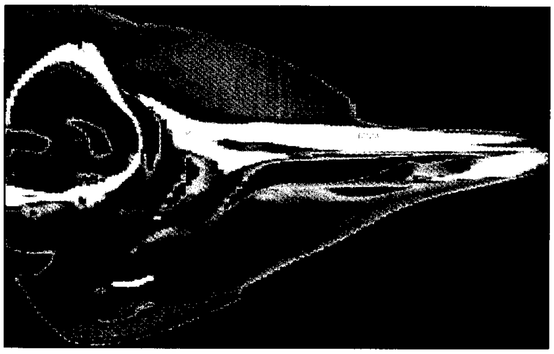
ANIMALS

DOLPHIN SONAR:
A biologist and physicist team up to find the source of sound beams

By Nina L. Diamond

How does the dolphin create its sonar signal? Scientists have long been puzzled by that question, offering many theories and attributing the sonar mechanism to so many different dolphin parts that if the dolphin had a big toe, scientists would have considered that, too.

Finally, it took two enterprising young scientists from different fields—biology and physiology—working together, and a novel computer simulation to come up with a possible answer.



The computer-generated images taken from CAT scans of real dolphins allow researchers much greater flexibility as they search for the source of sonar pulses.

It all started when biologist Ted Cranford, finishing up his Ph.D. at the University of California at Santa Cruz, "had a notion of how the dolphin sonar worked, and thought, *How do we find out?*" First, as a dolphin made sounds, he peeked into its blowhole with an endoscope, recording video images. "That gave me suggestive evidence that things were happening in the area of the 'monkey lips,'" Cranford recalls. (Monkey lips? Don't worry; we'll get to that.) He computerized CAT scans he took of dolphins who had died of natural causes. That way, he could take a dolphin apart over and over again without cutting into the real thing. Next, he needed someone who knew the physics of sound. Enter Jim Aroyan, a Ph.D. candidate at the University of California, Santa Cruz, specializing in acoustical physics, who's also an accomplished guitarist.

With a computer program that would simulate sound propagation, Cranford and Aroyan were on their way. "We built a dolphin's head model in the computer from the CAT scans, redigitized it, and assigned sound characteristics to the geometry of the parts of its head," says Cranford, now a research associate with the National Research Council. "The geometry is the most important element. You can move the sound source to different locations and run the simulation to see if the beam comes out in the right place—in front of the animal's head—with a pattern similar to a real dolphin's." There's only one place in the simulation where it comes out just the way it does in real life, and, fortunately, that's exactly where Cranford and Aroyan theorized it would be. "When you put the sound source where my hypothesis says it should be, the model puts out a sound beam very similar to that of a real dolphin," he says.

In the process, they weren't just looking for an answer to a nagging question; they were blazing some brand new research trails. "No one had tried to simulate sound propagation through dolphin tissues before," says Aroyan. "We've opened up a whole new field, simulating bioacoustics."

Why was the problem of dolphin sonar unsolved for so long? "All previous studies were inconclusive," says Aroyan. "That's because scientists were working with real dolphins on what we call the *near field*—close to the sound source—and they were hearing complicated signals and lots of interference. It was difficult to map it back to the source. Simulation on the computer was the perfect tool for this.

"The major question," he continues, "has always been, How are dolphins producing their pulses and how is the pulse focused into a forward beam?" Aroyan's and Cranford's computer simulation seems to have answered both aspects of the question. "We found strong evidence that the source of the sonar pulse is two to three centimeters above the dolphin's nasal plugs in an area Cranford named the MLDB—the monkey-lips dorsal bursae—just below the first air sac below the dolphin's blowhole."

When a dolphin breathes, air enters through the blowhole into the nasal passages. As the air leaves the respiratory system, the pull of the larynx pressurizes it before funneling a bit of air at a time up through two small liplike parts (the monkey lips) located near the top of the nasal passages. These lips vibrate when air passes between them, and when they slap together, they produce the pulse. The dolphin stores air in a sac above these lips and recycles it back down to repeat the process; that way, it doesn't have to resurface each time it needs to send out a series of pulses."When those lips close," Aroyan says, "the sound is pulsed into the dolphin's tissues, into the melon (the round forehead area), and directly out into the water."

In the end, the success of such an interdisciplinary collaboration may prove to be Cranford's and Aroyan's most important achievement if it encourages other similar collaborations. "There's a great deal more that can be done by having physicists and biologists working together," says Aroyan.