Reversed broadcasts key to underwater secrecy

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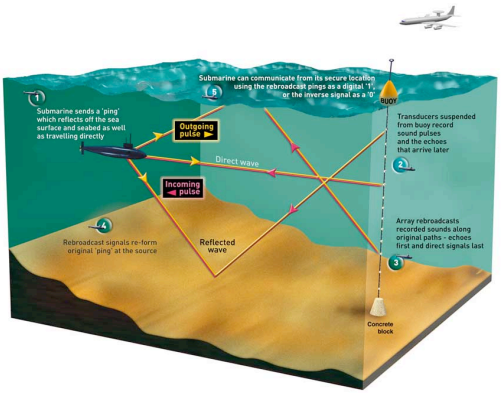
Playing sound waves backwards could help the US Navy set up secure communication links with submarines or unmanned submersibles. The system works by broadcasting messages in such a way that they can only be received at one point in the water - so no one else can intercept them.



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Underwater communications are very primitive, says Geoff Edelmann at the Scripps Institution of Oceanography in San Diego. Most use simple underwater transducers called hydrophones to send and receive messages. But because sound waves travel in all directions in the ocean, reflecting off the seabed and the surface and also interfering with each other, acoustic signals are often too garbled to understand.

"They tend to be very unstable, very short-range and only good in deep water," says Edelmann. To communicate for any length of time, or over large distances, submarines either surface or use a floating antenna. But that's not always possible in covert operations, says Jeff Simmen of the Office of Naval Research in Arlington, Virginia.

Edelmann and his colleagues think a solution may be to harness a technique for locating enemy subs called "acoustic time reversal". To test this idea, Edelmann and his colleagues dropped an 80-metre line fitted with 32 hydrophones over the side of a boat 10 kilometres off the coast of Italy. A buoy was fixed to one end of the line and, to keep the array of sensors vertical, a concrete block acted as an anchor at the other.

Original ping

The scientists then broadcast a short ping from a hydrophone moored near the shore, which acted in place of a submarine. The ping, garbled by complex interference patterns and echoes produced as the sound waves bounced off the seabed and the surface, was recorded by each hydrophone on the column moored out at sea.

These recorded signals were then processed so they could be played backwards. Rebroadcasting the signals in the reverse order they arrived sent sound waves back towards the shore. Because they travelled back through the same environment, the signals interfered to reconstruct the original ping at the exact location where it was sent - at the near-shore hydrophone.

By manipulating the recorded sound signals, Edelmann used the effect to make a communications link. Sending a simple, time-reversed signal from the array to reconstruct the original "ping" counted as a digital "1", while inverting the time-reversed signals before rebroadcasting them produced an "inverse ping" or a "0".

The system can transmit data at 1 kilohertz.

What they had done was to establish a unique communications path between the array out at sea and the point on the shore. Everywhere, apart from the point of reception, the signal only exists in meaningless pieces - so no one can intercept it, Edelmann will tell the Oceans 2001 conference in Honolulu next month. "You can focus the signal in one spot and only the person located at that spot can hear you," he says.

"It's completely contrary to regular communications, because you can't intercept it along the way," says Mathias Fink, who works on acoustic time-reversal technology at the University of Paris VII.

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