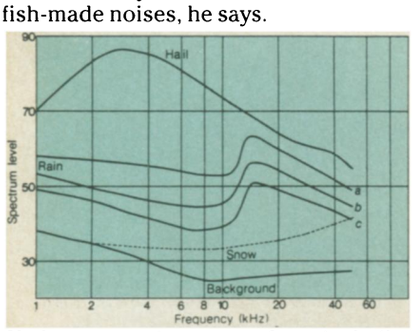
The Underwater Sound of Rain

From deep underwater, amid the rumbles, squeaks, whistles and other noises often heard, researchers are beginning to pick out the distinctive sounds of rain, hail and even snow striking the water's surface. This newly confirmed technique may make it possible to detect and measure rainfall over the oceans, filling a wide gap in knowledge about global weather patterns.

The experiments show that measuring and detecting rain over the oceans using buoy- or bottom-mounted acoustic sensors is, unexpectedly, feasible. Currently, rain gauges on ships provide unreliable, spotty data, and microwave measurements from satellites can't be properly calibrated.

One experiment, reported in the Dec. 19 NATURE, was done in Cowichan Lake on Vancouver Island, British Columbia. There, says Joseph A. Scrimger of Jasco Research, Ltd., in Sidney, British Columbia, "you get as much rain as you'd ever want." In winter and at night, when the measurements were made, the lake is also relatively free of human-made and fish-made noises, he says.



Scrimger/NATURE

Underwater noise spectra for rain, hail and snow at wind speeds greater than 1.5 meters per second. For rain, the upper trace (a) corresponds to the heaviest rainfall, the lower trace (c) to the lightest rainfall.

Scrimger mounted a hydrophone in 35 meters of water about 300 meters from shore. A cable carried the hydrophone's signal to a shore-based instrument, where it was recorded as a spectrum showing how the sound's intensity depends on its frequency. Great care was taken to ensure that the detected signal was truly "the signature of the rain and not of the equipment," he says.

Scrimger managed to observe several rainstorms and, by chance, hail and snow episodes. "We were flabbergasted," he says, "to find that [the rain's signature] was so structured."

Sound spectra for rain, under calm conditions, have a sharp peak at 13.5 kilohertz. Wind tends to round and spread out the peak. Hail, on the other hand, has a broad peak at 3 kHz, while snow tends to get "louder" with increasing frequency. However, these snow sounds are largely at frequencies beyond those detectable by human ears.

Scrimger's results are similar to those obtained by Jeffrey A. Nystuen, now at the Institute of Ocean Sciences in Sidney, British Columbia. While a graduate student at the Scripps Institution of Oceanography in La Jolla, Calif., Nystuen measured rain-generated underwater noise in an Illinois lake, then developed a computer model of a splashing drop to try to explain why the spectral peaks fall at a particular frequency. Nystuen reported his results at a recent American Geophysical Union meeting in San Francisco.

The effect is like that of a "water hammer" banging into the surface, says Nystuen. The impact of large, floppy drops of rain produces a lot of white noise, similar to the buzz heard on a badly tuned radio. Smaller drops produce less white noise.

But an instant after the initial impact, water must begin to flow. For drops of any size, this appears to take about 0.06 millisecond. After this time, no further sound is generated. This means that rainfall spectra should have a peak at close to 15 kHz. Through an earphone, a listener hears a kind of snapping or crackling noise.

"All of the drops contribute to the peak," says Nystuen, "but only the bigger drops cause a rise in the spectral level at low frequencies. That may explain the change in the spectral character from the heavy rain when big drops are present and light rain when small drops are present."

The spectral differences are often quite noticeable. "At Scripps," says Nystuen, "I could look at the spectrum in the lab and tell you what was coming down outside."

Scrimger says he has heard stories about lakes that "sing" when there's a very fine drizzle. These little drops are like explosive charges, he says. "When they hit the surface, they go off with a little ping." In the case of gently drifting snowflakes, the sound is probably generated by a process associated with the melting of snow.

Scientists are already starting to measure the speed of ocean surface winds by detecting their sounds underwater. Rainfall may be next. — *I. Peterson*

FDA may attach strings to artificial heart

Surgeon William DeVries should be allowed to complete the remaining three of the seven artificial heart implants for which he has received permission, but under closer Food and Drug Administration (FDA) oversight, an advisory panel has recommended.

The panel, prompted by generally poor outcomes of the first four implants, met late last month and heard from artificial heart proponents and opponents. Its recommendation, expected to be approved by the FDA commissioner: that the next three implants be allowed on a quarterly basis, with a full FDA review of each one before the next is allowed.

All four recipients of a Jarvik-7 heart from DeVries subsequently had problems with bleeding. Two suffered strokes and one seizures. Only two are still alive, and both of those remain in the hospital.

Surgeons using an artificial heart as a "bridge" while awaiting a donor heart have also encountered problems with strokes and bleeding with the Jarvik-7 and other models.

Mary Lund, the first woman to receive an artificial heart, has thus far avoided the postoperative bleeding and stroke problems, according to a spokesperson at Abbott-Northwestern Hospital in Minneapolis. She came out of a light coma several days after the Dec. 19 implant of a smaller version of a Jarvik-7, and at press time her recovery was going well.

The problems identified by speakers at the recent meeting come at the interface of medical research and human rights. On the one hand, potential artificial heart recipients are dying and the artificial heart may help them or future recipients. On the other hand, critics told the panel, recipients may be the "guinea pigs" of well-intentioned researchers.

George Annas, a professor of health law at Boston University, asked the panel, "If what happened to the first four isn't bad enough [to call a halt to the implants], what is?

"The artificial heart cannot save their lives. It can only change the way that they die."

Among other criticisms leveled at continuation of the procedure: that the review board at Humana Hospital-Audubon in Louisville, Ky., where three of the operations have taken place, has done an insufficient job of oversight; that DeVries's failure to publish what he considers interim data has denied the scientific community the chance for an open evaluation; and that determining when a patient is likely to die and thus in imminent need of an artificial heart is difficult.