Snapping Shrimp Drown Out Sonar With Bubble-Popping Trick, Described In Science

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Summary: The oceans' shallow waters are noisy places, what with the waves, rain, and those chatty marine mammals. Loudest of all are the colonies of snapping shrimp, whose underwater cacophony is the bane of military and scientific efforts to "see" through the ocean using sonar. In the 22 September issue of the international journal Science, a team of researchers reveals the surprising trick behind these creatures' noisemaking.

FULL STORY

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Snapping shrimp have one normal claw and one large snapper claw that can be up to half its body size, making the shrimp look like it's wearing an overgrown boxing glove. The claw stays cocked open until a closer muscle contracts, causing the claw to close with lightening speed.

The shrimp uses its snap to stun its prey, defend its territory, and communicate with other shrimp. Colonies of these shrimp usually are so dense that they produce a constant crackling background noise, similar to the sound of burning dry twigs.

Until recently, scientists had assumed that the snapping noise occurred when the two parts of the claw banged shut. Now, however, a team of physicists and a biologist have discovered that the noise, in fact, comes from the collapsing of small bubbles generated by the claw's closing motion.

The bubbles form through a process called cavitation, which occurs when objects move quickly through fluids. It's primarily known for damaging ship propellers and pumps, because the energy released from the tiny implosions pits and weakens metal surfaces.

The idea that shrimp snaps might come from cavitation germinated at a colloquium in Munich, where Detlef Lohse, of the University of Twente, in the Netherlands, had just given a talk on sonoluminescence, the process by which bubbles in a liquid emit light when excited by sound.

Biologist Barbara Schmitz, of Technische Universität Munchen, in Germany, mentioned to Lohse that she had seen a bubble near the claws of the snapping shrimp using high speed video recordings in her lab.

"When I heard there was a bubble, I was excited, because I knew collapsing bubbles would produce sound," Lohse recalled.

When the moving part of the snapper claw snaps into the closed position, a tooth-shaped plunger moves into a niche in the other half of the claw. This motion shoots a jet of water out of the niche. To investigate what happens next, Schmitz and Lohse collaborated with University of Twente colleagues Michel Versluis and Anna von der Heydt.

In Schmitz's shrimp lab, she and Versluis tethered seven shrimp to a platform inside an aquarium. After setting up an ultra high speed camera (40,000 frames per second) and a hydrophone to record the snaps, the researchers tickled the shrimps' snapper claws with a paintbrush to get them to snap shut.

The photographs showed bubbles forming between the two parts of the closing claw, and then shooting away, along with the jet. Adding the sound recordings revealed that the snap occurred when the bubble collapsed, well after the claw itself had closed.

Lohse and his colleagues hypothesized that the snapping sound was produced by cavitating bubbles. To show how cavitation would arise in this situation, the scientists simulated the process using a numerical model.

When liquid moves above a certain speed, the pressure within the liquid decreases. This phenomenon, known as Bernoulli's principle, occurs in a wide variety of environments, from rivers to liquids flowing through pipes. When the pressure drops, it allows tiny air bubbles in these fast-moving fluids to expand. If the pressure builds back up, the bubbles implode.

A mathematical description of this process emerged in the early 20th century, according to Lohse. In 1916, perplexed by the damage that cavitating bubbles were causing to their ships, the British Royal Navy asked physicist Lord Rayleigh to solve the problem. While Rayleigh didn't find a way to stop the process from happening, Lohse says, the scientist did come up with a useful set of equations to describe the bubbles' growth and collapse.

The researchers used variations of these equations in their model. Their simulations closely matched what the camera and hydrophone had recorded in the aquarium.

The collapse of the bubble generates a shock wave that stuns small prey, such as small crabs, worms, goby fish, or other shrimp, when they are just a few millimeters away, the researchers propose in Science. In encounters with other snapping shrimp, the shrimp are farther away and the implosion isn't dangerous.

"This animal is utilizing cavitation damage, which has been extremely harmful for ship propellers. And here, it's being used to stun prey," Lohse said.

These findings should be particularly interesting to naval researchers, according to Lohse, since the shrimps' snapping is the dominant source of background noise in the shallow ocean. This noise seriously interferes with efforts to detect underwater objects by sonar. In fact, Lohse says, the study of snapping shrimp acoustics began in World War II because the enormous noise created by these small creatures made it so difficult to detect hostile submarines.