Another Marine Pollution Threat: NOISE

Are Whales 'Shouting' to be Heard?

When we're talking with friends and a truck rumbles by or someone cranks up the radio, we talk louder. Now scientists have found that North Atlantic right whales do the same thing in their increasingly noisy underwater world.

Marine biologist Susan Parks found that right whales call louder when the level of background noise goes up.

Parks drew on whale sound data that she, Mark Johnson and Peter Tyack of WHOI, and Douglas Nowacek of Duke University compiled between 2000 and 2005. Parks earned her Ph.D. in 2003 from the MIT/WHOI Joint Program and is now on the faculty at Pennsylvania State University. The team's findings were published July 7, 2010, in the online edition of *Biology Letters*.

The scientists had attached temporary recording devices called "D-tags" to the backs of right whales. The tags record the whales' calls and background noise around them, as well as the animals' movements. Parks analyzed the right whales' distinctive "upcalls," which start at a low pitch and then swoop upward. Whales use upcalls to let other whales know they are around.

The researchers assessed up to 18 calls from each of 14 whales. Every one of the whales, regardless of age and gender, got louder as ambient noise levels went up. They all maintained a level of about 10 to 12 decibels above the background noise. One whale called at 117 dB when the background noise level was 105 dB, 132 dB when the background noise rose to 120 dB, and 138 dB when background rose to 126 dB. Two whales recorded in highly noisy surroundings were practically shouting during every call, reaching nearly 150 dB. (Parks cautioned that decibel levels in air and under water cannot be directly compared.)

Parks also found that whales in the 2000s started their upcalls at a frequency between 100 and 200 Hertz (roughly an octave below middle C). By contrast, in recordings made in the 1950s by WHOI whale song pioneers Bill Watkins and Bill Schevill, right whale upcalls started about an octave lower, at 50 to 100 Hertz. Parks speculated that over time, whales may be able to change their call frequency to make themselves heard above rising background noise. Still, a noisier environment could affect the ability of the endangered whales, whose population is fewer than 400, to find mates and reproduce.

"To the extent they can, animals will try to keep up with [changes in] their environment," Johnson said. "The difficulty occurs when they are challenged by both a reduced population, as is the case with the right whales, and sudden or difficult-to-combat changes in their environment—for example, shipping noise that is so loud or so frequent that they are unable to fully compensate for it."

Parks said having to call louder could affect the whales in other ways as well. It takes more energy. It might also distort the meaning of the call—what it sounds like to other whales.

"We don't know what a whisper or a shout sounds like from a whale," Parks said. "We can tell for humans, but not for whales.

"We also don't know if they just stop calling at some point," she added. "Like being in a loud room, you talk louder to be heard—but if it's noisy enough, you just stop trying."

—Cherie Winner with additional reporting by Kate Madin

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Will a More Acidic Ocean be Noisier for Whales?

In 2008, a group of marine chemists raised a red flag: As the ocean becomes more acidic over the next century, they said, noise from ships will be able to travel farther and possibly interfere with whales and other animals that rely on sound to navigate, communicate, and hunt. The press ran with it. Even the reputable magazine *Scientific American* posted a blog entry titled, "Could ocean acidification deafen dolphins?"

But when Tim Duda, who studies sound propagation in the ocean at Woods Hole Oceanographic Institution (WHOI), read the same reports, he thought, "Time out, it's not that simple!" He and colleagues decided to apply their acoustical know-how to investigate this potential increase in ocean noise.

It's true that the oceans are becoming more acidic as excess carbon dioxide spewed into the atmosphere by fossil-fuel burning dissolves into the sea. And as improbable as it might seem, there *is* a connection between ocean chemistry and sound propagation.

Several chemical reactions in the ocean influence and are influenced by sound waves, and at least one of them is also affected by acidity. Here's how it works: Sound waves exert pressure as they pass through water. Pressure "squeezes" borate ions [$B(OH)_4^-$] into boric acid [$B(OH)_3^-$], a more compact molecule. In the process, the molecules absorb energy from passing sound waves.

"What that essentially means is that the water is squishy," Duda said. "When you push on it [with a sound wave], it gives."

It's akin to bouncing a ball off a pillow. Just as the ball loses energy to the pillow, a sound wave loses energy to the borate-to-boric acid reaction. As a result, sound won't travel as far.

Ordinarily, the boric acid is quickly changed back to borate, a reaction that does *not* absorb sound. But more acidic conditions tend to reduce the amount of borate in seawater. That, in turn, will mean less of a "pillow effect." The chemists calculated that the increase in ocean acidity predicted in the near future could reduce the "pillow effect" by half, which would allow sounds such as shipping noise to travel farther and interfere with marine animals over greater expanses of the ocean.

All very well, said Duda, but that scenario does not take into account how sound actually behaves in the ocean. He got together with WHOI scientists Ilya Udovydchenkov, Scott Doney, and Ivan Lima, and colleagues at the Naval Postgraduate School in Monterey, Calif. They split into three groups. Each group designed a mathematical model of sound propagation in the ocean. Starting with hundreds of hypothetical ships generating noise at three frequencies (100, 500, and 1,000 Hertz) in the northern Pacific Ocean, they tested how far the noise would travel today and under ocean pH levels projected for 2050 and 2100.

Results of the three models varied slightly in their details, but all told the same tale: The maximum increase in noise level due to more acidic seawater was just 2 decibels by the year 2100—a barely perceptible change compared with noise from natural events such as passing storms and big waves. The three teams published their results in three papers in the September 2010 issue of the *Journal of the Acoustical Society of America*.

Duda said the main factor controlling how far sound travels in the seas will be the same in 100 years as it is today: geometry. Most sound waves will hit the ocean bottom and be absorbed by sediments long before they could reach whales thousands of miles away.

"We did these studies because of the misinformation going around," Duda said. "Some papers implied, 'Oh my gosh, the sound absorption will be cut in half, therefore the sound energy will double, and the ocean will be really noisy.' Well, no, it doesn't work that way."

—Cherie Winner

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