

## Shark Repellents / Expert Responses

<https://roberteovaldi.zenfolio.com/shark-repellent-commentary.pdf>

Responses are organized by country

Australia – Brazil - Canada - France & Reunion Island

New Zealand - Scotland - South Africa – Spain – United States of America

### AUSTRALIA

Well done on getting the discussion going. I think we've taken a rather piecemeal approach to the testing of shark repellents and it's hard for consumers to know what to believe. Being a scientist I naturally gravitate towards the need for robust, empirical, peer-reviewed testing of the various options. As was concluded from the shark summit in Sydney last week, the technology still has a long way to go. I've worn shark deterrent devices ('shark shields') a lot while working on the east coast of Australia, but I only wore them because it was EH&S policy of my University - not because I trusted them. Funnily, we used to work a lot with State Government and their EH&S policy banned the use of shark shields because their shark scientists believed it actually increased your chances of being attacked! From my reading of the various scientific testing that has been done on shark shields and other similar deterrent devices, their effectiveness is really context specific and depends on the motivational state of the sharks. For example, a shark's shield may be effective for a curious great white that approaches a surfer with curiosity, but not for a great white that is charging from below in full attack mode.

Dr Peter I. Macreadie

Senior Lecturer | Australian Research Council DECRA Fellow

Plant Functional Biology and Climate Change Cluster - UTS; &

Centre for Integrative Ecology, School of Life and Environmental Sciences, Faculty of Science Engineering & Built Environment, Burwood, Deakin University

### Response

The potential threat that sharks pose to ocean users has led to the adoption of a range of shark control programs around the world that often involve the removal of sharks to reduce risk. These programs are at odds with the important ecological role that large predatory sharks play in ocean ecosystems, as they do not discriminate by species or size, so they place increased pressure on non-target and potentially vulnerable species. The effects of removing sharks from our oceans, although complex and rather unpredictable, can be ecologically and economically damaging. There is, therefore, a clear need for alternative non-lethal shark mitigation solutions that will allow humans and sharks to safely co-exist. Research has shown that certain low-voltage electric fields can be effective at deterring a range of shark species, but questions still remain about the effectiveness of this type of stimulus over a prolonged period. My own previous research has shown that shark embryos will habituate to electric fields resulting in a reduced response to the stimulus over time. Now, my current research is investigating this effect in a range of wild sharks, including white sharks, to see if they will also habituate to an electric stimulus, and if so, determine how their behaviour may change over time. Once this information is published, we will be in a better position to develop new effective electric deterrents, and also provide advice on how we can improve current technologies. However, it is important to remember that no deterrent is ever going to be 100% effective. We must always take precautions to reduce our own risk of injury, and although a deterrent may well be part of the solution, it is unlikely to be the whole solution.



Dr. Ryan M. Kempster  
Shark Biologist & Founder of Support Our Shark  
The UWA Neuroecology Group  
School of Animal Biology  
University of Western Australia

### **Response**

Given that I have surfed (Frequently) at very shark infested breaks – South Africa (Cape Town), East Coast of RSA (Nahoon Reef), and now in SW WA, Margaret River region, I feel that common sense should prevail!

Also, now if you check on the situation on the Island of Reunion – where surfing is basically banned!! It appears that sharks movements and behaviours have changed quite radically over the last few years. Causes: Multi-factorial (Global warming, over –fishing, cage – diving, plastic pollutants, noise pollution etc)

Added to this we have many more humans on the Planet, and now many more surfers.

We are on their turf, and even when all the above is taken into account the Great White, and Bull Shark sightings are still rare.

After a run of attacks in WA last year, we had Drum Lines, and Baiting to draw the GW's in for culling: Guess What – Over a whole summer season, not One sighting.

So in the interim – striped boards and wetsuits Might be part of the solution.

Electro-magnetic fields might also help.

But, If the GW is hungry, or in a bad mood, and you are nearby – best you have your best game on to escape!!

Life will never be without risks, and I feel that it's a good thing to step outside one's comfort zone at times.

Keep the research flowing (tagging / monitoring)

But in the interim, enjoy the ocean and embrace the risk!!

As I said before: Relax, Assess and React!

My 20 cents worth.



Phil Chapman, MD  
Emergency Medicine Attending (Specialist)  
Surfingdoctors.com

### **Response**

I love the ocean. I grew up in the water on the West Coast of Australia (where shark attacks are not uncommon). Sure, there's always that slight fear about what I can't see, but in reality, I'm probably surfing with sharks every day I go out without even realising. I think people get wound up in the hysteria and forget that we are humans entering their environment.

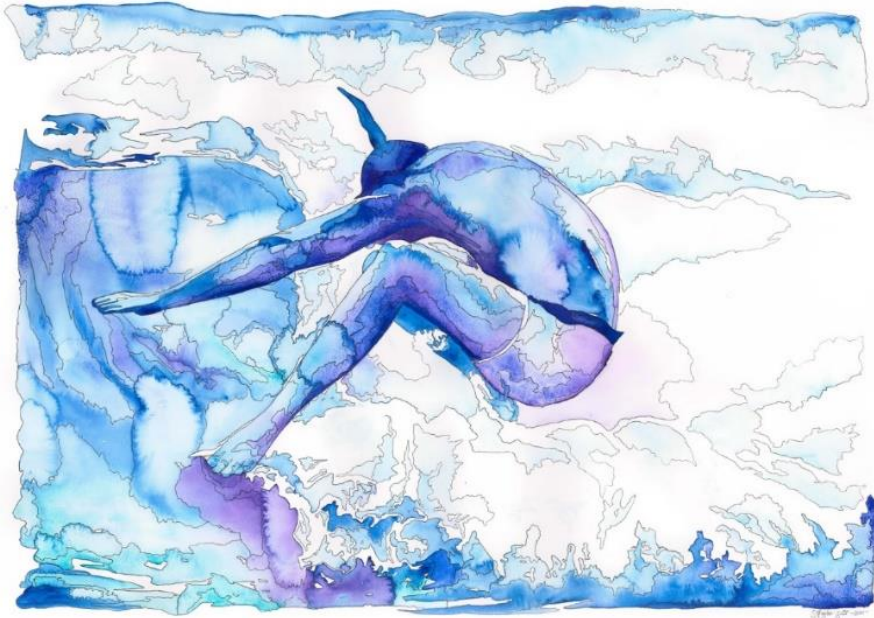
I am by no means a shark expert. I have opinions, but they're not educated and could perhaps contradict views from experts in fields related to this topic, however there's no doubt that Sharks play a vital role to the ecosystem of the ocean, and definitely shouldn't be culled just because they have teeth and occasionally bite humans.

I feel that an issue which should be addressed, is the over fishing of our oceans. The fact that there are less and less fish in the ocean would surely be a reason as to why sharks are coming in closer to shore looking for food?

