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DO FISH HAVE EARS? ACOUSTICS RESEARCH MAY BENEFIT SUBMARINES AND HELP DOCTORS CHECK FOR DISEASE

Research into how fish hear underwater may one day allow submarines to listen quietly for adversaries -- and help doctors better diagnose disease.

"A fish and a submarine have the same problem," said Dr. Peter Rogers, a mechanical engineering professor at the Georgia Institute of Technology. "They're both in an environment that propagates sound well, but propagates light poorly. Fish have developed a good sense of hearing. They obviously must get some information through sound."

In a project sponsored by the U.S. Navy, Rogers and former Tech professor Dr. Mardi Hastings measured sound-induced vibrations produced by various portions of goldfish, including the inner ear and the swim bladder, a gas-filled sac that regulates buoyancy.

To study physical responses to sound without dissecting the fish, Rogers and Hastings developed a non-invasive vibration measuring device. Since it can measure vibrations from outside a living fish's body, Rogers believes the patented device could be modified to check for diseased tissue, kidney stones or glaucoma.

The device may provide researchers with the first accurate mechanical measurements of actual sound responses in living fish. Hastings said submarines could benefit from a better understanding of the fish's passive listening system. Imagine a small fish hovering quietly above the ocean floor. It doesn't need to emit any signals to hear the approach of a larger fish. Submarines, on the other hand, often "hear" with sonar locators, and these devices emit a signal that can be detected by adversaries.

"A sonar locating device that detects other objects underwater is an active device," said Hastings, now a member of the technical staff at AT&T Bell Laboratories in Whippany, N.J. "You emit a sound beam and wait for it to bounce off something. If you've detected something, it has probably also detected you."

Until recently, inappropriate measuring devices have hindered researchers hoping to solve the mystery of fish hearing. Many existing devices use invasive tactics like dissection, Rogers said, and instruments that emit electrical signals may alter the vibration of an object being examined.

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The Georgia Tech device works this way: First, an anesthetized goldfish is suspended in a 50-gallon water tank. On one side of the fish, researchers set up a projector that broadcasts a continuous wave of sound that can be 'heard' by the fish. On the other side of the fish, a pair of ultrasonic devices called transducers are positioned so that their signals cross at a specific focal point within the fish. The transducers transform low-power electrical input into ultrasonic beams, and vice-versa. One of the transducers emits an ultrasonic sound beam while the second transducer receives a beam that has been modified by sound-induced vibrations occurring inside the fish. This system feeds information back to the researchers, allowing them to measure the fish's mechanical response to sound.

"We can get an absolute measure of the vibrational amplitude of what we're looking at," Rogers said. "We can measure vibrational amplitudes that are as small as 10 Angstroms -- atomic-scale vibrations."

How Do Fish Hear?

Rogers has theorized that fish use hearing in much the same way that people depend on sight. In other words, people don't often look directly at a lightbulb or the sun because we see scattered-light images. Since underwater environments don't produce much light, Rogers said, fish may hear scattered-sound images. To support his theory, Rogers notes that fish hear sounds that coincide with the frequency range of ambient noise in their environment. Similarly, people see most clearly when looking at images bathed in scattered ambient light.

Like its environment, a fish is primarily fluid, and its entire body may rock gently as sound waves flow through it. But the fish has a stone-like anchor, called the otolith, inside its inner ear. (Yes, fish have ears, but unlike humans, they don't need an outer ear.) The otolith interacts with the fish's swaying body, thus stimulating hair cells that send an electrical signal to the brain.

Though its role hasn't yet been fully explained, scientists know that the swim bladder also plays a key role in fish hearing. When sound waves hit a fish's swim bladder, the sound is then broadcast to other fish. At the same time, Rogers said, the swim bladder may work in concert with the otolith to set off vibrations within the inner ear. Scientists have theorized that a fish's inner ear may respond to acoustic particle motion, rather than the pressure caused by sound waves.

The research is not yet complete. But an understanding of fish hearing could ultimately help researchers develop improved surveillance equipment for submarines and underwater researchers. Meanwhile, Rogers said, the measuring device probably could be re-engineered for medical use. "It should tell us about the mechanical properties of objects inside the body," he said. "For example, you might be able to measure the elasticity of blood vessels or check for cancerous tissue."

Hastings and Rogers described their research in the January, 1987 edition of The Journal of Vibration, Acoustics, Stress, and Reliability in Design.

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