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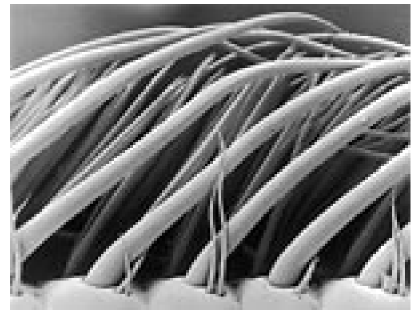
Scent of a lobster

No question about it… spiny lobsters aren't pretty. Keith Ward, chair of ONR's Biomolecular and Biosystems Science and Technology Group, doesn't particularly like their looks either, but he knows their sense of smell is astounding. Researchers funded by Ward figure that a lobster's extraordinary ability to sniff out all kinds of odor trails in the water is just what the Navy would like an unmanned vehicle to be able to do.



CAPTION: A scanning electron micrograph of the chemosensory hairs on the end of the antennules of the spiny lobster, Panulirus argus. The hairs sensitive to odors are in the center, protected by a phalanx of strong guard hairs. Credit: Jeff Goldman/Duke University, ©Oxford University Press

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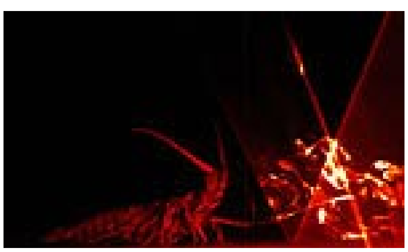
Mimi Koehl at University of California, Berkeley and her colleagues are studying the small hairs on the lobsters' olfactory antennules. They've discovered that these hairs can capture odors at very resolution, but they've yet to figure out exactly how that information gets to the lobsters' brains.

Koehl, along with Jeffrey Koseff and John Crimaldi at Stanford placed a mechanical lobster rigged with fresh real lobster antennule in a tank and used fluorescent dye to simulate an odor plume. They illuminated the plume with a thin sheet of laser light to see just the slice of the plume that the lobster's antennule encountered. The laser revealed that the plume was not just a diffuse cloud, but rather that it was made up of many fine filaments (about a millimeter wide) of swirling dye. A computerized motor reproduced the motion of a real lobster's flicking antennule, and a high-speed camera caught the filaments of dye flowing into the chemosensory hairs when the lobster rapidly flicked its antennule. This sample of the odor plume stayed trapped between the hairs until the next rapid flick of the antennule cleared it out and replaced it with another. Apparently, with each flick of the antennule, a detailed map of the swirling filaments of odor in a plume is captured.



CAPTION: A discarded lobster shell fitted with a motor-operated antennule that mimics the flicking used by lobsters when they sniff. A laser illuminates fluorescent dye in the turbulent water, allowing scientists to study how odors penetrate the lobster's nose. Credit: Mimi Koehl/UC Berkeley, Meg Wiley & Jeffrey Koseff/Stanford

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Work is now underway measuring the behavioral algorithms used by the crustaceans when their antennules encounter odor filaments. The next phase of the study will get neuroscientists involved who can relate odor concentrations in the hairs to electrical signals in the brain of the lobster.

"Our work capitalizes on a growing trend called biomimicry, " says Crimaldi, who now continues odor research at the University of Colorado. "We use nature as a model for designing an engineered system. The lobster had millions of years to learn how to accomplish an exceedingly difficult task with relative efficiency, but hopefully we won't take that long."

"We now understand the mechanism that allows the chemosensory hairs to catch odor traces," says Koehl. The big question now is how various crustaceans use the odor maps to locate the source of the odor. "Lobsters and other crustaceans are very successful at finding the sources of odors in the messy, turbulent water flow in the ocean. By understanding the physics, we gain insights for the design of man-made chemical-sensing antennae that can be used in the same kind of environments."

Which is precisely why the Navy is interested spiny lobsters and their sniffing abilities…. "We expect that these studies will provide us with important clues about how we can best develop a new class of sensitive chemical sensors that the Navy needs in order to locate and identify unexploded ordnance in very shallow marine waters," says Ward.