I think it's tragic when we lose another fellow ocean lover to a shark, but at the same time, we all take the risk when we enter the water.

I've watched a few talks and read articles on ideas such as visually confusing sharks (whether it be via painted patterns on the underside of boards, patterned wetsuits etc) but I think sharks generally have pretty poor vision- they work off smell and vibrations rather than sight- so I'm not entirely sure if these visual distractions would work (again like I said, I'm no shark expert- so perhaps I'm completely wrong).

I'm totally keen on the idea of tagging sharks that continually enter an area- I think that is a relatively non-invasive way of tracking sharks, and ensuring the public know if a shark may be in the area...again, I'm not sure how viable the idea is- financially, and practically- but I feel like this would be the best way to combat the rising number of shark attacks.



Sharma Heylen-Silvia  
Design and Illustration  
Artist

## Response

As a professional surf photographer based in Margaret River Western Australia which over years has had a number of fatal shark attacks around the area and with all the over the top press it was certainly in the back of my mind when swimming out to sea on my own. The only time I have ever used a so called shark repellent is when I swim at a place called the "Right", being the only one in the water a mile out to sea where we have seen a number of Great Whites and been bumped on the ski is the only time I have to overcome a mental hurdle, to be honest I don't even think the shark shield would even work on a Great White (I wear it only for peace of mind), I rely more on the feel of the situation and then I make my decision to swim or not swim. I would love to see an amazing scientific study on everything to do with sharks; amazing creatures and I look forward to swimming with them in the future to gain more knowledge on the subject.



Russell Ord  
Photographer

## Response

I am not a shark expert, and have no experience with any shark repellent. Nor am I a surfer. What I am is a marine biologist, who has spent a lot of time SCUBA diving in blue water studying larval fishes. Most of my diving has been in the tropics, and in many hundreds of hours doing this sort of work, we have only rarely even seen sharks (that is not to say that sharks have not seen us when we have been unaware of it!). I have had a lot more encounters with sharks diving on reefs, and the only time I have ever been threatened by a shark was while snorkeling on a reef.

The sharks we saw in blue water were almost always species of the genus *Carcharhinus*, and usually were only slightly to moderately interested in us. The exception was during an experiment on the Great Barrier Reef when we were observing the behaviour of fish larvae while we were broadcasting underwater for about 30 minutes sounds recorded over a coral reef, and alternating with similar periods of no broadcast. A species of *Carcharhinus* appeared, and aggressively approached our dive team in the classic threat posture (back arched, and pectoral fins spread). The divers immediately exited the water. We think this was either a bull shark or the closely-related pig-eye shark. Nothing similar happened when we were continuously broadcasting the same sounds over several days, so it seems that the changing sounds were the thing that attracted the shark, and initiated its aggression.

We have done similar studies (but without the underwater sounds) in temperate waters off New South Wales, and never saw sharks, even though it has subsequently been shown that we were working near Stockton Beach where juvenile Great White Sharks are common.

So, my only real experience in manipulating shark behaviour, was unplanned, and attracted them rather than repelled them. Therefore, my experience does not really add anything helpful to the discussion. I would add, however, that no one should rely on aerial surveys to accurately assess the presence or absence of sharks. Studies off both the east and west coasts of Australia have shown that aerial surveys miss most of the sharks that are present, and can actually mislead the public, giving them a false sense of security when no sharks are reported. A final word – given how unpredictable sharks are, and the multiple senses that they possess, I would not be optimistic about finding a ‘silver bullet’ repellent.

Jeff Leis

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and

Adjunct Professor, Institute for Marine and Antarctic Studies, University of Tasmania, Hobart

## Response

Historically, our interaction with the environment has often reflected an anthropocentric and domineering perspective. Thankfully, there appears to be an emerging paradigm that not only questions this perspective, but offers a more compassionate and altruistic alternative (Bekoff 2013). Our biological dependence on nature means that nature’s survival is integral for our own. Thus, environmental conservation and management that is based on compassionate philosophies, could provide the new model we need to ensure our survival on this planet.

The public are challenging shark management policies that reflect an assumption that humans’ right to the marine world, trumps that of sharks’. For instance, a lethal shark management policy that was

implemented in Western Australia generated a lot of controversy (McCagh et. al. 2015). While some of our interaction with sharks has resulted in injury and deaths (on both sides), people are becoming less convinced that our reaction should be lethal. Instead, increasingly, there is a call for alternative strategies that encourage the co-existence of sharks and humans. Fortunately, there have been responses to this call including studies that investigate the effectiveness of shark repellents. Studies such as these, will help maintain our intrinsic bond with the marine environment, without destroying it.

I believe that the paradigm from which we decide to interact with our natural world will largely dictate how compassionately or oppressively we will manage our environment, which will ultimately affect our own survival.

Christine McCagh (Dip. Biological Sciences)  
University of Western Australia

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## Brazil

I do not believe that shark repellents are effective. Sharks are unpredictable and these repellents can bring confidence for people to get in the water considering "without risks of shark attack". I believe that the more reasonable solution may be to just keep people out of the water in areas prone to shark attacks, and the government needs to invest more funds in educational awareness programs and research on how to avoid encounters with sharks.

Logically, with fewer people in waters, the probability of a shark attack is concomitantly reduced. In Brazil, for instance, the sum of the two actions: Shark Monitoring Program (Hazin F.H.V. & Afonso A.S. 2014. *Animal Conservation*, 17: 287-296) and environmental education campaigns (Liberal C.N. et al. 2006. *Tropical Oceanography*, 34: 85-97) has been responsible for reduction of the rate of shark attacks by 97% in Recife, northeastern Brazil.

The "formula" cited above used by a developing country can serve as example of how to reduce shark attacks in other countries of the world, without resorting to capturing and culling sharks.



Dr. Hugo Bornatowski  
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## Response

In Brazil a recent study published in Fernando de Noronha Archipelago found tourists exhibited positive attitudes toward sharks while local people were less aware of the potential for shark watching on the island (Garla et al., 2015). The Archipelago belongs to the state of Pernambuco, whose capital, Recife, has been experiencing a problem with shark attacks since 1992 (Hazin et al 2008), as well as recent shark culling retaliation organized by local NGOs (Bornatowski et al. 2014). Under this scenario, the use of shark repellents would be desirable instead of extermination, as claimed by some groups. However, the efficiency of these shark culling programs has not been clearly proven (or approved) by scientists. Beyond the discussion on the effectiveness of any shark repellent to really deter sharks, there are additional ecological concerns to be pondered. Do we really need to ban sharks from certain areas? What would the effects to the local ecosystem be if shark were repelled? What effect would restricting the access of sharks to certain areas have upon the overall shark populations? As large apex predators sharks require extensive areas for feeding, reproducing or simply living. Restraining their use of the ocean does not sounds fair and may result in undesirable effects on the local marine ecosystem and on shark populations.



