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# Shark Deterrents

**FACT 1:** MOST DIVERS GET ASKED, "BUT WHAT ABOUT SHARKS?"
**FACT 2:** MOST DIVERS ANSWER, "NAH, THEY DON'T WORRY ME."
**FACT 3:** MOST DIVERS ARE LIARS... MAYBE.

: CAPT JOHN SILBERBERG

I DON'T HAVE A PROBLEM WITH SHARKS. I HAVE RESPECT FOR THEM, FASCINATION FOR THE MYTH AND AWE FOR THEIR CAPABILITIES. I DIVE IN 'THEIR' OCEAN AND DO SO ON THEIR TERMS. IF A SHARK BITES ME, THERE'S NOTHING PERSONAL IN THE BEHAVIOUR OF THE ANIMAL, IT'S JUST WHAT SHARKS DO. NO MORE THAN A JELLYFISH ITS STING, OR AN URCHIN ITS SPINE, IS A SHARK RESPONSIBLE FOR THE BEHAVIOURAL CONFLICT THAT THREATENS ME EVERY TIME I DIVE.

All animals have a survival instinct, an inbuilt defence mechanism allowing a species to survive and thrive: a subconscious awareness of predators. *Homo sapiens aquatica,* or scuba divers, are no different, we understand that in the ocean certain animals kill, a reflexive throwback to primal times. But as highly developed thinking beings, we're able to rationalise and reason, to deny our survival instinct and suppress its significance. We don't quiver at the prospect of sharing the oceans with predators; instead, we thrive on the adventure, seeking interaction with potentially dangerous animals. Why else would shark diving be so popular? Subconsciously, divers retain the flight-or-fight instinct common to human evolution, the instinct that triggers the hormonal secretions familiar to extreme sport purists, the 'adrenaline rush'. Is it blasé to deny the real risks involved, to rationalise? Just as car crashes only happen to others and war only happens in foreign countries, the underwater "It won't happen to me" syndrome is alive and well.

Summer 2008/9 saw a tragic series of shark attacks around Australia. Like many, I watched the TV news and read the papers, and was grateful it wasn't me. I admired the family who, despite the loss of their husband and father, wanted the shark left alone; not hunted as some perverse example to other sharks, but left in peace, as the casualty, a man of the ocean, would want. I sympathised with the snorkeler bitten whilst spearfishing, by a shark possibly attracted to the recently killed fish; but like many, considered it a predictable outcome. I thought about these incidents and denied their relevance to me – geographically I was isolated and I'm not a hunter-gatherer.

Then, not far from my home, a shark bit a teenager who was surfing. Suddenly the threat was on my doorstep. I started to think about my own vulnerabilities, my family responsibilities and, if I were the casualty, the impact it would have on them. I admit I was shaken.

Days later I witnessed a dead sperm whale floating at sea. This much food couldn't help but attract sharks. Sure enough, five minutes after we arrived on the scene a 4-metre great white swam under my boat. A study in primal power, the shark tore chunks of flesh out of the whale, gorging itself – an awesome way to see my first white 'in the flesh'.

By now the coincidences were stacking up, but when I realised that next to me on the boat was a relative of one of Australia's best-known shark-attack survivors, I heard the jungle drums loud and clear! I could no longer pretend I was immune to sharks. It was time to consider a deterrent.

A quick Google of 'Shark Deterrent' turned up 162,000 hits and 'Shark Repellent': 80,500. The more I read, the more I realised there's a huge interest in sharks. I also found there are very few practical deterrents available. It seems sharks are hard to deter (!) and everyone has a pet theory about the best way to keep them at bay. Given the mountains of information available, the entire deterrent issue deserved empirical review, a back to basics approach.

So what are the desirable characteristics of a deterrent? Obviously, it must prevent shark attack, preferably without user intervention; reportedly, 54% of shark attack survivors did not see the shark before the first contact. It should be simple to use, because a panicked diver suffering narcosis will struggle to perform a complex operation. And it should be non-polluting and non-lethal, in line with environmentally friendly diving practices.

Deterrents target sharks' sensory systems by modifying the environment in a manner that sharks find abhorrent. They fall into two categories, active and passive. Commercially-available active deterrents are chemical, electrical or laser based. Passive deterrents are visual.

**CHEMICAL DETERRENTS** World War II triggered serious chemical deterrent research. Devastating seaborne warfare resulted in many ship and air-wreck survivors floating in the oceans awaiting rescue. Unfortunately, sharks attacked many who survived the initial wreck. Research centred on a chemical package, based on a theory that sharks don't eat dead sharks. The package contained copper acetate and a black dye that supposedly smelled like rotting shark flesh. Whether it worked is debatable, but many fishers will attest to successfully catching sharks using the flesh of other sharks as bait. More recently, chemical compounds isolated from a Mediterranean fish successfully repelled sharks, but required squirting directly into sharks' mouths to be effective; a technique not practical as an everyday deterrent. Other projects continue researching chemical deterrents, but so far, there are no new commercially available products.

