

Originally published Monday, June 25, 2007

## Part Boat. Part Laboratory. It's Roboduck.

**When the stench in Redondo Beach's King Harbor started driving people away, scientists had an idea.**

**By Nick Green**

*Staff Writer*

A series of "red tides," algae blooms that turn the surf an unappetizing color and kill thousands of fish, plagued Redondo Beach's King Harbor two years ago.

Swimmers avoided the murky waters and beaches.

The stench of rotting fish forced diners to abandon outdoor patios at ocean-view restaurants and some eateries to temporarily close.

"It smells like rotting flesh," said Councilman Chris Cagle. "We have over 8 million visitors a year. When something like that happens people can't stand it and they leave. It not only affects ocean water quality, but it hits Redondo hard economically."



**Bruce Hazelton / Staff Photographer**  
USC student Jnaneshwar Das controls RoboDuck1 at King Harbor Marina with a laptop computer. The robot boat samples seawater.

Cagle, whose council district includes the harbor, was appointed to a City Council subcommittee to find solutions to the problem. He spoke at a meeting of the Southern California Academy of Sciences the following spring about the frustrating issue and the city's efforts to find answers.

In the audience was USC professor David Caron, a researcher at the Wrigley Institute for Environmental Studies and one of the world's foremost authorities on algae blooms.

He offered to help. So began a groundbreaking study of the water quality in the 150-acre harbor.

"We want to have our finger on the pulse of the ecosystem so when something begins to happen it's time to mobilize our limited resources and get our experiments in the field," Caron said.

Since humans and their equipment can't be on call around the clock awaiting the beginning of an algae bloom - at least not inexpensively - the answer is to have an automated monitoring system in place.

The study combines Caron's expertise in microbial ecology with the robotics knowledge of fellow USC professor Gaurav Sukhatme, director of the Robotics Embedded Systems Lab.

The lab is dedicated to designing and developing large-scale robotics systems with applications in everything from military reconnaissance to environmental monitoring.

In this case the maritime robot that's been developed is dubbed RoboDuck1. Its smaller predecessor, RoboDuck0, was about the size of a goose but RoboGoose was not a snappy name, especially for something that operates in a marine environment, so enter RoboDuck.

RoboDuck1 is a 6-foot bright orange battery-powered boat, complete with computer, geographic positioning system, compass, gyroscopes, two cameras and a winch it can deploy brimming with biological sensors.

RoboDuck1 is capable of measuring a half-dozen different conditions as it motors along at 1.7 meters per second, including water temperature, salinity and dissolved oxygen.

RoboDuck1 can be operated by remote control.

But the ultimate goal is to have an autonomous data-collecting machine, navigating the harbor on its own, making decisions on where to collect data and what data to collect, working in concert with its even more sophisticated successor, RoboDuck2.

Think of RoboDuck1 as an oceangoing Roomba, the cute little round vacuum cleaner that you switch on and then allow to navigate around a room by itself, cleaning the carpet while avoiding tables and chairs, with a couple of essential differences.

"We can tell you where the dirt is, but the robot isn't doing any cleanup," Sukhatme said of RoboDuck1 with a laugh.

But an ocean is a much more hostile environment than a carpeted room. Large boats, sea lions, the corrosive effect of salt water, strong tides, currents, varying water depths and waves all can pose a threat to RoboDuck1.

"Contrary to what people see in movies, robots aren't very good at navigating by

themselves," Sukhatme said. "Making intelligent decisions in an environment where the robot doesn't really know anything about the environment is an open problem in robotics."

Right now RoboDuck1 has a very "rudimentary level" of autonomy.

For example, it has trouble "seeing" with its cameras and negotiating the tight confines of the harbor and its 1,500 boat slips - and boats - remains a challenge.

"It just kept circling round and round," said graduate student Arvind Pereira, 26, one of the members of Team RoboDuck, of a recent voyage. "It was `afraid' of everything."

Still, RoboDuck's sophistication is gradually improving.

Right now, it can follow a sequence of GPS coordinates going from one place to the next without being told how to get there.

Sukhatme envisions RoboDuck operating ever more "independently" as the team continually improves the robot.

For instance, RobotDuck1 is gradually creating an underwater map of the harbor that over time will allow it to become smarter at moving around, Sukhatme said.

Combining data from the robots with that from stationary floating monitoring units could eventually yield an early warning system alerting officials that an algae bloom is imminent, Caron said. Moreover, he hopes the interdisciplinary marriage evolving in the waves off the South Bay's coast can eventually be applied elsewhere.

"I see the work we're doing in Redondo Beach and King Harbor as a template to how these technologies might be applied in municipalities up and down the coast ... to address specific water quality and environmental issues," he said.

Of course, Redondo Beach just wants to know how to stop the periodic "red tides" that are capable of causing environmental and economic havoc.

While researchers are still trying to find out what prompts a bloom and why, Cagle is ecstatic about getting world class environmental research essentially for free.

And already it may have saved the city money.

Cagle's committee, reasoning that oxygen-starved fish perhaps could be saved from suffocation if some sort of aerator were placed at the harbor's bottom, was mulling whether to install such a system when he met Caron.

The idea could work, said Caron, but what if for some reason the approach actually encouraged more deadly blooms for reasons researchers didn't yet understand.

It would be better to know for certain whether the solution "is the appropriate solution or if it is a solution at all," Caron said.

That goes to the crux of what this union of basic research and applied science is all about. It's a great example of how you can get government and the academic-scientific community working together to solve a problem, Cagle said.

What they come up with will not only help Redondo, it can help the whole nation," he said.

[nick.green@dailybreeze.com](mailto:nick.green@dailybreeze.com)