wavelet transform (XWT) and wavelet transform coherence (WTC). *Torrence and Compo* [1998] discuss both, but provide no software.

Grinsted et al. [2004] give this software and additionally formulate statistical significance tests. XWT exposes regions in time-frequency space with high common power, and further reveals information about the phase relationship between the two series. If the two series are physically related, a consistent or slowly varying phase lag would be expected that can be tested against mechanistic models of the physical process.

WTC can be thought of as the local correlation between the time series in time-frequency space. Where XWT unveils high common power, WTC finds locally phase locked behavior. The more desirable features of the WTC come at the price of being slightly less localized in time-frequency space.

The significance level of the WTC has to be determined using Monte Carlo methods. The XWT significance level can be tested analytically against red noise (which, unlike white noise, is autocorrelated, and hence can mimic long-term trends) using the first-order autoregressive coefficient of the time series. The WTC and XWT methods are useful especially in nonstationary time series where there may be statistically significant periods of correlation for only certain intervals of the whole record.

It is advisable to have a good understanding of the data before starting wavelet analyses; the time series, for example, should be close to normally distributed. If the time series is not, then it should be transformed. Consider what outcomes are expected given the proposed linking mechanism. It is cautioned against blindly applying these methods to randomly chosen data sets.

ENSO and Temperatures in England

An example of the XWT and WTC methods can be seen in Figure 1, which shows part of the 340-year-long central England temperature (CET) series [e.g., *Plaut et al.*, 1995] that overlaps with the atmospheric representation of El Niño–Southern Oscillation (ENSO), the Southern Oscillation Index (SOI). Both series exhibit strong power in the 4- to 8-year period band. However, here, a 14-year cycle that *Plaut et al.* [1995] find clearly in the full CET is discussed. *Jevrejeva et al.* [2004] also found a 13.9-year periodicity SOI signal that is transmitted, with a 1.8- to 2.1-year lag, by equatorial coupled waves and fast boundary waves to the polar regions.

To test whether the CET is also recording this signal, the XWT and WTC plots were examined; indeed, there is a peak of power and coherence around the 14-year period. However, the phase varies considerably over the time series, suggesting that the mechanism must have changed appreciably—or alternatively, that there is no cause and effect mechanism involved and the coincident power is merely accidental.

The authors believe that there is most likely a causative relationship but that atmospheric

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