Glow-in-the-dark shark has killer smudge

A dark band below the jaw of a luminescent dwarf shark reveals a new kind of underwater dirty trick.

Viewed from beneath, the soft glow from the shark's many light-emitting cells blends in with dim light filtering from the sky and disguises the predator's outline. Against the glow, the dark chin patch looks like just the sort of little fish a predator such as a tuna is hunting, suggests Edith A. Widder from Harbor Branch Oceanographic Institution in Fort Pierce, Fla. The big fish darts up for the kill—only to be bitten itself by the smaller predator called a cookie-cutter shark.

This shark does what its name suggests: It gouges round, or cookie-shaped, plugs of flesh out of bigger animals. If a tuna is swooshing upward in an attempted attack, so much the better for the shark, Widder notes. The tuna's motion helps the shark's teeth sink in and slide around in a curving scoop, like the action of a melon baller.

If the tuna has the misfortune to attack what looks like a school of little fish but is actually a school of cookie-cutters, "the damage these sharks inflict would make their company as appealing as a swarm of wasps," Widder observes. The wounds are not fatal. Widder's discussion of the cookie-cutter shark's dark patch is scheduled to appear in an upcoming issue of ENVIRONMENTAL BIOLOGY OF FISHES.

For more than 100 years, scientists have recognized that the shark's underside glows in the dark. Perhaps the majority of fish and squid in the dimly lit water 200 to 1,000 meters below the surface use similar luminescence to disguise their shapes, Widder explains.

The cookie-cutter shark has carried this phenomenon, called counterillumination, to an unusual degree of refinement, she says. Other counterilluminators may rely on a few crude glowing spots, which make a blur resembling sunlit or moonlit water only when they are viewed from a distance. Yet the cookie-cutter's underside sparkles with so many light cells that its luminescence looks uniform even when viewed up close.

The density of the light cells make the blank patch all the more puzzling, Widder points out. "You've got this absolutely perfect counterillumination pattern, and you screw it up—why?"

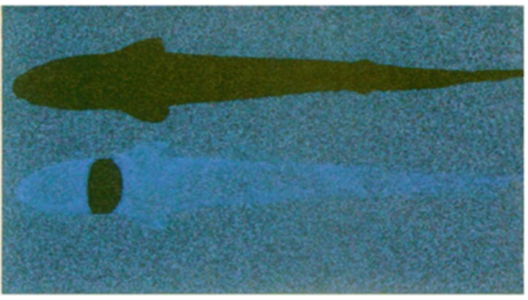

Calpoly University, San Luis Obispo

The cookie-cutter shark's teeth gouge plugs of flesh out of bigger creatures.

The possibility that the dark patch works as a lure struck her as she was writing a review article on bioluminescence. Part of the beauty of the lure idea, she says, is that it explains how a fish as small and slow-moving as the cookie-cutter keeps nailing big, fast animals like tunas, swordfish, and porpoises.

The cookie-cutter shark stretches only 30 to 45 centimeters long. Widder ranks its fins as small and its muscles as "flabby." But if the power swimmers of the depths will rush toward a dark smudge, who needs speed? All the shark has to do is sit, wait, and glow.

Other deep-sea creatures, such as anglerfish, waggle luminescent tissue as lures, but Widder can't think of another example of the absence of luminescence working as an attractant.


Widder

From beneath, the cookie-cutters true silhouette (top) blends in with light filtering from the sky because of the shark's luminescent underside. A dark patch in the glow resembles a smaller fish.

The oceans glow with novel strategies of bioluminescence, says Margo G. Haygood, who studies flashlight fish at Scripps Institution of Oceanography in La Jolla, Calif. In what may be a mating display, sea worms off Bermuda swim in swirls forming "fire wheels." Some squid, when alarmed, shoot out smoke screens of luminescent ink instead of the usual black. And tiny crustaceans called ostracods emit little luminescent puffs that hang in the water with clumps and spaces characteristic of their species. "It looks like a little set of Indian smoke signals," Haygood says. The shark strategy, however, is "a new twist," she notes. —*S. Milius*

Illuminating 3-D chaotic mixing in liquids


Ottino

Fluorescent dyes illuminated by a sheet of laser light expose a vertical cross section of a liquid flow pattern in a mixing tank. Dark areas represent relatively quiescent regions of poor mixing, whereas stretched and folded dye streaks indicate chaotic regions of good mixing. Inset: A motor (yellow on left) rotates a tilted disk, which generates two rings of moving liquid, one above and one below the disk.

From cream stirred into coffee to hurricanes generated over the Atlantic, mixing is an important process at home, in industry, and in nature.

Researchers have now developed an apparatus for studying three-dimensional flow patterns in a stirred liquid to help elucidate the connection between mixing and the mathematics of chaos.

"We wanted a simple, manageable system on which you could do experiments and compute theoretical results, making it easy to compare experiment and theory," says Julio M. Ottino of Northwestern University in Evanston, Ill. In previous efforts, his team and other research groups had focused primarily on two-dimensional chaotic flows and mixing in thin films or at surfaces (SN: 1/23/93, p. 53).

Ottino and his coworkers describe their apparatus in the July 31 SCIENCE.

The mixing tank consists of a transparent, cylindrical container, 30 centimeters tall that is partly filled with glycerine. A tilted, rotating disk at the liquid's center causes the liquid to circulate in the same direction as the disk. The liquid also swirls at right angles to the disk.

In effect, the apparatus is an idealized model of mixing tanks often found in industry, the researchers note.

Continuously injecting fluorescent dyes of different colors into distinct parts of the circulating liquid produces streaks. Illuminating the liquid with a sheet of laser light reveals the amount of mixing in different regions of a vertical cross section of the liquid.

Changing the disk's tilt alters the flow pattern. "When the disk is horizontal, a very simple flow occurs," says Igor Mézic of the University of California, Santa Barbara. Tilting the disk greatly complicates the pattern, producing areas of turbulence intermingled with areas of relatively steady flow.

"We believe that what we see in our experiments is generic to all [three-dimensional] flows," Ottino says.

Recent experiments show that when the tank and disk rotate in opposite directions and the disk is only slightly tilted, the liquid flow becomes almost completely chaotic. One gets "explosive" mixing, Mézic observes. —*I. Peterson*