Staying silent or out of reach

A frequent victim of naval sonar, the beaked whale muffles her own voice to stay hidden

A killer whale hunting a beaked whale

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Animals that use sound to communicate end up giving themselves away to predators. The way to stay viable is then to spend time at places where predators cannot venture.

Natacha Aguilar de Soto, Fleur Visser, Peter L Tyack, Jesús Alcazar, Graeme Ruxton, Patricia Arranz, Peter T Madsen and Mark Johnson, from University of La Laguna, Tenerife, Canary Islands, Spain, University of Amsterdam and Utrecht University, The Netherlands, University of St Andrews, Scotland and Aarhus University, Denmark, describe in the journal, *Scientific Reports*, how the beaked whale has adapted to avoid becoming the prey of the killer whale.

The beaked whale, at four to 13 metres long and one to 15 tonnes in weight, is a middling whale, and is marked by the nature of its teeth — teeth erupt only in the males and of these there is generally only one pair, rather like tusks, than teeth. What distinguishes beaked whales from other deep diving species of whales, however, is their manner of diving in groups, of vocalising only at depths and the way they return to the surface.

The way they rise to the surface after a dive is at a shallow angle, which takes time. This manner of rising limits the time they can spend at the depths, where they forage. Rising slowly had been considered to be an adaptation to avoid decompression sickness, an effect known to human divers when they rise too fast after a dive. Reasons for this to happen, however, have not been found and other, toothed whales, which dive to similar depths, are seen to make nearly vertical ascents. These other whales also vocalise when they reach shallow water, to re-establish contact with their herd. Whereas the beaked whale typically stays silent when not diving deep. As the beaked whale uses echolocation, or listening for echoes for locating prey, they are able to actively forage for only 20 per cent of the time, the paper says.

An alternate explanation for the way the beaked whale rises to the surface, and limits hunting to greater depths has been proposed as a means of predator evasion, the paper says. Beaked whales can be attacked by sharks and it is known that they are harassed by dolphins. But their main predator is the killer whale. Killer whales are toothed whales, the largest of the marine dolphin family, and known as apex predators, as no animal preys on them. They are found in all parts of the world and prey on fish, other marine animals like seals and other species of dolphin, even whales.

The killer whale, like many predators of the sea, has sharp hearing to locate its prey. The beaked whale or other animals that use sonar to locate food are thus easily detected by the killer whale from afar. The killer whale, however, is silent and does not provide its victims the same courtesy. As an adaptation, the paper says, some toothed whale species have evolved to echolocate at frequencies that are higher than the limits of the killer whale's hearing. Other species, dolphins, sperm and pilot whales, the paper says, find social safety in cohesive groups.

The beaked whales, however, have adopted neither strategy. They produce clicks at mid frequencies and can be heard by predators from a distance. And they live in small groups that offer no protection. That the beaked whale has developed no defensive strategy is at odds, the paper says, with the intense reaction they show when exposed to recordings of killer whale sounds or mid-frequency sonar sounds. Data shows that beaked whales are prominent among whales that are beached or stranded as a result of the sonar emissions of naval exercises. This suggests that the mortalities are the result of anti-predator response, the paper says. And a further conclusion that the behaviour of vocalising only after diving deep, and then ascending at a shallow angle, are also for predator evasion.

The authors of the paper note that the beaked whale's behaviour has a heavy price tag as it limits the time available for echolocation of food. The authors then carry out trials to quantify how far the features of diving, vocalising and manner of ascent contribute to predator avoidance, to make the price worthwhile.

The killer whale, the paper says, is a powerful predator, but with limited diving capacity. Data suggests that they spend most of their time in the top 20m of water. As intense effort is needed to capture whales and dolphins, and the killer whale needs to come to the surface every 10 minutes, the killer whale really cannot seek prey at substantial depths. Deep water is hence a safe refuge for the killer whale's prey, specifically the beaked whale. The authors therefore propose that beaked whales restrict echolocation to deep water, and keep silent, to give the least evidence of their presence, when they need to return to the surface.

This they achieve by coordinating their movements, by group diving, and by not echolocation, which would give them away, till they are too deep for the killer whale to follow. The echolocation that they do use, however, would show the predator where its prey is foraging and it would lie in wait, directly overhead. Hence the slow ascent of the beaked whales, at a shallow angle, and in silence, so that the predator cannot make out where to get at them!