**LASER DETERRENTS** One unique deterrent is a green laser suitable for underwater use. When a shark starts behaving in a threatening manner, the potential casualty shines the laser at the shark's eyes. The dazzling effect supposedly causes the shark to leave the area. This is the same type of laser used illegally to dazzle airline pilots. For this reason, Australia bans these lasers. Additionally, this method will not work in the majority of cases, where the casualty does not see the shark before the first contact.

**VISUAL DETERRENTS** Visual deterrents employ the natural colouration of certain species of marine life that appear impervious to shark attack. Sharks' eyes are complex organs and they appear to have excellent vision. The theory is that the striped patterns on some sea snakes and lionfish warn sharks that they aren't suitable prey. Also, mimic octopus appear to imitate these patterns when threatened by sharks. Many shark bites on humans resemble 'sampling' behaviour, rather than a feeding attack, so it is conceivable that the striped patterns may be effective as a deterrent. However, poor visibility and low light levels reduce the effectiveness of visual deterrents, as sharks will rely on non-visual methods to hunt under these conditions.

**ELECTRICAL DETERRENTS** Electrical fields are the best-documented commercially available deterrents. In the 1960s and 1970s, scientists showed that electric fields repelled sharks, but field-testing of early devices proved inconclusive. Then in the early 1990s, a South African scientist successfully repelled captive sharks using an electrically energised wire loop. This finding stirred interest at the Natal Sharks Board (NSB), a South African organisation entrusted with the protection of beachgoers from shark attacks. At the time, the NSB's primary tool was beach netting, but nets indiscriminately, catch non-targeted species such as dolphins and turtles as well as non-dangerous sharks. With the global increase in environmental awareness, the NSB funded research into electric field deterrents as an environmentally friendly alternative to netting. This led to the discovery of a pulsed electrical waveform that successfully deterred sharks.
Extensive testing over the next few years confirmed the effectiveness of the waveform and eventually the SharkPOD (Protective Oceanic Device) became commercially available.
The SharkPOD consisted of two electrodes and an electronic unit. Divers attached one electrode to a fin while the other electrode and the unit attached to the tank. The electric field extended about five metres and was like an invisible barrier that turned sharks away. The SharkPOD was expensive and bulky and did not enjoy high sales levels.
In 1999, an Australian business, SeaChange Technology, started to sell shark repellent devices. Recognising the unique opportunity offered by the technology of the SharkPOD (despite the poor sales), they approached the NSB and obtained an exclusive worldwide license to use the electric waveform. In 2002, the first Shark Shield products were commercially available and in 2006, SeaChange Technology changed its name to Shark Shield Pty Ltd. Today, Shark Shield produces a range of deterrents suitable for almost every type of water sport. The product aimed at recreational divers is the Freedom 7. This is an electronic module that straps to the ankle of the wearer, with a two-metre long tail. The tail contains the electrodes that produce the waveform.
Exhaustive testing of the Shark Shield units confirmed their effectiveness.
Testing included the use of burley trails to attract great white sharks towards deterrents attached to pieces of tuna.
According to Shark Shield, the deterrents were 100% effective and the sharks took none of the tuna.
Multiple anecdotal accounts from Shark Shield wearers repeatedly state that the devices effectively repel large sharks.
One account from a spearfisher describes

# Shark Senses

Sharks are pure predators; apart from occasional scavenging, they must hunt and kill to survive. They use no tools, only their bodies, jaws and teeth. But first, they must find their prey. With up to 13 different methods of sensing their environment, sharks hunt with a formidable arsenal.

Humans have five basic senses: taste, touch, smell, sight and hearing which allow us to survive and prosper in a range of environments. As evolutionary gatherers of food, our best defence was avoidance of predators. To hunt food, we utilised tools, allowing us to attack from a distance to reduce the risk of injury from our prey. Without tools we're slow and awkward, lacking the speed to chase prey and the strength to dispatch it efficiently.

But do we really have five different senses, and do sharks have 13? Closer analysis groups our five senses into just three sensory mechanisms: **chemoreception** (taste and smell), **mechanoreception** (touch and hearing) and **photoreception** (sight). Sharks' sensory methods fit into the same groups, but they have a fourth mechanism: **electroreception**.

Sharks detect electrical activity with sensory organs on their heads. Known as *ampullae of Lorenzini*, they're sensitive to electrical fields generated by the nervous activity that signals muscles to contract. Even in zero visibility, sharks can use this sense to locate their prey.

