New Faculty Brushes Aside Disciplinary Boundaries

Modeler and systems ecologist Dr. Mark Brush, the newest member of the VIMS faculty, embodies the Institute's emphasis on interdisciplinary research, teaching, and advisory service.

Brush will occupy the vacancy in the Dept. of Biological Sciences created by the retirement of Dr. Dick Wetzel, who stepped down last spring after 30 years at the Institute.

Brush, who earned a B.S. from Cornell University in 1995 and a Ph.D. from the University of Rhode Island in 2002, arrived at VIMS in 2002 as a post-doctoral researcher, working on the Fisheries Ecosystem Modeling and Assessment Project (FEMAP) with Wetzel and Dr. Rob Latour. He then served as an Assistant Research Scientist within Biological Sciences.

Combining the high-tech world of computer modeling with the muddy realities of estuarine and coastal ecology—two often-disparate fields—is at the core of Brush's interest and expertise, and one of the main reasons he was hired at VIMS.

Dr. Emmett Duffy, Biological Sciences Chair and head of the search committee that hired Brush, says "Mark's combination of experience in modeling and empirical ecology, and the rapidity with which he established research collaborations, were strong selling points. His interdisciplinary background makes him a great addition both to our department and to VIMS as a whole."

Brush says that what he's tried to do since coming to VIMS is to "cut across departmental and disciplinary boundaries, to develop strong working relationships with modelers like Harry Wang and Jian Shen in Physical Sciences, Liz Canuel and other biogeochemists, and with Rob [Latour] in Fisheries Science."

He is also collaborating with Dr. Ken Moore to analyze the high-frequency time-series data collected by National Estuarine Research Reserve (NERR) sites across the mid-Atlantic; with Drs. Larry Haas, Howard Kator, Iris Anderson, and Shen to use the 3D Acrobat monitoring system to visualize oxygen levels in the York River; and Drs. Wang, Shen, and Anderson to study ecosystem functioning in the Lynnhaven River.

Another interest is in working with large databases like those maintained by NERRS and by the Chesapeake Bay Monitoring Program, in which more than 30 scientists from 10 institutions have been collecting data on 19 physical, chemical, and biological characteristics at more than 165 stations in the Bay since 1984.

"I've done a lot of work synthesizing that database and trying to analyze it," says Brush. "We're trying to turn it into useful information. Empirical analyses of existing data can help us to better understand how the Chesapeake Bay ecosystem is functioning."

Brush's quest to understand the function of whole ecosystems—Chesapeake Bay, or the York and Lynnhaven Rivers—is what defines him as a "systems ecologist."

"System-level ecology treats an estuary as a complete unit," says Brush. "It involves looking at key processes within the system and determining how they fit in the context of the entire place. How, for instance, does nutrient enrichment affect the entire York River ecosystem? What does it do to major processes like the rate of photosynthesis or respiration, or to dissolved-oxygen levels?


Dr. Dick Wetzel (4th from L) retired from VIMS in March after 30 years at the Institute. Wetzel was a pioneer in applying ecosystem modeling to Chesapeake Bay. Joining him at the retirement ceremony were (from L): Biological Sciences Chair Emmett Duffy, Dean and Director John Wells, SMS Dean Iris Anderson, and long-time collaborators Betty Berry-Neikirk and Ken Moore.

Another aspect of Brush's interest in ecosystem ecology is his study of "top-down" and "bottom-up" control of food webs. These are hot topics in both ecology and modeling, but rarely investigated by an individual researcher.

"Top-down effects are those that propagate from the top of the food chain," says Brush. "They include things like changes in the population of a predator or fishing pressure. That's what most fisheries models deal with."

"Bottom-up processes impact the ecosystem from the bottom of the food chain—including nutrient-driven eutrophication or climate change. These first and primarily influence phytoplankton growth and biomass, and then propagate up the food web. That's what most nutrient-load and water-quality models involve."

"One of the exciting things today in modeling'" says Brush, "is that we're starting to combine these processes by creating models from nutrients through fish. You can build a model and manipulate climate or nutrient loading while at the same time manipulating harvest of menhaden or striped bass, and study the net effects of such changes and identify the dominant processes."

"There are issues and concerns about doing that," he cautions, "but you can start to play with these bottom-up and top-down effects in ways that you usually can't do through experimentation."

Of Brush's many current projects, his study of menhaden's role as forage and filter feeders in Chesapeake Bay (see p. 1) best illustrates the power of integrating models and fieldwork with studies of both top predators and plankton.

The menhaden project, a three-year effort funded by the Chesapeake Bay Program, seeks to quantify the filtering capacity of menhaden. Like oysters and clams, these small fish feed primarily on plankton, thus potentially improving water clarity and quality. The Bay Program has funded similar studies of other filter feeders in the Bay, and will use the results to compare this "top-down" control on water quality with what they might see from nutrient management.

The modeling aspect of Brush's menhaden project builds on his post-doctoral collaboration with Latour, in which they modeled interactions between the menhaden and its predators.


Dr. Mark Brush

"Now," says Brush, "we're using the menhaden model to look at how menhaden impact lower trophic levels." Menhaden may help clear Bay waters by consuming large quantities of phytoplankton, "but at the same time they are excreting nitrogen and perhaps stimulating further algal blooms. We can use the menhaden model to compare the amount of nitrogen they export and recycle to the anthropogenic load, and to put these fish in the context of the Baywide nitrogen budget."

"It's like a cost-benefit analysis," adds Brush. "Do you manage your menhaden fishery to maximize yields, or to maximize water clarity if it turns out they have an effect? They're also a major prey source, so there are all kinds of different, competing reasons for how you might manage them."

Brush contends that ecosystem models provide the best tool for addressing these types of complex management issues.

"One of the key tools for getting at [ecosystem management] is through ecosystem modeling," says Brush, "simulating a variety of different species and how they interact."

Doing so, however, requires continued refinement of the models.

The early estuarine models of the 1960s and 70s were built to answer basic questions—how estuaries operate, how they recycle nutrients. Today, some of the same models are being used to inform major management decisions, concerning, for instance, possible nutrient-reduction strategies.

"That's a very different goal for a model," notes Brush, "with different expectations of accuracy and precision.

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"What we try to do," he says, "is come up with different ways of formulating, simplifying, and aggregating major processes, to decrease the parameterization and error propagation. We're trying to take out some of the uncertainty in these models and to make them more useful for making a prediction for management applications." That philosophy guides Brush's current project with several colleagues at his alma mater to better predict low-oxygen levels in Narragansett Bay, Rhode Island.

Today's models have a litany of key uses, both for management and basic science. "Modeling developed as a way of synthesizing disparate data sets that had been collected by a variety of investigators on a variety of different processes," says Brush. "Models allow you to understand how all those processes and different trophic groups interact as a complete ecosystem. Usually when we do fieldwork or lab experiments we focus on a particular organism or a particular process that we're studying, but models give you a way to piece all of those things together, to see how the whole system works together as an integrated unit."

Perhaps most important for VIMS' advisory role is that models allow for what-if scenarios.

"That's really the key," says Brush. With a model, "you can do a series of virtual experiments that you could never do on a natural system. No one would ever allow you to dump 100 times the ambient load of nitrogen into the York River to see how it responds. But you can do that in a model in about 30 seconds, push the run button, and see what happens. It's the virtual what-if. What-if scenarios have great potential for guiding sound management practices."