



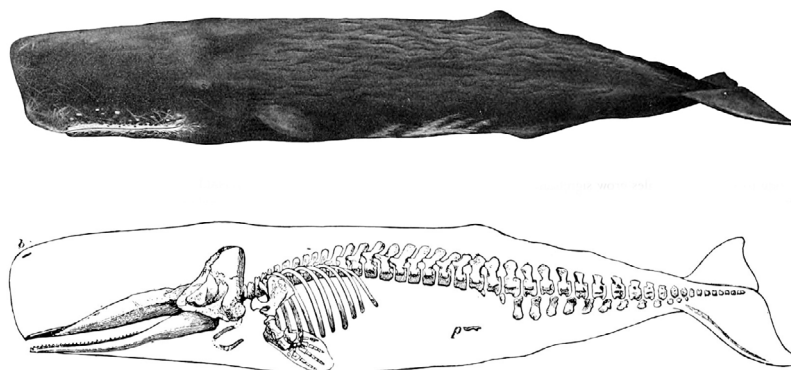
Whales and waves

Key words

whales
electromagnetic
waves
sound waves
decibels

Humans use waves for all kinds of things. The waves that we are most familiar with are light and sound. Since humans evolved, we have used **visible light** to see (as this is the wavelength of light that penetrates furthest through our atmosphere) and **sound waves** to talk to and listen to each other. As our scientific knowledge has advanced, we have gone on to discover the entire **electromagnetic spectrum** of light. When Heinrich Hertz discovered radio waves in 1887, he stated of his discovery, “*It’s of no use whatsoever.*” Of course we now use radio waves and microwaves to send information all over the globe at the press of a button.

But what if it was possible to talk to another person on the other side of the planet without needing a mobile phone or the internet? As the loudest creatures on Earth, this is what sperm whales can do.



This illustration, drawn by Richard Lydecker in 1894, shows how the sperm whale’s skeleton fits inside its body.

Despite having a name that incites awkward laughter in teenagers across the world, sperm whales are not named after the amount of semen that they produce. When one was caught by an American whaling boat in 1712, the crew opened its head to find 500 gallons of 'sperm-like' spermaceti oil which they then believed to be its 'seed'. For over a hundred years, almost every light on Earth was lit using this whale oil until we discovered how to distil crude oil in the 1860s.

Seeing in the dark

So why do sperm whales have this vast amount of oil inside their heads? It is thought to be used for two purposes: firstly, as a means to alter the whale's buoyancy, helping it dive to depths of 2500 m and return to the surface to breathe; secondly, the spermaceti organ acts as a vast resonance chamber allowing the whale to send and receive sound waves for **echo-location**.

At just 100 m under water, 99% of the surface light has been absorbed. There is next to no light at depths of 2500 m where sperm whales hunt. As such, they have evolved to see in sound as well. The whale emits a pulse of sound into the water. When this sound hits an object, it is reflected back to the whale. Highly intelligent, the whale can work out how far away the object is by timing how long the sound pulse took to reach the object and return. If an object is close to the whale, the timing of this echo will be small; if an object is far away, the sound will take longer to reach it so the echo will be longer also.

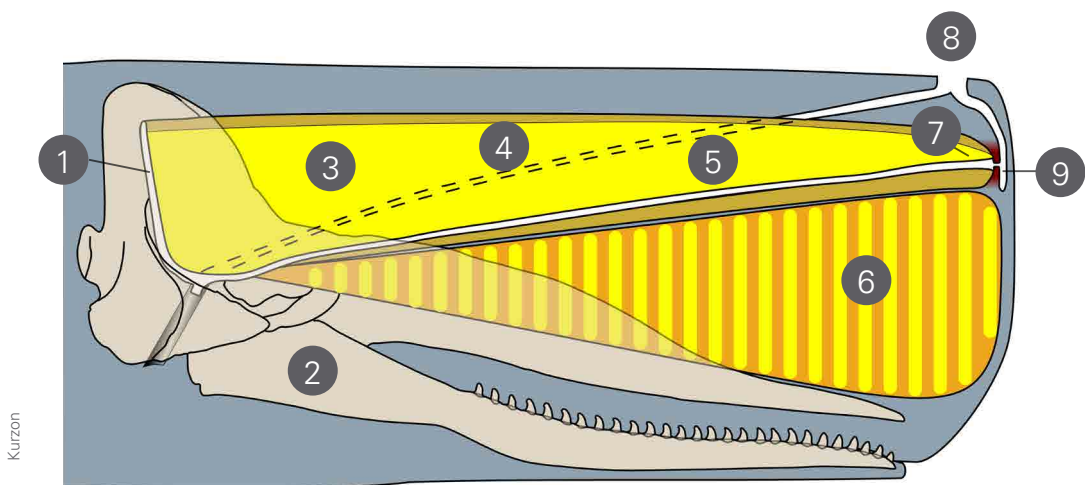
1 frontal sac	6 junk (melon)
2 lower jaw	7 phonic lips
3 spermaceti organ	8 blowhole
4 left nasal passage	9 distal sac
5 right nasal passage	



