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# The Crest

*Current Issues in Coastal Ocean and Estuarine Science*

## Virtual Solutions to Real-World Problems: Physical Modeling at VIMS

*By David Malmquist*

When the U.S. Army Corps of Engineers realized they needed to expand Hampton Road's Craney Island landfill, they faced a dilemma common to resource managers everywhere. They needed to minimize further impacts to an already stressed ecosystem, but how could they determine the best course of action before the costly project began?

The answer to their dilemma came from researchers in VIMS' Physical Sciences Department, who were able and willing to explore the possible environmental impacts of landfill expansion using their state-of-the-art computer model.

By allowing evaluation of likely impacts before a project physically begins, computer models can help save millions of dollars. In many cases, they are the only practical method for making complex environmental decisions.

The VIMS three-dimensional Hydrodynamic Eutrophication Model (HEM-3D) allows researchers to simulate the response of an estuarine ecosystem to natural and human alterations by representing it mathematically inside a high-speed computer. By manipulating model input to reflect intended or expected changes in the actual system, the researchers can determine how the virtual system

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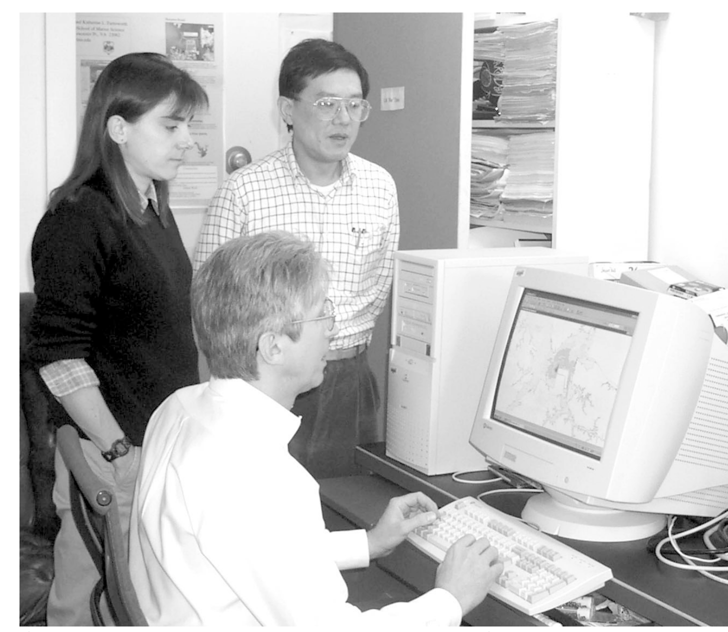

Courtney K. Harris, Harry Wang, and Mac Sisson, running a numerical model.

## ChesSIE Sighted at www.bayeducation.net!

*By Sally Mills*

Have you seen ChesSIE? We're not talking about the fictitious Bay beast, but an online resource center of current K-12 Chesapeake Bay science education materials. ChesSIE (Chesapeake Science on the Internet for Educators) is maintained by VIMS marine educators, and an advisory committee and a teacher focus group provide valuable feedback about the site's content. ChesSIE is also supported by the EPA Chesapeake Bay Program and is part of the Chesapeake Information System (CIMS).

ChesSIE provides educators with access to quality Bay-related education resources, online data, and professional development opportunities. Researchers, resource managers, and other Bay stakeholders are supplied with a venue for sharing information and connecting with K-12 classrooms. Interested in traveling? Take part in an online field trip throughout the Bay or find a great field-trip destination. Do you need to identify a Bay critter you found sampling? Use ChesSIE to key out

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*Physical Modeling at VIMS continued from page 1*

responds, and use those responses to predict behavior in the real world.

Hydrodynamic models have applications far beyond Craney Island. "Researchers are using these models to help solve problems in geology, ecology, and the atmospheric sciences," says VIMS researcher Courtney K. Harris. "We use them to predict modification of sediment texture, dispersal of pollutants and larvae, and interactions between water masses and storm systems."

In the Craney Island project, VIMS researchers John Boon and Harry Wang led a multidisciplinary team including Albert Kuo, Sung-Chan Kim, and Mac Sisson that used the HEM-3D model to investigate how the Elizabeth River estuary would respond to expansion of the Craney Island Dredged Material Management Area (CIDMMA). CIDMMA is a Federally owned and operated facility near Portsmouth that receives dredged material from navigational channels and dock areas in the lower Chesapeake Bay. Operative since the 1950s, CIDMMA is now near capacity, and must be enlarged to meet plans for expansion of Virginia's deep-water ports.

The VIMS team modified the HEM-3D model, originally designed for use in the James River, to explore the least disruptive direction for landfill expansion at the mouth of the Elizabeth. To comply with EPA regulations, the Corps of Engineers and Virginia Port Authority needed to know how different expansion options might affect the river's tidal currents, salinity, flushing ability, and sedimentation potential. Because the Elizabeth River's sediments are highly polluted from almost 400 years of industrial activity and urban growth, it was imperative that expansion not mobilize them by accelerating erosive bottom currents. At the same time, regulations required that expansion must not decrease the ability of the river to flush suspended contaminants out to sea.

The first phase of Boon and Wang's modeling efforts, completed late in 2001, suggests that eastward expansion is the least disruptive option under normal river conditions. The team is now entering phase two, in which they will explore the river's response to landfill expansion under a wider range of conditions, including the occurrence of nor'easters during both flood and drought conditions.

Although computer models give scientists and planners a powerful decision-making tool, they are only as good as the data they are fed (as modelers put it: "garbage in, garbage out.") In addition, modelers can only test their models' predictions by comparing them to observations of the real system. Thus a synthesis of model output and field observations is a crucial component of any modeling effort.

