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STORY *Julian Cribb*

Oceans

In less than three generations, the oceans have filled with the sounds of motors, sonar and seismic tests; has it affected marine life? Some scientists think so.

DESCEND A FEW METRES into the ocean and objects that are a mere arm's length away take on fuzzy outlines. Go deeper and, as the light begins to fade, your hands appear like shadow puppets. At 1,000 metres you enter endless night, where eyes are of limited use and hearing is everything. Here, noise moves five times faster and infinitely farther than on land. The oceans are the true realm of sound.

Most sea creatures, from whales and dolphins to fish, sharks, squid, shrimps and possibly even anemones and jellyfish respond to sound and many can produce it. They use it to hunt and to hide, find mates and food, form and guide shoals, navigate

'blind', send messages and transmit warnings, mark territories, warn off competitors, stun prey, deceive predators, 'illuminate' their surroundings, avoid obstacles and sense changes in water conditions.

Marine animals click bones and grind teeth; use drum-tight bladders and special sonic organs to chirp, grunt, sing and boom; belch gases and liquids; and vibrate special organs or their entire bodies. They gather to form great choirs. Sounds emitted by undersea animals span the range from 0.1 Hertz to 300 kiloHertz, says Michael Stocker, consultant acoustician and naturalist. Far from the 'silent deep', the oceans are a raucous babel.

Into this age-long tumult, in the blink of an evolutionary eye, has entered a new thunder: the throb of mighty engines and the thrash of propellers as 46,220 large ships displacing 600 million tonnes of water plough the world's shipping lanes. The hammer of diesels and the scream of outboards reverberate through the waters as 4 million fishing boats and more than 10 million ferries and pleasure craft surge to and fro. Then there's the thump and ping of sonars; the deafening crash of ships seeking oil; the blare of acoustic harassment devices; the grinding of dredges; and the low-frequency growl of experiments to detect global warming.

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of noise

Within barely a century, the long-silent oceans have been filled with a cacophony of human origin. Scientists say that background noise in the ocean has increased roughly 15 decibels in the past half century. It may not sound like much – in absolute terms it's less than the volume of a whisper at distance of a metre – but it is enough, according to many marine biologists, to mask the normal sounds of ocean life going about its business.

At its most intense, some even say the noise is causing whales to become disoriented and die; dolphins to develop 'the bends'; and fish to go deaf, flee their breeding grounds or fail to form shoals.

"Undersea noise pollution is like the death of a thousand cuts," says Sylvia Earle, former astronaut and chief scientist of the U.S. National Oceanic and Atmospheric Administration. "Each sound in itself may not be a matter of critical concern, but taken all together, the noise from shipping, seismic surveys, and military activity is creating a totally different environment than existed even 50 years ago. That high level of noise is bound to have a hard, sweeping impact on life in the sea."

Sarah Dolman of the British-based Whale and Dolphin Conservation Society agrees. "Today the seas are a far noisier place than they were a few

decades ago." In its report, *Oceans of Noise*, which was published recently, the society states: "There is increasing concern amongst scientists and conservationists that noise pollution poses a significant and, at worst, lethal threat to whales and dolphins and other marine wildlife. A deaf whale can be expected to be a dead whale."

Others disagree, arguing the human addition to natural ocean noise is vestigial, being localised within certain busy spots, and falling away rapidly only metres from the source as the water blankets it. While it is possible to deafen fish in a tank, it is very difficult to prove that changes in the health

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Once more with porpoise

The 7th-century BC pop idol had just made a fortune playing to capacity crowds across Italy when the Corinthian sailors who were sailing him back home to Greece casually informed him they were going to steal all his gold and throw him overboard.

Playing for time and plucking his lyre, Arion offered to sing them his number one hit, the "Stirring Song", from the vessel's stern before taking his own life. This was so high-pitched and beautiful that dolphins milled around the ship in curiosity. When the artist took his final leap, one of them bore him up and carried him safely to the beach at Point Taenarum.

This Greek myth, recorded by Herodotus and other authors, and illustrated on ancient vases, shows that as long as 2,700 years ago people clearly understood the importance that sound had for sea creatures – and they respected dolphins for it. — Julian Cribb

The bottlenose dolphin
(*Tursiops truncatus*)

or behaviour of wild whales, seals or fish are due to sound alone. The fine details of their behaviour patterns are extraordinarily difficult to monitor and interpret, so who really knows? In short, the society's critics claim, ocean noise is just another overheated issue generated by environmentalists and fed by a media frenzy.

We know sound can travel both fast and far in the ocean – but for many reasons it does not travel evenly. "In the sea, noise drops off very quickly with distance from the source, then it drops off much more slowly," said Rob McCauley, a marine biologist at Perth's Curtin University of Technology, who has studied ocean bioacoustics for the past 15 years.