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## CANADA

I don't have much expertise when it comes to shark repellents and would echo those responses that suggest that we need to accept the usually small risk that sharks represent to humans. I would not be in favor of killing sharks, especially given how low shark numbers have dropped worldwide. I would be leery of EMF repellents and acoustic repellents because of the unintended consequences and low predictability to both sharks and other marine life. They would have to be thoroughly studied long-term in terms of effectiveness and impacts to all components of the marine ecosystem, which is quite an undertaking.

Lindy Weilgart, Ph.D.  
Adjunct, Department of Biology  
Dalhousie University  
Halifax, Nova Scotia, Canada

### Response

My name is Scott Seamone, and I am a PhD student at the University of Calgary exploring how morphology influences locomotor behaviours in fishes. My experience with sharks extends from scuba diving with 15 species of sharks around the globe, in addition to academic and personal research.

I do not support any safety measures that involve the killing of sharks. I also do not advocate for shark barriers that are potentially harmful to these animals via entanglement, yet I have been rather impressed by the Eco Shark Barrier (<http://www.ecosharkbarrier.com.au>), and I have read nothing but positive reviews thus far (see Case study: Coogee Beach, <https://www.dpc.wa.gov.au/science/SiteCollectionDocuments/Review%20of%20the%20Dunsborough%20Beach%20Enclosure%20Trial.pdf>)

In addition to exploring the Eco Shark Barrier further, in areas of high risk for unwanted shark-human interactions, I believe attention should be focused on increasing lifeguard/shark watch on land, on water (by watercraft), and in air (by aircraft), pending on finances. Consequently, this helps prevent an even greater coastal threat - drowning. Further, raising public awareness about sharks, including how to behave in the presence of a shark that has not yet attacked (both aggressive and non-aggressive), in addition to how to respond to an attack (personal or to another individual) is necessary. I would also advocate to ban swimming/surfing activities and beach/pier fishing from occurring in same location, designating separate zones for both activities that are strictly enforced. I agree with cage diving, or chumming the water to scuba dive with sharks, but I would encourage banning shark-feeding activities where a scuba diver is directly feeding a shark outside of a cage. I believe this changes the behaviour of sharks, like a stray animal that is timid at first, but then becomes more comfortable the more it is fed. We do not feed wolves, cougars and bears at National Parks for this very reason.

Tagging research is very important (to understand times that one may be more prone to a shark encounter, in addition to many other reasons), yet the idea of tagging all of the great white sharks in the ocean just does not seem possible because of how much it would cost, the lifespan of tags, and the notion that you just are not going to get your hands on "every shark". Also, from my understanding bull sharks, tiger sharks, and possibly others pose more threat to humans than great whites.

There are currently no shark-deterrent devices that I would trust for all of the reasons that have been discussed throughout this forum, but I will reinforce a few main reasons. Research, especially the paper by Gardiner and Motta 2012 (<http://scholarcommons.usf.edu/etd/4046/>), has revealed that predatory behaviors in sharks differ from species to species, and thus, I agree that a device that may work on one species is not necessarily going to work another. Also, I too would worry that a device sending electric signals strong enough to deter a shark may cause biological damage to myself. In terms of devices that send out sound signals, from my understanding very little is known regarding the capabilities of hearing in sharks, and how this changes from species to species. Thus, I would not be confident in the orca-sounding device that has been mentioned, and it would be unfair to the consumer to sell this product without proper testing. With regards to colourful wetsuits or surfboards, any visual pattern will become a silhouette when viewed from below and into the sun. Also as mentioned, orcas are massive, and the thought keeping a shark away by painting an orca design on a small surfboard just does not seem very effective.

Finally, I too believe that we should enter the ocean accepting of the risks that may come. Most people who grew up around the ocean seem to think this way. My condolences to those who have been affected by an unwanted shark-human interaction.



Scott Seamone  
PhD student, University of Calgary  
Calgary, Alberta, Canada

## FRANCE & REUNION ISLAND

I'm a surfer and I agree with Dr Christopher Lowe. The ocean's a dangerous place. It is very difficult to predict shark attacks. We tested electromagnetic waves in longline fishing vessel (Biton Porsmoguer et al., 2015). The results showed that electromagnetic waves were ineffective to reduce catches of blue shark (*Prionace glauca*) and with others pelagic species (shortfin mako). I also agree with Dr Marc Soria. The mixing of caution (local knowledge, scientific studies) could be a good solution. The better solution: we are only privileged visitors, so we need to respect the oceans.



Photo Caption: Biometric data. Shortfin mako (*Isurus oxyrinchus*) caught by a Spanish longliner in Vigo, Spain (march 2012). SBP.

Sebastian Biton Porsmoguer  
Ocean Engineer - Shark Researcher

Aix-Marseille University - Mediterranean Institute of Oceanography (MIO)

Biton Porsmoguer, S. Banaru, D. Boudouresque, C-F. Dekeyser, I. Almarcha, C. 2015. Hooks equipped with magnets do not reduce by-catch of blue sharks (*Prionace glauca*) by long-line fishery. *Fisheries Research*, 172: 345-351

## **Response**

Whatever the repellent type used it seems that none of them can offer a full protection. Patterns on suits or surfboards need to be tested on lures before to be sure they are effective. From my knowledge these tests have never be done. The same goes for orca sounds and electromagnetic emission, although preliminary tests on sounds were negative (sounds could not be heard by sharks at very long distances and electromagnetic fields seemed to actually be attractive at low intensity or worse induce frenzy behaviors.)

I have seen barriers of artificial kelp beds to be effective against sharks. From my point of view the success will be in the mixing of caution and wariness (by taking into account the knowledge of scientists and local people to avoid risky behaviors) with alarming systems (by tagging sharks), avoiding systems (for example by trans-locating sharks as it was done at Recife) and repelling or protecting systems (as with experienced underwater divers for example).

Marc Soria  
Coordinator of CHARC Program in Reunion Island  
Research Engineer at IRD (UMR Marbec)

## **Response**

It is common knowledge that the regular practice of water sports & water based activities provides wellbeing to many people across the globe, thus benefitting their mental & physical state and helping them to balance their life. Therefore, not being able to access the ocean while living on a tropical island is a real torment, especially when you've been born & raised by the sea.

With each new attack, a choir of so called "experts" implicates and pinpoints "careless" or "risky" human manners, but in some places (such as Reunion Island and Recife in Brazil) there are no more "safe conducts": the simple fact of entering the water is a risky behavior, where you are putting your life on the line!!

In many places, water sports & activities were able to be developed and thrive thanks to the fishing pressure exerted on sharks, but here, the lack of foresight & consideration from the authorities about this extreme danger led to the imposed total ban on surfing and swimming.

You have to understand that we do not try and fight the shark conservation effort of the past 15 years (which naturally led to the increased numbers of predators) but we do protest about the implementation of marine reserves right in the middle of recreational seaside areas, as it is the case in Reunion Island. Protecting potentially dangerous sharks in an aquatic kindergarten is pure madness and should incur responsibilities.