Harris notes that this interplay between virtual and actual is precisely where VIMS' strength in physical modeling lies. The newest member of VIMS' modeling team, Harris was drawn to the institute because it "has the expertise to get real data to help test model results."

For the Craney Island project, VIMS field researchers had to provide the model with accurate measurements of the Elizabeth River's tides, salt content, currents, and water quality. They also had to gauge non-tidal changes in water level caused by variations in atmospheric pressure and in freshwater runoff during periods of flood and drought. John Brubaker, Jerome Maa, and other VIMS researchers collected the data by deploying a network of tidal gauges, salinity meters, current profilers, and optical sediment sensors throughout the Elizabeth River estuary, a task made difficult by busy ship traffic.

Once they had collected and analyzed these instrumental data, the VIMS scientists used them to assign numeric values to each parameter (such as salinity, depth, current strength and direction) within the 45,000 grid cells on which the HEM-3D model is based. By running the model under these baseline conditions, the modelers were able to test whether it realistically simulates the estuary's current behavior. This process of initialization and calibration is a crucial first step in any modeling project, as a model must be shown to accurately emulate a system's observed behavior before modelers can confidently use it to predict the system's future behavior under altered conditions.

To model the behavior of the Elizabeth River estuary at the fine time and space scales mandated by stringent EPA requirements, the VIMS researchers were obliged to significantly increase the resolution of their original HEM-3D model. Resolution refers to the spatial dimensions of a model's grid cells, and the amount of elapsed time between model calculations. As with the pixels that make up images on a computer monitor, smaller grid cells in a model provide higher resolution, and thus a more realistic depiction of the actual system. The original HEM-3D model, which was designed to simulate movement of water and sediment throughout the James River, had a grid size of 370 meters, so that each data point represented conditions within a square of about 1200 ft. per side. In the Craney Island version, VIMS researchers decreased grid size within about 2,500 cells near the Island to only 123 meters (about 400 ft. per side). The model divides each grid cell into six vertical layers between the surface and bottom, and uses mathematical equations to calculate the physical state of each cell layer every 25 seconds. These detailed settings allow the researchers to simulate conditions around Craney Island on the much finer time and space scales needed to predict local changes.

Of course, higher resolution carries a price—each time model resolution is halved the time required for a model run increases by a factor of eight. To simulate one month's behavior of the Elizabeth River, VIMS researcher Mac Sisson must run the HEM-3D model for six straight hours. The model also generates copious output—a single model run produces three gigabytes of data, enough to fill five CD-ROMs. To meet these computational demands, VIMS relies on a Dec/Compaq/HP ES40 computer, similar to the one used to help map the human genome.

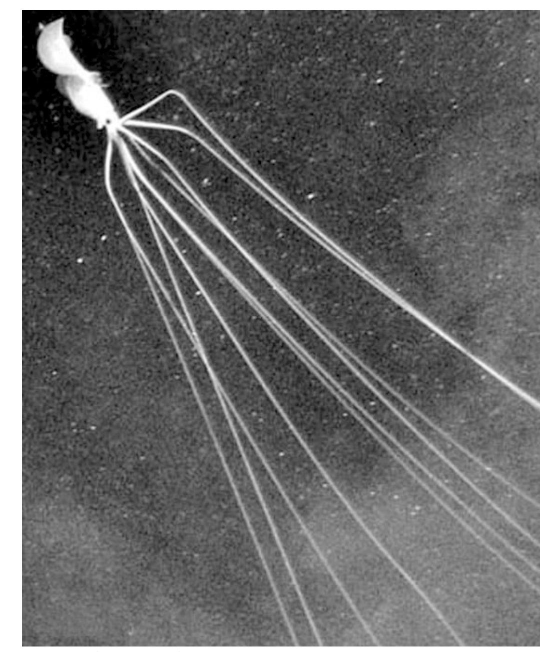
VIMS' state-of-the-art modeling capabilities allow little rest for either computers or researchers in the Physical Sciences Department. In addition to Craney Island, VIMS modelers and field researchers are currently involved in numerous other projects, including the U.S. Geological Survey's Community Sediment Transport Modeling effort, and the Office of Naval Research's STRATAFORM initiative.

For further information on physical modeling at VIMS (including on-line access to the Craney Island Project final report), visit the VIMS Physical Science web site at http://www.vims.edu/physical/projects

# Large Squid Discovered

In a recent article in *Science,* Dr. Michael Vecchione, Adjunct Faculty VIMS Dept. of Fisheries Science, published the first reports of what may be a new family of very large squid. The squid, which differs from any other squid previously described is estimated to be 22 feet long including a 2 foot long body, and has been observed in deep waters (over 1,000 meters) at several sites worldwide. Vecchione explains that the bathypelagic or deep-water realm is basically unexplored in spite of being the largest ecosystem on earth. "Scientists are generally looking at specific sites, such as hydrothermal vents, ship wrecks, etc. when they are in this realm. They rarely have the opportunity to simply browse. Several colleagues just happened to bump into these animals while doing other research in deep-water submersibles."

Three years ago, Vecchione and colleague Dick Young from the University of Hawaii described a new family of squid from juveniles they discovered living within 200 meters of the surface. Vecchione suspects this new squid may well be an adult of the same family. "The juveniles we described had unusual tips on their arms and tentacles. Their general body shape with large fins and the way the fins connect to body leads me to suspect that we may now be seeing adults." It is not unusual for adults to live in deeper waters than juveniles. Vecchione emphasizes that this underscores how little we know about life on Earth.





Video frame of unusual deep-water squid observed from a submersible in the Gulf of Mexico.