"It's a logarithmic decay. High-frequency sound attenuates very rapidly because the water literally absorbs it. But low-frequency sound in the range 10–200 Hertz can travel a long, long way," he said.

To make the picture more complicated, shallow waters absorb sound at the sea-bottom as well as the surface, so they are potentially less 'noisy' than deep waters. And the oceans contain a structure that allows low-frequency noise to propagate along a 'sound channel', about 1,000 metres down, for thousands of kilometres, all over the globe. It is the existence of this sound channel, says McCauley, that has given rise to a widespread belief that all noise in the ocean travels all round the world.

"That's not true," insists McCauley. "The busier parts of the Atlantic do contain a lot of man-made noise, but it rapidly decays to background levels and we are not seeing its effects in waters around Australia. There's a lot of noise here, but it is mostly biological, made by whales and so on."

However, he adds, there are still problem areas for noise in Australia, including busy ports along the northwest coast where ship-borne air-guns blast away in the seismic quest for oil and gas.

And some species are more susceptible to noise pollution than others: toothed whales and dolphins, for example, are sensitive to high-frequency sound, whereas baleen whales operate at lower frequencies. A seismic-survey vessel "acts like a giant plough", McCauley says, frightening away sea life with each blast. "But they do tend to come back afterwards. Permanent displacement of sea life due to noise has been claimed, but there's not much evidence for it."

However McCauley has firsthand proof that seismic blasts do affect snapper. In a behavioural experiment conducted in the waters of Western Australia's Cockburn Sound, he exposed a cage of pink snapper to shots from a seismic air-gun over a distance of 500 metres and less. At each shot, the snapper bunched together, circled wildly and dived for cover at the bottom of the cage. But when McCauley repeated the experiment 58 days later, he was surprised to see the fish didn't react at all.

"When we came to examine the anatomy of their ears, the sensory part was a mess," he said. "We concluded they were stone deaf, and that any fish in the wild that suffered such an injury would be dead, eaten by sharks or whatever."

Michael Smith, a U.S. biologist at the University of Maryland, has likewise demonstrated noise-induced stress and deafness in goldfish, a species

that tends to rely on its hearing. And Sonja Amoser, a research associate at the University of Vienna, has shown that catfish, which rely on sound even more than goldfish, suffered longer hearing loss.

There is mounting evidence that noise can cause sea life to change its behaviour. Canadian scientists have demonstrated that killer whales are deterred by 'acoustic harassment' (loud alarms that are installed to stop them poaching stock from salmon farms); researchers in California have shown that certain low-frequency sounds change the diving behaviour of elephant seals; and the U.S. Navy has found that humpback whales change their song when obliged to compete with military low-frequency sonar.

"Within barely a century, the long-silent oceans have been filled with a cacophony of human origin. Background noise has increased by 15 decibels over the past half century."

But McCauley says research into floating hotels on the Great Barrier Reef suggests some sounds may actually attract sea larvae – and hence the larger fish and animals that feed on them. Amusingly, fish also seem better able to regulate their noise emissions than people: McCauley's early research revealed that the deafening choruses of certain fish on the Barrier Reef were timed or located in such a way as not to interfere with the singing of other sea species.

Ocean noise pollution is an issue of growing importance among, and within, groups concerned with the environment. The seminal report, *Sounding the Depths: Supertankers, Sonar and the Rise of Undersea Noise*, was published in New York in 1999 by the Natural Resources Defence Council.

However, before this report could be published, a number of fiery spats took place, including a bitter, unifying argument between physicists and biologists over a global experiment that involved transmitting acoustic waves in the deep ocean as a way to measure global warming. The physicists argued their low-frequency sound waves, known as ATOC (Acoustic Thermometry of Ocean Climate), were harmless; the marine biologists contended they would interfere critically with one of the main communication channels used by whales, in effect scrambling their long-distance conversations.

Scenting another rising environmental issue, green groups have been quick to take up the cause of ocean noise. At its meeting in Bangkok, Thailand, in November 2004, the World Conservation Union adopted a resolution that declared noise was a form of ocean pollution. Later that same month, a U.N. Environment Program meeting of 16 countries





The humpback whale
(*Megaptera novaeangliae*)

SPL

Listening out for whales

French marine scientist Michel André has developed the world's first passive sonar system designed to prevent a growing problem – fatal collisions between high-speed vessels and whales in busy shipping lanes. The system was scheduled to go on trial in the Mediterranean in September 2005.

André has found evidence that the modern underwater cacophony has interfered with whales' method of echolocation, disorienting them and making them more likely to collide with ships.

André's team at the Universitat Politècnica de Catalunya in Barcelona, working together with groups in Netherlands and Singapore, as well as the Spanish submarine company SAES, has devised a 'passive acoustic' system that warns speeding vessels about whales in their path. It creates a 'safety corridor' for whales by placing 12 acoustic buoys at 10km intervals along the 120km seaway stretching from Tenerife to Gran Canaria islands.