Steve Backshall, naturalist and adventurer, gets close to a sperm whale.

Not only can whales use sound to work out how far away an object is but they can also tell what an object is made from, what shape it is, how fast it is moving and in what direction! New research from the DAREWIN Institute postulates that once a whale has obtained an image of an object using sound, it can then send a holographic image of what they saw to another whale using sound. That's like sending a 3D-picture to your friend using only your face.

Sperm whales also have one of the largest frequency ranges out of any animal on Earth. The hearing range of a human is limited to 20 Hz up to 20 000 Hz. Humans are unable to hear any sound outside of this range so frequencies under 20 Hz are classed as **infrasound** ('below sound') and any frequency above 20 000 Hz is known as **ultrasound** ('above sound'). By comparison, sperm whales have a vocalisation and hearing range as low as 0.2 Hz and up to 32 000 Hz. So just as medical professionals use high-frequency ultrasound to view inside the human body, divers who swim with sperm whales have reported instances where they have been 'probed' by sound as the whales view inside them using sound to work out whether they are worth eating (luckily they weren't)!



The sperm whale produces clicks using its phonic lips (7). The sound travels back through the spermaceti organ (3) and then reflects forwards through the melon (6), an organ which focuses the pulses of sound into a narrow beam. Reflected pulses are detected by the lower jaw (2) which connects to the whale's hearing organ.



Louder and louder

But we still haven't even touched on how *loud* sperm whales are. Sound energy is measured in **decibels (dB)**. The more energy that is carried by a sound, the higher the decibel level. Normal human conversation clocks in at around 65 dB while noisy roadworks can be as high as 95 dB (the level at which you may start to experience damage to your hearing). If you've ever been to a loud rock concert or club night, you will have been exposed to around 115 dB and probably had ringing in your ears (tinnitus) the next day. At 125 dB pain begins and the scale keeps going up to 194 dB, the loudest sound possible in air. Any louder than this then the sound becomes so distorted that it becomes a pressure wave. However, because water is **denser** than air, it is capable of allowing louder sounds to propagate through it. Sperm whale clicks as loud as 236 dB have been recorded; this is louder than a ton of dynamite exploding or a rocket taking off. In fact, sperm whales have the potential to produce a sound so loud that it would not only completely blow your ear drums but could in fact vibrate your body to death. It is not unheard of for divers to have been knocked unconscious by sperm whale clicks.



A sperm whale and a diver investigate each other.

But despite having these amazing sonic abilities, whales and dolphins around the world are becoming victim to ocean noise pollution. Ships' motors, drilling for oil, naval testing, military SONAR, and oil and gas exploration all add up to produce a cacophony of man-made sounds that interfere with the ability of cetaceans (the collective name for whales, dolphins and porpoises) to use sound. At the very least, the noise acts as an irritant causing them to behave unnaturally, driving them away from feeding areas. Louder sounds can not only cause entire pods to strand on beaches but can also physically harm whales and dolphins. Sound pulses produced from seismic surveying are amplified inside whale and dolphin skulls which can result in permanent brain damage.

As mankind continues to explore our oceans, it is important to be mindful of the other creatures that we share the ocean with. With the largest brain on Earth, it has been suggested that sperm whales are at least as intelligent as humans and have a culture as complex as ours to match. Still recovering from the onslaught of whaling where 60% of the global sperm whale population was destroyed, it would be a shame if our continued actions resulted in their demise when we have only just started learning about these amazing animals.

Russell Arnott is Outreach Officer for WhaleFest

Look here!

WhaleFest is the largest marine festival on Earth. Last year, it attracted over 15 000 people a day. Incredible Oceans is the educational outreach part of *WhaleFest*. It aims to teach people of all ages about the marine environment by visiting schools and events across the country:
www.incredibleoceans.org

Increasing noise from human activities including shipping has interfered with whales' ability to communicate with each other over long distances.