Study reveals previously unknown component of whale songs

November 2 2016

A breaching humpback whale in Hawaiian waters. Male humpbacks in Hawaii produce long songs during the mating season. This song contains high levels of acoustic particle motion, the vibratory component of sound, which may be used in both communication and hearing. Credit: T. Aran Mooney, Woods Hole Oceanographic Institution/NMFS permit #: 1468

Researchers have known for decades that whales create elaborate songs, sometimes projecting their calls for miles underwater. A new study from the Woods Hole Oceanographic Institution (WHOI), however, has revealed a previously unknown element of whale songs that could aid this mode of communication, and may play a pivotal role in locating other whales in open ocean.

In a paper published in the November 2 issue of the online journal *Biology Letters*, WHOI biologist Aran Mooney describes approaching a group of humpback whales off the coast of the Hawaiian island of Maui. From aboard small research boat, he and his team measured two components of the whales' songs—pressure waves (the type of sound wave that pushes on human eardrums, allowing us to hear), and particle motion (the physical vibration of a substance as sound moves through it). Surprisingly, he notes, particle motion in the water propagated much further than expected.

"We threw our gear over the side, and let ourselves drift away from whales while measuring both particle motion and sound pressure. We didn't expect particle motion to be projected much at all—just a few meters away at most. But as we got progressively further away, the particle motion stayed loud and clear," he says.

The group measured only as far as 200 meters from the whales, but their data shows that this particle motion, especially in lower frequencies of sound, could travel much further than the distance recorded. "It's a whole other avenue of sound that we never knew whales could use," he notes.

To envision the difference between these two modes of sound, Mooney says, imagine pulling up next to a car blasting loud music. "The stuff you hear is pressure waves; the stuff you feel vibrating your seat is particle motion," he adds. "When it comes to whale songs, particle motion hasn't really been studied much. It's a lot more complex to measure than pressure waves, so we don't have a great sense of how it propagates in water or air."

Pressure waves are relatively simple to detect using specialized underwater microphone called a "hydrophone"—a type of sensor that has been sold commercially for decades. Detecting particle motion, however, requires sensitive underwater accelerometers, which until recently have not been widely available to researchers. Mooney and his team, however, had both sensors on hand for an unrelated study in the area, allowing them to collect these unexpected recordings.

Mooney is quick to note that his team didn't gather enough data to say definitively whether these whales could sense the particle motion present, but the anatomy of whale ear bones suggests that low-frequency vibration could be a major element of their hearing.

Unlike dolphins and toothed whales, humpback whale ear bones are fused to the animals' skull, providing a direct link to any sort of vibration in the water column. "This could mean that their hearing is influenced by the way sound conducts through their bones," he says. "It raises the question: does a whale's lower jaw act like a tuning fork to direct vibrations to their ears? Previous papers have shown this bone conduction might be a viable mode of hearing."

From an evolutionary standpoint, he adds, there's some precedence for this sort of vibratory hearing. Although most mammals sense sound via pressure waves in their eardrums, the closest living relative to whales—hippopotamuses—are known to sense sound underwater using their bodies, even while their ears remain above the surface. Elephants, another close relative to whales, can pick up ultra-low frequency vibrations through their feet, a trait that may help them locate their herd from miles away.

Although Mooney's findings open the door for a range of evolutionary questions, he notes that it raises a much more immediate concern. If whales can in fact sense particle motion, similar vibrations caused by humans might interfere with the way the giant animals communicate.

"Most human-made noise in the ocean low frequency, and the level of sound is doubling every decade. There's constantly more shipping, more seismic exploration for oil and gas," he says. Mining and construction, such as pile-driving machinery, is also increasing, contributing low-frequency particle motion that might propagate for miles underwater. "We humans don't hear well in water, so we overlook noise in the ocean, but it's very relevant cue for marine animals," Mooney adds. "This could be a major concern for whales."

More information: Singing whales generate high levels of particle motion: implications for acoustic communication and hearing? *Biology Letters*, rsbl.royalsocietypublishing.or … .1098/rsbl.2016.0381

Provided by Woods Hole Oceanographic Institution