The coordinated diving behaviour was studied by tagging whales with sensors that would transmit depth and orientation data. Pairs of whales in the same social group were tagged to see how soon after the first whale began a dive did the second one follow. The result, the paper says is that the overlap of the time spent in a deep dive by the pair was 99 per cent. As the whales were selected at random, it can be taken this shows coordination of diving behaviour. And then, the analysis of the vocalisation behaviour, or the time the whales used echolocation, showed an overlap of 98 per cent.

In respect of the slow ascent, again, the positions of the whales from just before the vocalising stops were plotted, using the pitch, roll, direction and depth data, over 101 instances of ascent. The whales covered a horizontal distance of one kilometre during the ascent, which created "a large circular locus of potential surfacing positions that must be searched by killer whales and which they must search visually rather than using echolocation to avoid alerting their prey," the paper says.

"The unique diving and vocal behaviour of beaked whales could only evolve if the severe costs it imposes are outweighed by survival benefits," the paper says.

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Lessons from Antarctica

Two hundred years of exploring the world's coldest, most forbidding and most peaceful continent has taught humankind a lot

DAN MORGAN

Adelie Penguins on an iceberg in Antarctica

Antarctica is the remotest part of the world, but it is a hub of scientific discovery, international diplomacy and environmental change. It was officially discovered 200 years ago, on 27 January 1820, when members of a Russian expedition sighted land in what is now known as the Fimbul Ice Shelf on the continent's east side.

Early explorers were drawn there by the mythology of Terra Australis, a vast southern continent that scholars imagined for centuries as a counterweight to the Northern Hemisphere. Others sought economic bounty from hunting whales and seals, or the glory of conquering the planet's last wilderness. Still others wanted to understand Earth's magnetic fields in order to better navigate the seas.

I am a geologist who specialises in understanding the timing and extent of past ice ages. Much of my work focuses on the glacial history of Antarctica, and I've been privileged to conduct five field seasons of research there.

For the next two years I'll be working with a field team made up entirely of undergraduate students from Vanderbilt University in the US to determine whether the East Antarctic Ice Sheet changes flow patterns as it changes shape. All of the research these budding scientists conduct will be done under the auspices of the Antarctic Treaty, a global agreement that promotes scientific cooperation and environmental protection.

Frozen but abundant

Antarctica separated from South America 35 million years ago, and its climate started to change. It began to grow ice sheets — masses of glacial land ice covering thousands of square miles. As plate tectonics shifted other continents, Antarctica became colder and drier. For the past 14 million years, it has been the frigid continent that persists today.

Antarctica is the only continent that was literally discovered, because it has no native human population. British explorer Sir James Cook circumnavigated the continent in 1772-1775, but saw only some outlying islands. Cook concluded that if there were any land, it would be "condemned to everlasting rigidity by Nature, never to yield to the warmth of the sun."

Cook also reported that Antarctic waters were rich with nutrients and wildlife. This drew sealers and whalers, mainly from England and the US, who hunted the region's fur seals and elephant seals to near-extinction in the following decades. This hunting spree led to the discovery of the Antarctic mainland and its ice sheets, the largest in the world.

Reading the ice

Today the combined East and West Antarctic ice sheets hold 90 per cent of the world's ice, enough to raise global sea levels by roughly 200 feet if it all melted. Antarctica is the coldest, highest, driest, windiest, brightest, and yes, iciest continent on Earth. And 200 years of research has shown that it is a key component of Earth's climate system.