It is important to note that sharks are neither evil nor good, they are just wild animals that do not experience mercy, and which consider humans as much of a danger as a mere prey. The problem with shark attacks is that modern society refuses to accept our ancestral common sense: when faced with a predator, humans have no choice but to act as a predator also. This basic principle is the very reason which has enabled us to survive as a species since the dawn of humanity, and it is astonishing that some modern conception of "romantic ecology" would have us to believe in pacific cohabitation, even though it's impossible.

In this context, shark attacks appear like a powerful symbol of nature fighting back and taking it on to its main enemy, us...This symbol is exacerbated with surfing (a “useless” hobby) – surfing -- a symbol of leisure and free time, the culmination of industrialization’s progress. Therefore, any security steps toward a regulation will be resented as a “massacre” of those “pillars of the marine ecosystem” to the sole benefit of an egoistic leisure, thus leading to mass (media) hysteria.

Ocean analysts base their opinions on a basic principle: "We do not belong there, so it is for us to adapt." Unfortunately, reducing prevention to a mere compliance with safety rules cannot be generalized. The risk in Hawaii for example (where almost only tiger sharks are incriminated), is extremely low with only 6 deaths over the last 35 years, despite an extremely widespread practice of surfing among its 1.4 million inhabitants and also among the 7 million annual tourists!

On Reunion Island on the other hand (where mostly bull sharks are incriminated), we had 7 deaths between 2011 and 2015, for only 800,000 inhabitants, 400,000 tourists, and fewer than 1000 practitioners subjected to a shark attack risk since 2012! It’s thus obvious that you cannot compare situations & dangers which are so different in nature.

There are places where sharks represent a very small risk, and where a simple “risk assessment & education” might be sufficient indeed, like in the USA where you had only 3 deaths to shark attacks between 2011 and 2015 for a population of 330 millions (Hawaii, Bahamas & Porto Rico included), with 3.1 million surfers, and tens of millions of bathers.

Since the beginning of 2015, while our ocean is banned & virtually deserted, we’ve had 2 deaths already, and 0 for the entire USA. This means that the risk of a shark attack in Reunion Island is several thousand times higher than elsewhere else. Proportionally if the United States were subjected to the same risk, there would be thousands of deaths each year. In this case, would “specialists” still try and justify shark attacks through a simple problem of "bad risk assessment" and “wrongful behavior”?

Moreover, it is unfair to compare a shark attack with drowning, jellyfish sting, injury by a falling coconut or injury due to a “selfie”. These kinds of comparisons (used solely to discredit & marginalize the media coverage surrounding shark attacks) are, according to communication experts, a "manipulation of statistics".

Furthermore, after each and every shark attack, it has become a routine for “specialists” and/or NGOs to intervene and to lecture us about the "100 million sharks which are killed every year by humans", thus diverting the public attention from the attack and reversing the roles with the shark then becoming the victim.

There is also some exaggeration about shark populations waning. Indeed, preservation actions conducted for the past 15 years are bearing their fruits, and shark population seems to be on track to recovery. Unfortunately, this kind of data is not "politically correct" and goes against vested interests about oceans resources grabbing and is helped by context of ultra alarmism.

We have to remain vigilant about the fact that the preservation & the protection of the oceans (and of their inhabitants) does not hide more “sinister” plans about the potential exploitation of natural resources (fishing stocks, minerals, etc..) and does not turn into a moneymaking business.

Our position is that we are for science but against dogma, and some “specialists” theories that are littered with contradictions. For example, how can they say that overfishing could lead sharks to come closer to shores, when speaking about species such as bull sharks (which are known to be living in coastal biotopes anyway) fully adapted to fresh water and therefore not impacted by overfishing?

Similarly, linking shark attacks with global warming or El Nino, beg the question about the credibility of the so called “experts”, who do not hesitate to use “apocalyptic fears” to divert the opinion from the evidence: a direct correlation between increased populations of sharks and increased attacks.

The failure of the scientific program CHARC (€ 800,000 over 2 years with 80 tagged sharks) for risk reduction purposes should be an example for the entire planet. As foresaw in the initial evaluation report (“Rapport d’évaluation du projet CHARC, mars/avril 2012, F. Gerlotto) : *“It is absolutely certain that if these results (in terms of governance) did not appear, it is because of the chaotic nature (in the sense of deterministic chaos) of the system which prohibits any prediction. Therefore, we can give up any hope of risk management through an environment study, and it will be useless to try any other scientific activities in that way. ”*

Simply put, it is absolutely unrealistic to seek to establish sufficiently reliable patterns to risk human lives in such a difficult area to understand such as the ocean and the unpredictable wildlife’s individual behaviors.

There is also a real ethical issue regarding the tagging programs of many potentially lethal sharks and their monitoring in the heart of a seaside area full of human activities...

Marking dangerous predators and releasing them right in front of the most popular beaches of the island, and latter on being able to study the attacks. Wouldn’t that be similar to a “scientific experimentation” with “human guinea pigs”?

All those dogmas and manipulations will lead to an increasing number of attacks worldwide and to an increasingly problematic access to the ocean. The “return to wilderness” policies, with the reintroduction of all sorts of harmless or dangerous beasts will lead to a gradual disappearance of human activities in many places. Our ocean here is already on its way to returning to its “wilderness state”, whatever the social, human and economical toll.

To that regard, Reunion Island is following the path of Recife in Brazil, which I visited in April 2014, only to find out that 20 years of “research” and ban had led to the permanent closure of the ocean. Some local actors there made me understand that the bull shark, a prolific species, is a plague, some kind of “opportunistic ocean rat.” Whenever an area of human activity constitutes a suitable habitat, with plenty of fresh water and a lack of territorial pressure (through fishing), it leads to a tragedy.

This means that for us, the “hotspots” of the planet, the only effective methods in 2015 are still the implementation of fishing gear (nets and drum lines) in the areas to be protected. Those methods’ effectiveness has been proven in Australia and South Africa for the past 20 years by significantly dropping the risk on protected beaches. Sharks are intelligent animals that have crossed ages, and like all wild animals, they learn to avoid areas that are dangerous to their survival.

No one wishes to empty the ocean of all sharks; this is just about preserving a part of coastal areas for human activities, applying territorial pressure through fishing.

Any other non-lethal methods either lack of perspective or have shown their limitation. We consider the zebra patterns logic to have limited effectiveness because often when there are waves, the water is cloudy and sharks won't use their sight to hunt in those situations. It is also illusory to imagine preventing attacks with real-time detection of tagged sharks via satellite. In addition to capture & marking difficulties along with the limited lifespan of the tags and the often too low percentage of tagged sharks, the main problem will be about spreading the alert and the immediate evacuation scheme.