These buoys comprise hydrophones and sensors able to detect and pinpoint the whales. To monitor 'non-vocalising' whales, the system uses ambient noise from waves, rain, ships and the whales themselves to create acoustic images.

"In this way, the completely non-invasive Whale Anti-Collision System acts as a permanent 'ear', tracking cetacean movement 24 hours a day," André said. He has built a prototype, an acoustic buoy linked to a computer on a research vessel, which is designed to demonstrate the system's efficiency in creating three-dimensional images of the submerged whales and their position relevant to the boat.

After successful testing of the system in the Mediterranean Sea, a larger trial is planned for the Canary Islands. André says that he hopes to make the system available to any other region of the world where shipping traffic is causing potential or actual problems to whale populations. — Julian Cribb

dedicated to protecting whales and dolphins in the Mediterranean, Black Sea and Atlantic adopted a resolution acknowledging man-made ocean noise as "a dangerous pollutant which can disturb, injure and even kill whales and other marine species". Groups have sprung up, such as the North American Ocean Noise Coalition and the European Coalition for Silent Oceans (ECSO), which are calling for sea sanctuaries in which all human activity is banned.

Whether sound can cause whale or fish deaths at sea remains debatable. The Whale and Dolphin Conservation Society report says "evidence of the lethal nature of noise for marine mammals comes from recent strandings associated with the use of military sonar, such as the mass stranding of beaked whales in the Bahamas in March 2000".

In its literature, ECSO has said that "a series of mass mortalities of cetaceans [was] associated with the use of mid-frequency active sonar in coastal environments." It said the best-documented cases were in the Bahamas in the Caribbean and Madeira off the southwestern coast of Portugal in 2000, and the Canary Islands off the coast of North Africa in 2002. Other incidents have occurred in Greece in 1996, the U.S. Virgin Islands in 1998 and 1999, the Canary Islands again – in 1985, 1986 and 1989 – and, most recently, the northwest coast of the United States, in 2003. "However, the magnitude of the problem is not known...whales may die at sea where carcasses sink," ECSO says. "The proliferation of active sonar poses a threat to already depleted fish stocks throughout the world's oceans."

The Royal Australian Navy, for one, isn't taking chances. When it discovered the Perth Canyon – the nearest deepwater exercise area to the submarine base on Garden Island in Western Australia – was also a favoured haunt of pygmy blue whales, the navy asked a team of local biologists to investigate.

Their research found that whale visits to the canyon were seasonal, from February to May every year. The navy tactfully decided to yield right of way to the whales, moving its exercises.

French biologist Michel André, who chairs the European Cetacean Society, considers sound can kill sea life in various ways. André investigated the carnage in the Canaries as fast ferries collided with sperm whales. His study of the dead whale's ears led him to conclude that the whole whale population had been partially deafened by noise pollution.

"The noise causes whales to become disoriented and die; dolphins to develop 'the bends'; and fish to go deaf, flee their breeding grounds or fail to shoal."

"The more noise that we put in the ocean, the more we affect the way the animals that live there communicate and orientate," André said. "And this means that we are compromising their survival. We're compromising the way they look for their food. We're compromising the way they breed."

"Nowadays there isn't a region anywhere that is unaffected by noise pollution. A sound source may propagate for thousands of miles because of its low-frequency components. The control of these sources is a scientific challenge and involves an important responsibility for society and governments."

In the rumble of claim and counter-claim one fact stands out: there is no law – international or otherwise – that controls noise pollution at sea. So far, it has mainly been the strength of public and scientific opinion that has induced oil explorers, ship owners and navies to investigate the possible side effects of their noisy activities on marine life.

Some governments are erring on the side of caution. Australia's Department of the Environment and Heritage classifies acoustic disturbance as an 'intermediate threat' to whales: "Any human activities which produce loud and persistent sounds under water are likely to interfere seriously with the acoustic perception and communication of any cetaceans in the vicinity, and have the potential to induce significant levels of stress...incessant or repeated acoustic disturbance could cause abandonment of important habitats such as narrow migration paths and calving and nursery sites".

Meanwhile, the World Conservation Union has urged governments to apply the precautionary principle to marine noise pollution; investigate mass strandings that may be associated with intense man-made noise; and encourage development of less noisy alternative technologies. They also say powerful noise sources should be controlled until their effects are better understood; avoided in sensitive areas; and subject to restriction under marine and coastal management guidelines.

"Regulating sound sources can be difficult, but one has to start somewhere," says Sylvia Earle. "Every breath we take depends on the ocean. Unless we really understand how that vast system works and take better care of it, it isn't just the ocean that's in jeopardy; it's our whole future that's at stake." ❏

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