Noise at sea: Cries of infant microbubbles

Breaking waves and rainfall splattering the ocean surface create vast numbers of invisible, microscopic bubbles. Several studies now suggest that these tiny bubbles generate most of the noise a diver might hear while swimming just below the surface.

"There is a lot of ambient noise in the ocean, and bubbles are very efficient generators of sound," says Lawrence A. Crum of the National Center for Physical Acoustics in Oxford, Miss. "It is our contention . . . that a great deal of the sound in the frequency range from about 100,000 hertz down to 10 hertz is generated by bubbles."

Studies of the sounds created by oscillating bubbles or scattered by quiescent bubbles may prove useful for tracking waves and near-surface ocean currents, for remote detection of precipitation over the ocean, and for monitoring a variety of processes, such as mixing in the ocean and the exchange of gases between ocean and atmosphere.

"Scientists are beginning to recognize that acoustical methods can help them enormously in tackling difficult problems that are of environmental significance," says David M. Farmer of the Institute of Ocean Sciences in Sidney, British Columbia. "There's a huge world of underwater sound – both natural and artificial – that provides a window on the ocean, which has not previously been exploited."

Bubble noise was the main subject of a session on acoustical oceanography at this week's meeting in San Diego of the Acoustical Society of America.

When a wind-driven, breaking wave crashes at sea, it traps large volumes of air, which quickly break up into tiny bubbles, perhaps only tens of microns in diameter. The newly formed microbubbles start their lives as pulsating sources of sound close to the ocean surface. Although they radiate sound for only a few milliseconds before settling into a passive state, these "screaming" bubbles contribute far more to the sounds heard underwater than does the splash generated by the impact of water on water.

Although researchers have known for more than 50 years that the amount and characteristics of underwater sound seem to depend on wind speed, they have only recently uncovered the link between the extent and strength of breaking waves and the number of microbubbles produced, which in turn generate the noise heard underwater. "The detailed mechanism of how [microbubbles] are formed is not well known, but they are apparently responsible for practically all the natural sound from 500 hertz to 20,000 hertz," says Herman Medwin of the Naval Postgraduate School in Monterey, Calif.

To account for the noise heard at even lower frequencies, Crum and his colleagues have been investigating the role of collective oscillations of "bubble clouds." Any individual bubble large enough to generate sound waves at 20 or 30 hertz would get quickly torn apart. But high-speed photographs now show that a sufficiently large, tightly packed cloud of microbubbles can operate as a unit, oscillating at a single, common frequency.

"We've been able to demonstrate in the laboratory that a whole cloud [of bubbles] will resonate and produce low-frequency sound," Crum says.

Because breaking waves create the noisy microbubbles, researchers can use arrays of hydrophones designed for detecting underwater sounds to listen to and track individual breaking waves as they move across the ocean. "That kind of information could be used for understanding the mechanisms governing wave conditions," Farmer says.

Microbubbles are so pervasive and persist for such surprisingly long periods that they can provide information about ocean currents. "Bubbles injected into the ocean by breaking waves tend to get organized into long rows, like furrows on a plowed field, which are lined up with the wind," Farmer says. "By looking at the way the bubbles are organized and the way they move, we can learn something about the circulation near the ocean surface."

Like breaking waves, raindrops striking water also produce tiny, briefly active bubbles. "We have found that the sound generated by raindrops is caused by bubbles whose diameter depends on the diameter of the raindrops," Medwin says.

The studies reveal that a small raindrop makes a crater in the water surface small enough that its sides come in faster than its bottom comes up, closing off the crater to create a tiny bubble. In contrast, a large raindrop produces a bigger cavity in the water surface and throws up a curtain of water that smashes together at the top to create a canopy above the water. The closing of the canopy generates a downward jet, which punches through the cavity's bottom, dragging with it a tiny bubble of air.

Because bubbles of different diameters oscillate at different frequencies, this discovery opens up the possibility of using "long-range listening" to determine raindrop size distributions and, ultimately, to measure rainfall rates over the ocean.

"Is it a fine mist or the large, heavy drops that come from a thundershower?" Medwin asks. "That can all be deduced from the sound that you hear underwater." *– I. Peterson*

New allergy vaccine brings relief to rats

An experimental vaccine blocks allergic reactions in rats and shows promise as a novel treatment for humans, British immunologists report. But other researchers express concern that the vaccine's design rests on an unconfirmed theory of immune function.

Denis R. Stanworth and his colleagues at the University of Birmingham, England, hold a controversial view of the immunological events that culminate in allergic reactions. They agree with other scientists that allergens – substances to which individuals are allergic – cause circulating immune proteins called IgE to bind to mast cells in body tissues. The mast cells then secrete histamine and other potent chemicals that create the itching, sneezing and watery eyes characteristic of allergic reactions.

But Stanworth's team believes that another critical event must occur between these two steps: A subunit of the cell-bound IgE protein must stick to another molecule elsewhere on the mast cell. The new vaccine consists of a chemically synthesized version of this IgE "trigger" subunit. Rats vaccinated with a dose of the subunit create antibodies that block allergic reactions, presumably by interfering with this middle step, the researchers report in the Nov. 24 LANCET.

In their experiments, five of six vaccinated rats allergic to egg white showed no signs of allergic reaction after receiving challenge doses of the egg protein. In contrast, two of four unvaccinated rats died of severe allergic reactions following the egg-white challenge, and the other two showed serious signs of allergic distress, including difficult breathing. Blood histamine levels were significantly lower in the vaccinated group.

"The method is based upon a rather shaky hypothesis, and even in the context of this hypothesis it remains rather confusing just how it is working," comments Henry Metzger, an immunologist at the National Institutes of Health in Bethesda, Md., who is investigating alternative means of blocking IgE's effects. Still, he says, "if one way or another these antibodies are doing what they report, then it may be promising."

"We might be wrong about how this thing works, but it's damn effective," Stanworth argues. "We think we have the makings of a novel vaccine for use in humans." He notes that a vaccine that blocks the IgE response should, in theory, prove useful for virtually any allergy, precluding the need to identify the culprit allergen.

Immunologist Philip W. Askenase of Yale University calls the work "interesting." However, he adds, "this is not something that's going right to the bedside." *– R. Weiss*