The method (invented in Reunion Island) of employing underwater lookouts may be considered but only in clear water (and thus in small waves conditions) as visibility will be insufficient in bigger waves. Furthermore, while seeking a "scientific validation/approval", this method has become too complicated and costly to expect a broader deployment. Indeed, it now necessitates a heavy protocol, with a total of 35 peoples involved, 2 boats, cameras etc... just to secure a group of surfers!

Regarding the so called "innovative" devices, especially the semi-rigid and the electromagnetic barriers, they could be of interest and we have met almost all their inventors/developers in the past three years here in Reunion Island.

Unfortunately, all of these methods are still experimental and their standardization is impossible due to prohibitive implementation and maintenance costs

That is the recent conclusion (August 2015) supported by the town of Saint-Pierre, which has just abandoned the idea of securing its beaches through innovative measures after three years of feasibility studies!

We should also ensure that this trend of "nonlethal innovations", greatly supported by the animalists do not become a money making scheme cashing on our fears and feeding the controversy by maintaining the illusion of a "magic solution" that would preserve both predators and humans.



Jean François Nativel  
Ocean Prevention Reunion Association Secretary  
<http://www.opr.re/>  
(author of a forthcoming book on the "shark crisis" in Réunion)



## New Zealand

This discussion is timely given the recent attention shark populations are receiving from both shark attacks and increasing regulations on the shark fin trade. While even the most skilled water person is not immune to the power of the ocean, I find the risk to be part of the allure. As a surfer, the idea of shark deterrent technology is compelling; and as a mother, I would likely encourage my children to use shark deterrent technology that has been shown to decrease the risk of an unwanted shark encounter. However, as a conservationist, I question the ethics of invasive technologies, such as shark nets or electric fences. Among others, this paper discusses the use of shark tags as triggers for an electric fence-type technology. Instead of “zapping” sharks, I would like to see this or similar technology used to improve more passive measures designed to reduce encounters between sharks and ocean users (e.g., shark spotting technologies).



Dr. Brooke Porter  
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Auckland University of Technology, New Zealand

### Response

Regarding sharks. I have never really considered using a repellent due to the fact that attacks here in Aotearoa are uncommon. In saying that, I am very aware that when I am shooting at dusk or dawn (when the light is optimal for creating images) and especially when I am shooting flash images in the water, there is always a chance that I will have an encounter with a shark. I guess I try to put it out of my mind and focus on enjoying being in the ocean and doing what I'm doing. The ocean is a shark's home; it's their environment and we are guests. I met a guy who worked for Sharkdiver Magazine and was shooting a feature on sharks at the bottom of the South Island for the Discovery Channel a few years back. You get some enormous Great Whites down in those waters and the interactions he is able to have with them blew my mind. I guess if a repellent was proven to minimize the risk of an attack while not harming the creature I would be all for it. Overfishing appears to be having the biggest impact on where sharks are looking for food, so I think getting this under control would be the optimal means of limiting future attacks.



Jim Culley  
Photographer

## Scotland

My comments come from research on sharks and from being an avid diver having spent a lot of time underwater with a wide range of species. The problem with the majority of shark repellents is that they come with the manufacturers claims of working, but they have not been rigorously tested and published through peer-review. That is starting to change but it's important to stress how difficult it will be to test repellents under the scenarios by which a shark may attack a human. For example, attracting sharks with bait while testing may still not elicit the same response as an animal that is naturally trying to forage on large prey on the surface. My own personal experience has been using a shark shield with bait experiments in Hawaii, which I was not impressed with. Other methods such as electric / magnetic / chemical / visual repellents may work in some situations but their effectiveness in other locations/situations are less clear.

There are some methods currently being tested that show promise, but I certainly would not bet my life on them working and have not seen nearly enough to say that they will work. I would personally not bother using any devices currently on the market, at least when it comes to diving.



Dr Yannis P. Papastamatiou  
Scottish Oceans Institute  
University of St Andrews

## South Africa

Having worked on this issue for 17 years and having dealt with 18 shark attacks below are the key points that I have learned:

- 1) It is the fear of shark attacks as opposed to the actual risk of shark attack that is a major factor. That fear can have a major and substantial impact on how people perceive and use the ocean. The real risk of shark attack is extraordinarily low, but human emotion is a powerful driver of fear and in short “emotions trump statistics when it comes to sharks”
- 2) Appropriate shark safety measures are important for people but are as important for sharks as part of an overall shark conservation and protection strategy
- 3) I don’t believe any deterrents at this stage are far enough developed or tested to be viable options. Here in Cape Town our Shark Spotting programme has worked very well and is the approach we advocate
- 4) It will never be possible to tag every great white and the cost of even trying will be excessive. In addition you would need to re-tag on a regular basis as batteries run out and tags fall off. Tagging itself can at times be quite damaging to the sharks
- 5) In Cape Town we are opposed to any safety measures that cause harm or kill sharks or reduce the population
- 6) Electronic barriers as being tested by the KwaZulu Natal Sharks Board at the moment hold much promise but are yet to be developed far enough to be used. In addition the financial cost of running such systems may make them unusable. Only time will tell

Gregg Oelofse

### Response

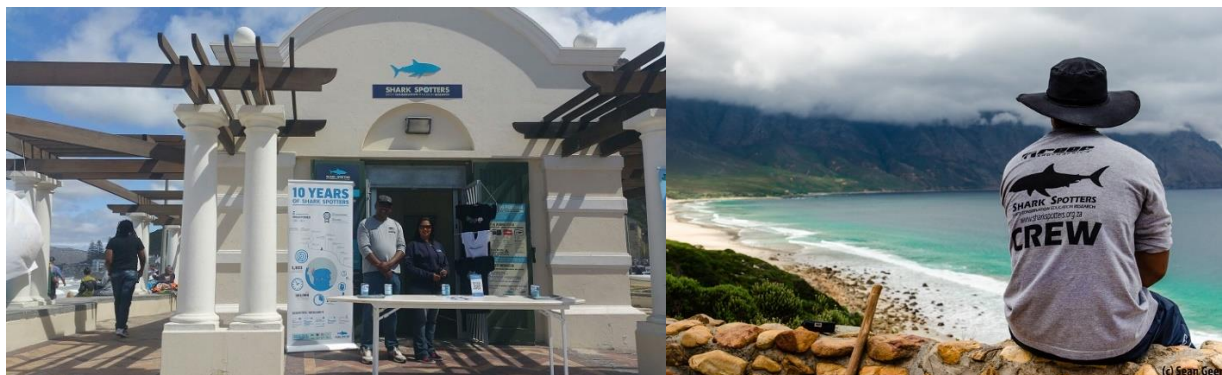
In my experience, a shark safety system, particularly in areas of high overlap between sharks and people is needed to keep people safer, but is just as important for shark conservation.

