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not cope well with bubble clouds resulting from breaking waves or other causes, which scatter sound and clutter the [sonar](#) image.

Professor Timothy [leighnton](#) of the University of Southampton's Institute of Sound and Vibration Research (ISVR), who led the research, explained:

"Cold War [sonar](#) was developed mainly for use in deep water where bubbles are not much of a problem, but many of today's applications involve shallow waters. Better detection and classification of targets in bubbly waters are key goals of shallow-water [sonar](#)."

[leighnton](#) and his colleagues have developed a new [sonar](#) concept called twin inverted pulse [sonar](#) (TWIPS). [twips](#) exploits the way that bubbles pulsate in sound fields, which affects the characteristics of [sonar](#) echoes.

"To catch prey, some dolphins make bubble nets in which the best man-made [sonar](#) would not work. It occurred to me that either dolphins were blinding their [sonar](#) when making such nets, or else they have a better [sonar](#) system. There were no recordings of the type of [sonar](#) that dolphins use in bubble nets, so instead of producing a bio-inspired [sonar](#) by copying dolphin signals, I sat down and worked out what pulse I would use if I were a dolphin," said [leighnton](#).

As its name suggests, [twips](#) uses trains of twinned pairs of sound pulses. The first pulse of each pair has a waveform that is an inverted replica of that of its twin. The first pulse is emitted a fract

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at detecting a small steel disc under bubbly conditions resembling those found under oceanic breaking waves.

Encouraged by their findings, they next conducted trials at sea aboard the University of Southampton's coastal research vessel the RV Bill Conway. They compared the ability of [twips](#) and standard [sonar](#) to discern the seabed in Southampton Water, which handles seven per cent of the UK's entire seaborne trade. The seabed in this area varies in depth between 10 and 20 metres.

"[TWIPS](#) outperformed standard [sonar](#) in the wake of large vessels such as passenger ferries," said co-author Dr Justin Dix of the University of Southampton's School of Ocean and Earth Science (SOES) based at the National Oceanography Centre, Southampton.

Possible future marine applications for [twips](#) include harbour protection and the detection of bubbles in marine sediments and manufacturing. Technologies based on the same basic principles could be used in medical ultrasound imaging, which was already using pairs of inverted pulses to enhance (rather than suppress) contrast agents injected into the body. The [twips](#) principle would work with other sensors such as in Magnetic resonance imaging (MRI), and [leighton](#) has proposed TWIPR (Twin Inverted Pulse Radar) for the detection of improvised explosive devices or covert circuitry.

But what about the original inspiration for the research do dolphins and other echolocating animals use

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"Key ingredients of a [twips](#) system appear in separate species but they have never been found all together in a single species," said [leighton](#). "There is currently no evidence that dolphins use [twips](#) processing, although no-one has yet taken recordings of the signals from animals hunting with bubble nets in the wild. How they successfully detect prey in bubbly water remains a mystery that we are working to solve. I have to pay credit to the team students Daniel Finfer and Gim-Hwa Chua of ISVR, and Paul White (ISVR) and Justin Dix

of SOES. Our applications for funding this work were repeatedly turned down, and it took real grit and determination to keep going for the five years it took us to get this far."

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