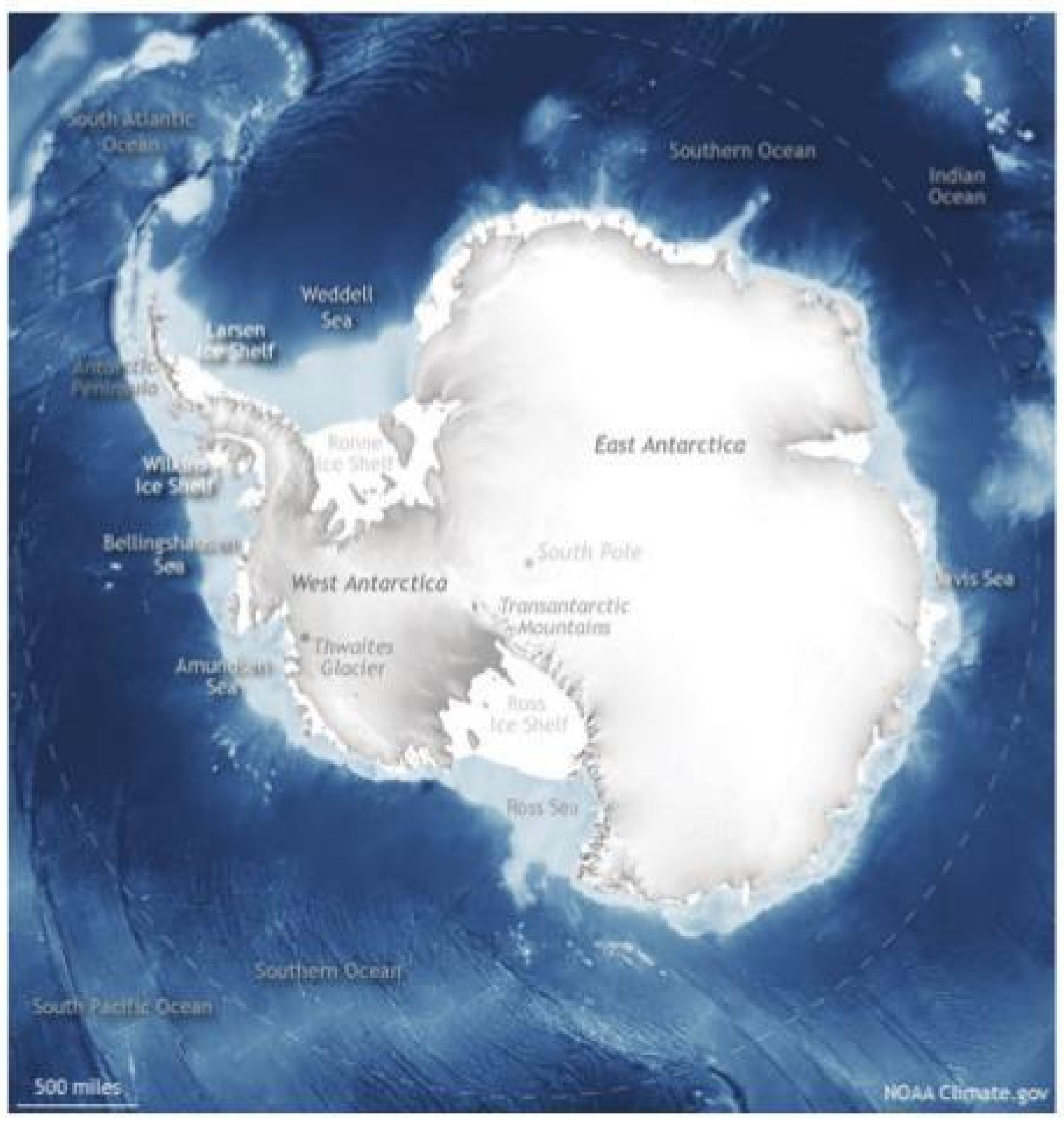
Despite the appearance that it is an unchanging, freeze-dried landscape, my research and work by many others has shown that the East Antarctica Ice Sheet does slowly thin and thicken over millions of years. Interestingly, my data also suggest that as the ice advances and retreats, it moves in the same patterns each time. Put another way, the ice flows over the same land each time it advances.

While East Antarctica adds and loses ice slowly, it is so large that it is a major contributor to sea level rise. Understanding how the ice has changed in the past is key to predicting how much and how fast it will melt in the coming years.

These questions are especially important in West Antarctica, where the bottom of the ice sheet is below sea level, making it very susceptible to changes in sea level and ocean temperature. By itself, the West Antarctic ice sheet has the potential to raise sea level by 16 feet if it collapses.

As climate change raises global sea levels, parts of the West Antarctica Ice Sheet, such as the Thwaites and Pine Island Glaciers, are particularly vulnerable to collapse. At the end of the last ice age, parts of West Antarctica thinned by an average of 1.5 to three feet per year. Today with GPS, satellite and airborne measurements, scientists are seeing parts of West Antarctica thin by three to 20 feet per year.

We also know from the geological record that this ice sheet is capable of rapid collapses, and has sometimes thinned at rates in excess of 30 feet per year. Recent models show sea level could rise by one metre by 2100 and 15 metres by 2500 if greenhouse gas emissions continue to rise at current rates and the ice sheet experiences a rapid collapse, as it has in the past.