Most shark deterrents have not been rigorously tested, and those that have been e.g. Shark Shield, are not 100% effective. However, these tested electric deterrents can provide a degree of extra safety in some cases and are therefore a viable option for water users - as long as the wearer is aware of the limitations.

When it comes to keeping people safer from sharks, it is important to remember that ‘one size does not fit all’ – each area needs a tailor made shark safety system. In some cases this may simply be a focus on awareness of high risk areas and times of encountering sharks, in other cases additional options could be available. In Cape Town, we have a large aggregation of white sharks living next to a major City and we have used a combination of methods to keep people safer. We provide an early detection and warning system in the form of dedicated Shark Spotters at 8 beaches, and we use an environmentally safe shark exclusion net at a single beach. The Shark Spotters programme itself has proven to be effective at reducing overlap between people and sharks, but is not 100% effective due to not being able

to spot sharks in all conditions, all of the time. On the other hand, shark exclusion nets provide 100% safety from sharks because they form a barrier between people and sharks, but they are limited to relatively protected bays. We also use the knowledge gained through applied research to advise people on high risk areas, times of year and certain local conditions. Education and awareness are an important part of the system with informative signage at all beaches, high risk signage at certain beaches, an information centre on one of Cape Town's most popular beaches and accessibility to a network of recent and confirmed shark sightings through various social media channels. Temporary beach closures are also used when there is unusually high shark activity in the area.

Detection and warning methods coupled with a response system, in my view holds the most promise in terms of practical application, low cost and use over larger scales. This is especially true for surfers that use surf zones where exclusion nets are not viable, or electric barriers which may also be a challenge to implement in surf zones or cover large areas. Trying to influence shark behaviour by deterring different species under all conditions has proven to be a major obstacle in the advancement of deterrents. While the Shark Spotting programme is not viable in all areas due to lack of elevation for human spotters or inconspicuous shark species, the concept of an early detection system combined with a response to temporarily get people out of the water, is replicable. Advances in technology, such as high definition cameras (possibly fixed on high structures overlooking beaches or surf breaks) or underwater sonar, might provide more high tech detection capabilities and should be investigated as viable options.



Dr. Alison Kock  
Research Manager  
Shark Spotters

## Response

The KwaZulu-Natal Sharks Board based on the east coast of South Africa has a long history of conducting research into the field of electrical shark repellent technology. It has been and remains the goal of the KZNSB to develop and optimize electrical shark repellent technology in an effort to improve on the current systems of nets and baited lines to provide bather protection from sharks.

In the field of personal shark repellents, the KZNSB during the 1990s developed and marketed the first successful electrical personal shark repellent unit called the POD™. In the mid-1990s this technology was licensed to SeaChange™ Australia now called Shark Shield™. The original shark repellent technology used in the POD is currently being used in the personal shark repellent units called Shark Shields which are freely available in the market.

Whilst it has been statistically proved that this technology as incorporated into the Shark Shield does have a repelling effect on sharks it nevertheless is incumbent upon all entering any marine environment to exercise due diligence, caution and be aware of potential threats as may be caused by sharks encountered. In many cases it really comes down to basic common sense and taking the time to familiarize oneself with any and all potential hazards.

The KZNSB has an ongoing program for the development of an Electrical Shark Repellent Area Barrier which could be used at bathing beaches, surf spots and the likes. Sea trials were conducted over a 6 month period this year past in False Bay, Cape Town. Even though the system proved sea worthy and performed as per specification from an engineering and design performance perspective, the lack of white shark interactions with the Area Barrier during the test period prevented the collection of the required animal avoidance validation data. The KZNSB is pursuing this research and we expect to continue field trials during the latter part of this year in this regard.

I am of the opinion that it may not be a single technology that provides the answer to the problem faced but that it may well end up being a combination of various technologies that provide the answer.

Much has and continues to be emphasized about the disproportionate reaction and actions taken in view of the recent shark attacks worldwide. The fact remains that shark attacks will continue and public education alone will not prevent all shark attacks. If different technologies can provide the answer to this problem without having any negative impact on the environment then surely we must peruse this research. Man walked on the moon over 46 years ago and as I write this email the Rover continues to drive on the surface of Mars, surely we can and must do better when it comes to the question of technology, sharks and man.

The KZNSB remains committed in its search for better methods of protecting both sharks and sea users.



Paul von Blerk

## Response

Excuse the brevity of this response. I recently attended the 3rd Southern African Sharks and Ray Symposium (SASRS) where shark repellents were discussed. Quite simply, I have come to believe that shark repellents can be a powerful tool of ensuring the safety of both ocean aficionados and sharks, although the proposition receives vocal dissent from shark scientists that emphasize the lack of adequate knowledge on behavior (that of both sharks and humans). Of course, for any rigorous scientific approach, the proof of the pudding is in the eating, in other words the results of shark repellent studies should wherever possible be validated by independent data. Shark repellents are better than “culling devices” that intend to minimize shark-human encounters through death of an animal in its natural environment, at least in my view.



Simo N. Maduna, M.Sc. cum laude  
Ph.D. candidate  
Department of Genetics  
Stellenbosch University

## Spain

I fully agree with Lindy Weilgart and Sebastian Biton Porsmoguer. Any system that uses electromagnetic radiation to scare away sharks particularly affect species with low mobility who live in the area (bivalves, algae, corals, small fishes, crabs ...) and affect much less to highly mobile species who often travel long distances and spend little time in the same place (like sharks...), because the effects of these radiations normally are long- term and the exposure time is an important variable to consider.

Alfonso Balmori  
Biologist, Spain



## United States of America

I've never seen or tested a shark repellent that I would bet my life on. I just don't think that we know enough about shark behavior to develop repellents that would be successful under a wide enough range of conditions and across a wide range of species. In addition, I've seen people exhibit more risky behavior because they believe the devices are 100% foolproof – and that is, in my opinion, a disaster in the making. The ocean's a dangerous place, if you want to play or work in it, accept the risks. However, you can reduce those risks by being smart about what you do and how you do it when out on or in the water.

Christopher G. Lowe, Ph.D.  
Professor and Director of the CSULB Shark Lab  
Dept. of Biological Sciences  
California State University Long Beach

### Response

Sharks are endangered already. We know the electromagnetic field exposure increases risk of leukemia and maybe other cancers in people that are excessively exposed, and brain cancer if they spend too much time on their cell phone. Will use of electromagnetic shark repellents increase risk of shark cancer? Perhaps we need to balance protecting the sharks verses protecting the surfers!

David O. Carpenter, M.D.  
Director, Institute for Health and the Environment University at Albany

### Response

It's bad enough we have to deal with sharks coming after us. Now we have to deal with sharks with cancer biting into us.