Not all sharks have every sensory method and the degree of development varies between species depending on their chosen environment and preferred prey. For example, pelagic sharks need a more developed sense of smell to track scents and find distant prey than bottom-dwelling ambush hunters that react to visual cues. Most sharks have highly developed eyesight that works especially well in low light conditions. They have a special layer at the rear of their eyes that reflects light back through the retina, effectively increasing the amount of light the retina 'sees'. Some 20 odd shark species, including the great white, also have an eye structure that appears to let them see different colours. Their eyes have special cells called 'cones' that in humans allow us to see colours. Some sharks can even use the pineal gland in their brains to determine ambient light levels through a thin section of skin on top of their heads. This may assist the sharks in the timing of their diurnal migration up and down through the water column.

Sharks' ability to detect blood in the water is legendary. While its unlikely they can detect a drop of blood from several miles away, they appear to be able to detect one part fish extract in 10 billion parts water, or about one drop in an Olympic swimming pool! They detect chemicals with two nostril-like openings on the front of their heads called *nares*. The nares' structure causes water to pass continuously over the sensory cells, which connect directly to the brain. Effectively, sharks are continually sampling for the scent of prey: an incredibly potent sensory tool and an early warning system that never switches off.

Arranged on sharks' bodies are a series of hair-lined pores used for detecting vibrations in the water. Known as *lateral lines*, they help sharks detect the presence of prey. As sharks swim, they create their own vibrations and it is possible that the lateral lines also detect changes in the reflected vibrations, much like dolphins' sonar.

Sharks utilise different sensory mechanisms during different stages of their hunting. However they do not turn one off as the other turns on; the additional senses are cumulative, providing more and more information about the prey as the range closes.

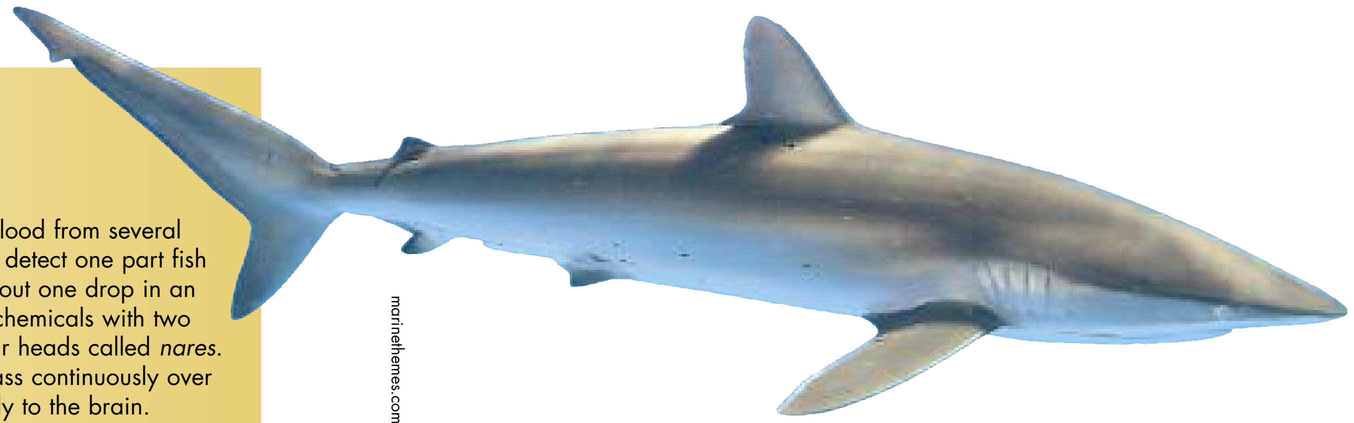
At long range, a shark's **chemoreceptors** (*nares*) are alert to any trace of prey. It will track a scent trail by moving its head from side to side and assumes that the prey is in the direction where the scent is strongest. The movement of the head corresponds to the natural swimming motion of the fish, but when a trail is very weak, observations show that sharks exaggerate the motion, seemingly searching harder for the direction of strongest scent.

As a shark gets closer to the prey, its **mechanoreceptors** (*lateral lines*) start to detect vibrations in the water created by the prey's movement. The nature of the vibrations can alert the shark to a sick or injured fish that might be easy to attack. The shark utilises both chemo- and mechano-reception to 'lock-on' to its prey.

As the range closes further, and if visibility is adequate, a shark will use its **photoreceptors** (eyes) to locate the prey and finally, will fine-tune the attack using its **electroreceptors** (*ampullae of Lorenzini*). At this stage of the attack, the shark has at least four distinct systems providing information about the location and behaviour of the prey.

