

Study pumps up the volume on understanding of marine invertebrate hearing

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A new study by researchers at Woods Hole Oceanographic Institution and their colleagues examined behavioral responses to sound by cuttlefish, a type of shell-less mollusk related to squid and octopi. The study is the first to identify the acoustic range and minimum sound sensitivity in these animals. Credit: Julia Samson

Noise pollution in the ocean is increasingly recognized as harmful to marine mammals, affecting their ability to communicate, find mates, and hunt for food. But what impact does noise have on invertebrates – a critical segment of the food web?

Very few studies have attempted to answer that question. The harder question to answer might be 'How do you measure hearing in ocean invertebrates?'

A new study by researchers at Woods Hole Oceanographic Institution and their colleagues examined [behavioral responses](#) to [sound](#) by [cuttlefish](#), a type of shell-less mollusk related to squid and octopi. The study is the first to identify the acoustic range and minimum sound sensitivity in these animals. Their findings, published in the *Journal for Experimental Biology*, can help decision makers and environmental managers better understand the impacts of noise in the ocean.

"It's hard to study loudness, or the perception of sound, with animals," said WHOI biologist Aran Mooney. "Generally, you need to train an animal, such as a chimp or a dolphin, to tell you its perception."

Some studies have inferred loudness by measuring how fast an animal responds to sound. But, says Mooney, that requires a leap in logic to conclude the animal perceives a sound as louder by measuring how fast the animals runs or swims away. He was interested in a well-designed, controlled study that measured all the right variables to truly map what a cuttlefish hears and its sensitivity to sound.

Mooney and lead author Julia Samson, then a student in Mooney's lab, set about to design a study to test hearing in cuttlefish, one animal at a time.

Their plan relied on previous studies by co-author Roger Hanlon of the

Marine Biological Laboratory (MBL) in Woods Hole, who had observed and defined a series of behavioral responses in cuttlefish, such as inking and jetting, mild color change, and twitching. Each response is associated with a perceived level of threat to the animal. For example, inking and jetting is done when cuttlefish predator is close by or they perceive some other threat; mild color change and fin movements demonstrates a reduced level of aversion such as when the animal is startled but not in fear for its life. Twitching is another behavior indicating a very mild response to a stimulus, from which the scientists can determine the sound is perceived but that it requires little response.

"What's cool about the cuttlefish is that you can get all these different graded responses. We could associate these pre-defined behavioral responses with different sounds," said Mooney. "We didn't have to train them—they were naturally exhibiting them."

Functionally, cuttlefish hear in ways similar to fish. They have an inner ear bone or otolith, which is like tiny grain of sand made of calcium carbonate, the same stuff corals are made from.

"This little stone sits on a bunch of hair cells, and the sound wave literally moves the animal back and forth – like when we stand close to a speaker and it vibrates us back and forth," Mooney said. The animal moves but the dense stone slightly lags behind and it bends the hair cells, and generates a nerve response in the brain. "It's like being on a rollercoaster and your body takes off faster than your stomach and you detect that movement," he added.

Using a test tank at WHOI, the researchers measured the responses of 22 cuttlefish to a range of sounds at different frequencies and loudness levels. The tank itself was calibrated twice. First, the sound pressure—which is like the vibration we feel when standing near speakers at a rock concert—was measured at several locations in the

tank using one hydrophone. Second, the particle acceleration—the 'rollercoaster' phenomenon Mooney described—was measured throughout the tank using two hydrophones to measure the sound pressure difference and derive the acceleration from this difference.

The researchers introduced individual cuttlefish to the tank and gave it some time to settle down in its new location. Then the researchers would play a sound and scored the animal's behavior. Each animal was exposed to four sounds per day, at random frequencies and levels. Depending on which frequency the animal was exposed to, there were different physical responses.

"During the sound experiments, we took notes of the animals' behavior, but we also videotaped their responses so we could analyze them later because responses happen so fast," explained Samson, "We would have to watch carefully to see, for example, whether the animal inked three or four times."

The researchers determined that cuttlefish hear in the same range as fish – approximately 80 – 1000 Hertz (Hz). This enables them to hear reef sounds, fish predators, and other biological activity – coincidentally the same range where there is lots of anthropogenic noise like seismic testing using air guns, small boat and commercial shipping traffic.

"Our study found that cuttlefish do react behaviorally to sound, especially in the frequencies human are really noisy at – around 300 Hz," said Samson. "Not surprisingly, the louder the sound the greater the response."

The study also suggests that cuttlefish possess loudness perception—a measure not just of sound level but also frequency—and that they can functionally use the sound to avoid a predator.

In a separate test, the team also exposed the animals to the same sound once per minute over 30 minutes, to see if the animals habituate to sound.

"They did get used to the sounds but the response didn't necessarily go away, it just decreased in intensity," said Mooney. "This means they are continually perceiving and monitoring the auditory world around them, and they can evaluate what's important and what's not."

Samson says this study upended her ideas of what cuttlefish could hear. When she joined Mooney's lab as a guest student, she wasn't even sure they could hear. Now with the University of North Carolina at Chapel Hill, Samson said, "I proved myself wrong; they do respond to sound. It's a very important finding because most people think invertebrates don't feel anything (like sound) and that's very much not the case."

Future studies will take the research out of the controlled environment in the lab and into the ocean to attempt to measure whether anthropogenic noise impacts their reaction to other sounds.

Provided by Woods Hole Oceanographic Institution

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