Brian Kelly  
Surfer

### Response

Patterns on the bottom of a board as a potential repellent does make some sort of sense. A surfer with appendages dangling over the edge of his board does look rather seal/sea lion like, and anything capable of changing that pattern might be a positive development. The electromagnetic idea might work, but sadly its effectiveness would probably be limited to very close quarters (unless vast amounts of power were used – inverse square law and all that). Tagging with beacons any significant percentage of Great Whites in this area would be a near-impossible task. Good idea, though.

Meanwhile, there is a sort of backward-positive bit of good news about this temporary inundation of sharks: Folks are beginning to think climate change is real, and about its effects on the ocean.

-Tom Garrison  
Orange Coast College

## Response

To be honest I do not know a ton about shark repellents. Maybe the best solution is to not swim or stay out of shark infested waters if one has a fear of sharks. There has been an increasing number of shark sightings in Malibu and surrounding areas due to warmer water temperatures. However, I feel sharks are a key part of our ecosystem in the ocean and humans should not be interfering with their habitat.



Skylar Peak  
City of Malibu, CA  
Councilmember

## **Response**

Most of the ideas you propose look OK, with the exception of these:

"2) Would emitting orca sounds from surfboards, swimsuits, or the bottom of the ocean at surf breaks provide any additional benefit?"

First, because sharks lack a swim bladder, they do not appear to have a very good sense of long distance hearing. And they certainly are very unlikely to be able to hear the high frequency "orca sounds". More importantly, there is the very real possibility that these sounds would adversely impact the behavior of marine mammal species (e.g., California grey whales) that are regularly preyed upon by orca. So it's very likely that the adverse unintended impacts of playing "orca sounds" would have to be thoroughly researched and the technique would need to be approved by state and federal governmental agencies involved with marine mammal issues, both of which can be lengthy and costly procedures.

"We believe a safe method would be to tag all great whites with a sensor/transmitter capable of interacting with strategically placed shark safety beacons dialed into the same frequency of the great white tags. When the tagged shark gets too close to the beacon they get a shock and leave the area – similar to an underground electric dog fence."

I'm very skeptical that you would be able to "tag all great whites with a sensor/transmitter..." because of the expenses and difficulties associated with doing so. Plus I doubt that you'd be allowed to do so, given the very real possibility of seriously injuring or killing great white sharks, and other species.

Richard Brill  
Fishery Biologist  
NMFS, NOAA & Adjunct Faculty VIMS

## **Response**

I definitely don't like the idea of electronic tags (dog collar style) for sharks but am glad to see that people are looking at methods other than culling, which is not the answer and was one of the main messages of the Ferretti paper.

Sue Silver PhD  
Editor-in-Chief, *Frontiers in Ecology and the Environment*

## Response

### *Passage from unpublished memoirs*

John Earle and a fellow diver had a frightening experience with a large Tiger Shark while diving off Waianae, O'ahu. They had made a deep dive for the Hawaiian Spiny Lobster, and each had a goodie bag filled with live lobsters. While decompressing at about 15 feet, the shark approached from deeper water and circled closely. John had his powerhead for protection, but the shells were at the bottom of his bag of lobsters. Remembering the loud sound-producing device that Bob Halstead had used to bring overdue divers to the *Telita*, he hit his steel scuba tank with the powerhead handle while swimming toward the shark. He was convinced that this caused the shark to swim away. I suggested to John that we go to the Maui Ocean Center and try hitting a scuba tank while diving in the Center's large oceanarium. I had dived in it previously and soon had permission from friends. I made the dive while John stood at the largest viewing window with his video camera to record the experiment. I waited until a Sandbar Shark was very close and hit the tank with a large wrench. The result was initially what one would classify weakly positive, but successive attempts produced little or no response. However, I could hear sounds produced in the oceanarium's kitchen, so we realized the sharks in the tank were conditioned to extraneous man-made noise. Also I was given an aluminum tank which did not produce as sharp a sound as a blow to a steel tank. John and I are convinced that research should be undertaken to determine the sound frequency that is most repelling to sharks. Sharks are well known to have very acute hearing, so we believe a frequency could be found which is strong enough to repel sharks but not damage the hearing of divers.

John E. Randall, PhD  
Senior Ichthyologist emeritus  
Bishop Museum, Honolulu

## Response

The thought that we can engineer nature to make it safer for humans sends a chill to my heart. People need to take responsibility for their actions, which includes being aware of and accepting the risks of entering the ocean. There is something unique in our fear of sharks that make many compelled to try to engineer ways of preventing them. Many more people die each year by drowning in rip-currents than by sharks, yet they do not spark the controversy and outrage that a shark attack does. If a surfer drowns politicians and communities do not close the beach or build a break-wall to stop the waves or currents. Yet, driven by our fear of sharks we invest millions into the design and implementation of shark culls, shark shields, and patterned wet suits and surf boards. I believe that the best way for us to protect sharks is to better understand Galeophobia (fear of sharks) and why humans respond to shark attacks in the way they do, and most importantly to change our cultural views of sharks. In my opinion engineering equipment, such as electric fences, to reduce shark attacks is unlikely to be met with any level of success. Our biggest investments should be in rewiring society's views of sharks.

Trisha Atwood  
Assistant Professor  
Watershed Sciences and Ecology Center, Utah State University  
(The views expressed above are those of Dr. Atwood's and do not represent the position or views of Utah State University)

## **Response**

In short, the sea belongs to its denizens and we are ecotourists when we enter it. Our venturing there comes with associated risks – drowning, jellyfishes, stingrays, and – yes – occasionally sharks. Sharks kill on average six humans a year (only a fraction of those are surfers) but thousands die by drowning.

A central tenet of ecotourism is not to leave behind any footprints and we should endeavor to do the same. We need to be smarter than the animals that inhabit the alien environment we choose to visit and avoid times and places where a negative interaction might take place. It's common sense.

This may necessitate us abandoning a great break because sea lions haul out there, drawing white sharks. Or we may choose to continue to go there at our own risk, but we can't blame the critters if a bite occurs because our playground is their dining room. Most surfers are already of that mindset, i.e. "Surfing is a wilderness experience that comes with risks that I'm willing to accept."

Can I have an "Amen," brothers and sisters...

George H. Burgess  
Director, Florida Program for Shark Research  
Curator, International Shark Attack File

## **Response**

I read through the responses, which are quite varied. I have no professional opinion about the efficacy of shark repellents, but I have an ethical view that sharks should not be killed as a precaution.

The little I can add, personally, is that some years ago while briefly living in Hawaii, I did daily swims across a wide bay mouth in Kauai. As the days went by I was increasingly spooked about looking down, quite far, into the fading deep and imagining something come up from below. Finally I decided I was not comfortable swimming in deep water and gave it up.

