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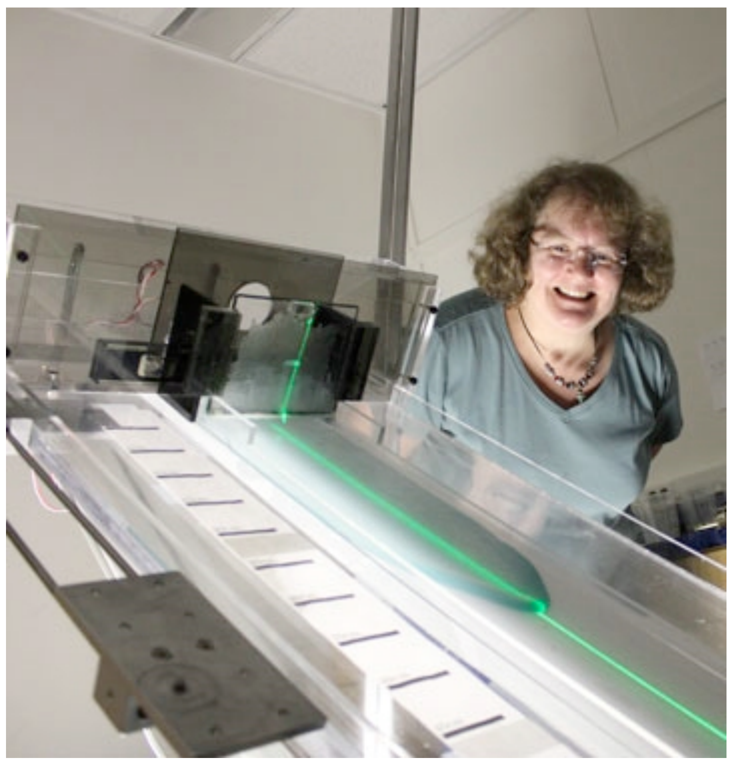
Applied math lab joins scientists working on oil cleanup in the Gulf

For five years Professor Andrea Bertozzi, director of UCLA's applied mathematics program, has been working quietly with her students and postdocs on experiments in a small Math Sciences lab to understand the physics of what happens when sand and oil mix together and flow down a slope.

While the experiments are simple enough for beginning researchers to do, the challenge of coming up with a mathematical model to predict how this sludgy mixture will behave, based on the size of the grain of sand (or in this case, silica beads), the viscosity of the oil and the angle of the slope, makes the problem a lot more complex and intriguing to young scientists.

With some modest funding over the years from the Office of Naval Research, the National Science Foundation and the UC Lab Fees Research program, the experiments gave undergraduates a chance to dig their heels into basic science research. Bertozzi's applied math lab is the first at UCLA to give students an opportunity to do hands-on experiments that are primarily driven by mathematics. Although the lab wasn't sophisticated and the results didn't create headlines, the papers it produced addressed some basic science questions of relevance to the food industry, coal recovery and mudslides.



Mathematician Andrea Bertozzi watches tiny glass beads, dyed blue, as they flow in the oil to the front to form a ridge. A laser captures the flow's profile. Photo by Dirk Peschka.

"I always felt that this project was something we did on the side," said Bertozzi, who has made big headlines recently with work she and her UCLA colleagues have done on a mathematical model of crime "hotspots."

Then something happened to give their research nationwide relevance: The Deepwater Horizon oil rig blew up in the Gulf of Mexico.

When crude oil began to wash up on the beaches of Louisiana, Bertozzi immediately began to see a connection between the theoretical work she and her students had been doing since 2005 and the tragic outcome of what has been called the worst environmental disaster in the history of the country.

"I had the thought that we might start thinking about problems that were more directed at the oil spill," the mathematics professor recalled.

A call for "rapid response" proposals related to the Gulf of Mexico oil spill by the National Science Foundation clinched it. Winning a year's worth of funding totaling $140,618, Bertozzi and her students have now found themselves working at the leading edge of oil spill-related research along with hundreds of other scientists funded by the same NSF grants.

The lab's research will address fundamental questions that relate to the monumental cleanup problem and hopefully will produce theories about the dynamics of oil and sand. For example, is there a critical angle of incline for beach sand dunes that would result in oil collecting in the dune itself instead of flowing to the bottom of the dune?

Scientists on the oil-contaminated beaches are finding not only globs of oil sitting on the sand, but layers of crude that have been deposited 6 to 10 inches beneath the sandy surface.

"Springboarding off our study, what we see happening depends on the angle of the incline, the viscosity of the oil and the amount of oil there in comparison to sand," Bertozzi said. "We might potentially be able to predict how the oil is going to separate from the beach sand."

Bertozzi (from the left) notes how the particles mixed with oil behaves with students Brian Le, Samantha Mersuro and Paul Latterman. They work in the only hands-on lab at UCLA devoted to applied mathematics.

To duplicate the basic physical forces that are involved in this study of fluid dynamics and sedimentation, where particles suspended in a fluid exert forces on other particles in complex ways, Bertozzi and her group use non-toxic oil of various viscosities and glass beads, like sand, but engineered to be identical in size, to make sludge. They then examine how it behaves as it flows down an inclined trough. Does the sludge stay well-mixed? Or does sand flow faster to the front edge to form a ridge? In some cases, some of the oil separates to flow in "fingers" ahead of the sand. Using a laser to help them see the profile of the flow, they can create a 3-D computerized mathematical profile of the flow to help them in their analysis.

In a recent paper, Bertozzi's team successfully compared detailed experiments with a new theory for how sand separates from oil.

As principal investigator on the study, Bertozzi is currently designing some experiments that will directly focus on some of the issues related to the cleanup of beaches.

She is also preparing to give lectures on mathematical modeling of the oil spill and of crime patterns at the University College in London in September. The American Physical Society's Division of Fluid Dynamics has invited her to speak on the oil research at its November meeting in Long Beach.

"It's exciting to have this very important application for our work," she said. "But it's also kind of sad that this [oil spill] is the reason for it."

UCLA's Mathematics Department was recently rated No. 2 in the country for its graduate program in applied mathematics by US News & World Report. To read more about the lab's work, click here.

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