During the final phase of an attack run, many sharks roll their eyes into their heads to protect them from damage. In the last few metres, the prey's electrical field is strongest and it appears that for the actual strike, sharks rely mainly on electroreception for guidance. This close range reliance on the *ampullae of Lorenzini* may explain why deterrents based on electric fields are so effective.

By interfering with the sensory mechanism that guides a shark's strike, the electric field deterrent may be taking advantage of an opportunistic coincidence that occurs just as the shark is expecting to sense the prey's electrical field. Instead of detecting the panicked movements of a tasty morsel, the electrical field of the deterrent assails the shark, overloading its electroreceptors. This is so unlike what the shark expects that it reverts to self-preservation mode and immediately retreats.



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how a large great white was speeding towards another fisher, apparently attracted by dead fish in a catch bag. With just metres between the shark and the fisher, the shark ran into the electric field surrounding the Shark Shield device, turned tail and disappeared – all without the knowledge of the near-victim.

So, the Shark Shield products appeared to meet the first two desirable characteristics of a deterrent. They are effective; a vast body of substantiation, both documented and anecdotal, supports their effectiveness. They are simple to use; the user activates the device on entering the water and it operates without user intervention.

But what of the third characteristic: non-polluting and non-lethal – environmentally friendly? The Shark Shield devices release nothing into the environment – they are non-polluting. The electric field they produce repels sharks but appears to cause no damage beyond temporary discomfort. As the technology develops into large-scale devices to replace beach nets, there will be no further harm to non-targeted species. The use of the devices does no harm to the environment and by replacing current lethal technologies improves upon the status quo.

**PERSONAL EXPERIENCES** The first time I used a Shark Shield, I was open water swimming. An upcoming charity swim event saw me training at my local beach by swimming back and forth, just outside the surf break. My schedule dictated that most of my training occurred late in the afternoon, a time of day known to have an elevated risk of shark attack. I strapped the module to my calf and off I went. Within seconds I knew the device was working, but I also realised something wasn't right; it was zapping my feet! Relocating the unit to my ankle solved the problem by moving the electrodes beyond my bare feet (as clearly stated in the instructions. Doh!) The Shark Shield was barely noticeable while swimming. I easily overcame the small increase in drag and found a two-beat or crossover kick the most effective. The weight of the module was noticeable with a six-beat kick but this technique is more suited to sprint swimming than open water swimming, so it wasn't an issue for me.

But the difference in my mind was amazing. I've never been spooked on a dive, but when I'm open water swimming, I sometimes startle at shadows on the edge of my vision. Swim goggles restrict my angle of view and do odd things to my peripheral vision; shadows dancing through the water become distorted and ominous when caught out of the corner of my eye. But with the Shark Shield strapped to my ankle, I relaxed. Over the space of just a few swims, my comfort in the water increased and my level of attentiveness eased. I concentrated more on my swimming and less on what was going on around me. This change of mental state was completely unexpected. I had no idea that my senses were on alert until I wore the device and was no longer concerned.

It took a few dives to get used to the Shark Shield. At first it tangled in my fin, tying itself in a half hitch. I solved the problem by adding a loop of cable tie to the side of my fin (as suggested by the manufacturer). Threading the antenna through the loop extends it past the end of the fin and helps stop it tangling. As a bonus, it helps keep it clear of the seabed. The antenna is slightly negative in buoyancy and unless moving through the water, it will settle; however, it appears to cause no harm, behaving like a frond of kelp drifting along the bottom. I even tried tangling the antenna in kelp, but couldn't, and only succeeded in catching kelp with the buckles on my fin straps.

The first time I used a Shark Shield on a deco dive I was truly convinced of its value. After a fantastic dive to 40 metres, I was facing a blue water ascent with 30 minutes of deco time. I usually enjoy hanging in the blue, just watching the plankton drift by, but occasionally I used to ponder 'What if…' Now I relax all of the time and I'm free to enjoy the serenity as I contemplate the meaning of life.

**INTERESTING LINKS**

**International Shark Attack File www.flmnh.ufl.edu/fish/sharks/statistics**
The International Shark Attack File records all known incidences of shark attack from around the world, and is recognized as the sole source of data and statistics for observing trends.

**Shark Academy www.sharkacademy.com**
Riccardo Sturla, from Sardinia founded Shark Academy and has a huge passion for sharks. He has been known to touch sharks with his bare hands and put them to sleep.

**The Natal Sharks Board www.shark.co.za**
The Natal Sharks Board is a service organisation that protects beach users in KwaZulu-Natal against shark attack. It has over 40 years of experience in prevention of shark attack and research on sharks.

**The Author:** John Silberberg is a Master Mariner who spends his life on, under, and by the sea. Living on the east coast of Tasmania, his favourite diving is amongst the deep sponges off Bicheno. A self-acknowledged gear freak, he loves deep diving and the challenge of making photos underwater.

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