Finding inspiration in scientific diplomacy

Despite the potential for environmental disaster in Antarctica, the continent also offers evidence that nations can collaborate to find solutions. The Antarctic Treaty System is the world's premier example of peaceful and scientific international cooperation.

This landmark accord, signed in 1961, sets aside Antarctica for peaceful and scientific purposes and recognises no land claims on the continent. It also was the first non-nuclear accord ever signed, barring use of Antarctica for nuclear weapons testing or disposal of radioactive waste.

The great Antarctic explorer Sir Ernest Shackleton said that "optimism is true moral courage," and the authors of the Antarctic Treaty were certainly courageous optimists. They were encouraged by the success of the 1957-1958 International Geophysical Year, a worldwide programme of scientific research during which 12 countries built over 50 bases in Antarctica, including McMurdo Station and the Amundsen-Scott South Pole Station.

Under the treaty, scientists from North Korea, Russia and China can freely visit US research stations in Antarctica. Researchers from India and Pakistan willingly share their data about Antarctic glaciers.

Thanks to the Antarctic Treaty, 10 per cent of Earth's land surface is protected as a wildlife and wilderness refuge. I have set foot in places in Antarctica where I know no one has ever been before, and the treaty sets areas aside that no one will ever visit. Antarctica's landscapes are unlike anywhere else on Earth. The best comparison may be the Moon.

Yet in these stark environments, life finds a way to persist — showing that there are solutions to even the most daunting challenges. If Antarctica has taught us anything in 200 years, it's that we can cooperate and collaborate to overcome problems. As Ernest Shackleton once said, "Difficulties are just things to overcome, after all."

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PLUS POINTS

Lunar breakthrough

A new technique could provide major insights into the Moon's surface, the scientists behind it have said. The approach — which should allow researchers to find entirely new breakthroughs in pieces of lunar rock that are nearly 50 years old — involves analysing the rocks at the most minute level, in the hope of learning about the Moon. It could also help future astronauts who Nasa hopes can live on the Moon's surface in a lunar base, by allowing them to find important materials in the ground.

"We're analysing rocks from space, atom by atom," said Jennika Greer, the paper's first author and a PhD student at the Field Museum and University of Chicago. "It's the first time a lunar sample has been studied like this. We're using a technique many geologists haven't even heard of." The technique is called atom probe tomography, and involves incredibly precise manipulation of individual grains. It has previously been used in industrial processes — but the new breakthrough has come in turning it for the first time to lunar samples.

The sample is placed inside a special probe and then shot with a laser that knocks off individual atoms, which then fall onto a special plate. Researchers can examine those elements by timing how long they take to hit the detector — since heavier ones take longer — and so the type of atom can be worked out.

It has already helped researchers see the weathering and materials that can be found inside the lunar soil. That in turn could help future astronauts as they move to live on the Moon, since they could survive by taking resources out of that dust.

The Independent

Glacial erosion

New insights into rates of bedrock erosion by glaciers around the world will help to identify better sites for the safe storage of nuclear waste, according to researchers.

A new analysis of global glacier erosion rates and flow speeds by scientists at the University of Sheffield, University of Dundee and Keele University has overturned previous findings about the link between glacial flow and erosion rates.

Published in *Nature Communications* last week, the findings confirm the importance of glacier flow speed in determining the rate of glacial erosion. But in an unexpected result, the scientists show that the increase in erosion rate with glacier flow speed occurs much more slowly than previously thought.

Darrel Swift, a member of the Energy Institute at the University of Sheffield, said, "As glaciers flow downhill, they slide over the bedrock beneath, causing the bedrock to be eroded. This analysis shows that a glacier that flows twice as fast as its neighbour does not necessarily produce twice the rate of bedrock erosion. This may be because, as glacier flow speed increases, spaces between the ice and the bed are formed in the lee of bedrock bumps. This means that the base of the glacier begins to separate from, or lose contact with, the bed.

"This effect has been suggested by some to enhance the rate of erosion, because it increases the stress placed by sliding ice on the few lumps of bedrock that remain in contact with the glacier's base. However, it is perfectly possible that this effect is negated by the fact that less and less of the bed is in contact with sliding ice."

For the first time, the analysis also shows the clear importance of local temperature and precipitation in determining glacial erosion rates at the global scale. The findings help to explain patterns of glacial erosion produced by glaciers and larger ice caps or ice sheets, which are responsible for creating spectacular Alpine landscapes — and also have implications for the safe long-term storage of hazardous nuclear waste.