Jim McWilliams  
Dept of Atmospheric and Oceanic Sciences  
University of California, Los Angeles (UCLA)

## Response

First off I'd like to make it clear that I am a 4th year PhD student with research interests in physical oceanography. So I work mostly with fluid dynamical concepts and problems, and am not necessarily qualified to confidently give insight on behavioral patterns of sharks as they respond to temperature or fish stock changes. That being said, there is a rather obvious intuitive inference that marine life will have a response to environmental conditions (water temperature, nutrient levels). The only confident claim I would make is that this response will temporarily shift patterns away from what is statistically normal. Maybe that is obvious, but without doing an actual quantitative assessment (potentially a couple of years of work) I do not know what the nature of that response would be from a statistical standpoint (e.g. what is the probability that you run into a shark while surfing during an El Nino vs La Nina year at the same location).

The ENSO (El Nino Southern Oscillation) event this year has already brought much warmer water along the California coast via the collapse of upwelling in the eastern equatorial Pacific and maintained by the eastward propagation of oceanic Kelvin waves along the equator and up/down the west coasts of North/South America. The California Current System has been shown to respond to an El Nino event with reduced upwelling. This essentially means warmer waters and less nutrients brought up from depth, thus lower primary productivity (i.e. plankton blooms). Lower primary productivity means less food in the water for larger organisms, so it is probably a safe assumption that there would be some migrations of California Current marine life in search of food due to the lower local food supply. Again, without giving a quantitative assessment, I would think it is reasonable to assume that marine life (starting from plankton all the way up to sharks) will show a transient response to these increases in water temperature and decreases in nutrients/primary production; the normal geographical patterns of where sharks are found could be influenced (and thus changed) by the trophic system's response to ENSO.

I think the most feasible shark deterrent system presently in place is Shark Shield (<https://sharkshield.com/>). Orca patterns on the bottom of a surfboard are easy and cheap, but a surfboard is nowhere near the size of an actual orca, so I have a hard time imagining why a 15ft Great White would back away from a ~6'1 x 19' x 2.5' orca. From what I read, the orca pattern is only meant to disrupt the shark's vision in the final phase of an attack (when the prey is near), so my interpretation is that this will not necessarily prevent collisions/onset of attack (it may change a bite to a bump). Also, attempting to tag every shark out there just strikes me as way to laborious with no guarantee that every shark is accounted for; it seems like a very costly way to go about solving the problem, with the constant need to update the system (i.e. find and tag new sharks).

To my eye, Shark Shield has shown the most promise in testing with actual quantitative results indicating less probability of attack with the Shark Shield turned on (<https://sharkshield.com/scientific-research/>) From a non-scientific standpoint it is also apparently endorsed by some professional surfers (<http://stabmag.com/shark-repellents-are-so-hot-right-now/>) who give anecdotal testimony to its efficacy (I would take the published papers more seriously, but the anecdotal evidence can be interpreted as promising).

I think there are two ways to think about the extrapolation of the single unit Shark Shield to cover a larger area. The first, I would guess would be heavily endorsed by the Shark Shield people: if most of the surfers in a crowded break have Shark Shields, you already have an array of units all sending signals out, thus protecting most of the surf-zone. The other, is some form of the idea mentioned in the article, in which the same technology used in Shark Shield is somehow retrofitted to a surf-break. I think I share

the same thoughts with most of the other people responding, that testing would definitely need to be done to see what the fundamental effects on all marine life are before that is implemented.



Daniel Dauhajre, PhD Student  
UCLA Department of Atmospheric and Oceanic Sciences

### **Response**

Sharks are a top predator in our marine (and estuarine) systems. The role that these species play is critical to proper ecosystem function. As humans have developed an increasing (and sometimes irrational) fear of sharks, these species have in some cases faced threats that have caused possibly irreversible damage to their populations. As many shark species are migratory, utilizing a variety of habitats over their life cycles, understanding just their basic demography and behavior is a logistic challenge for scientists. Given the gaps in knowledge related to many shark species, I am hesitant to support any type of shark "repellent" that might have direct impacts to how these species function within their habitats. Additionally, the use of acoustic transmissions (e.g. orca vocalizations) or altering the electromagnetic field of a geographic location may have consequences beyond the targeted shark species. Many marine organisms rely on acoustic and sonar information to assess their environments. The use of and sensitivity to electromagnetic fields is not limited to sharks. Marine turtles, spiny lobsters, sea slugs, and other species have been demonstrated to use magnetic field for orientation and navigation. Elasmobranch species (sharks, rays, and skates) and other marine species rely on electromagnetic fields to detect their prey. Disrupting these fields could have devastating consequences to important habitats for these species. Dr. A. Peter Klimley used wet suits designed to replicate the color pattern of orca whales while conducting field work in the Pacific. I think this latter approach is far more innocuous and with less consequences for unintended species.

Sheila V. Madrak, M.S.  
Doctoral Candidate  
Joint Doctoral Program in Ecology  
San Diego State University/UC Davis  
Department of Biology

## Response

It appears that my concern and opinion are pretty consistent with those more directly involved with the field of study...I think that products or ideas such as this feed the fear and seek to profit in some manner than to really help...the magnetic anklets are a good example...you have a higher risk of getting speared through the leg, gut or head with your or someone else's surfboard. Pura vida.



Robb Havassy  
Artist



## Response

### Shark Repellent Strategies:

In light of the success of mimicry strategies in deterring predators in the wild (Viceroy butterflies versus Monarch butterflies or scarlet king snakes versus coral snakes), Orca patterns on surfboards, or devices to emit Orca sounds from surfboards, swimsuits, or the ocean floor would seem to be the most promising.

Strategies to tag white sharks with a sensor/transmitter capable of interacting with safety beacons seems to be a good strategy, although the challenge is to make sure that all sharks that might appear in the area are tagged. The main concern in this respect is the huge range of great white sharks tagged and tracked in the wild.

The electromagnetic field strategy would have to be tested. Location strategies in electric fish work well in navigation and for locating prey, and involve very low voltage. The safety of higher voltages and the effectiveness of specific electromagnetic fields to repel sharks would need to be tested. I expect that insufficient information is available on the safety effects of the proposed voltage ranges on humans (and marine life).

Julian H. Lombard, Ph.D.  
Professor—Department of Physiology  
Medical College of Wisconsin

## Response

As to mutagenesis or carcinogenesis from electromagnetic fields, while I'm not qualified to speak authoritatively, I harbor doubts about any significant effect. Every news note or study I ever heard reported on the subject came back negative or (in rare cases) a small trend effect "worthy of further study" (but perhaps not even statistically significant) was seen. Given the pervasiveness of such fields in modern society and their absence in remote environs, we're not seeing the difference in cancer rates among city and wilderness residents to suppose any strong effect. (Also, unlike "ionizing radiation" at the highest end of the EM spectrum, EM fields are not ionizing, and it's therefore a little harder to imagine how they would significantly prompt mutations or other chemical changes predisposing to cancer (or other major disease). An MRI is still safer than a CT...

Case Ketting, MD

## Response

I'm an avid surfer and spearfisher which puts me in the highest risk groups for shark bites, but I don't use shark repellents because I'm skeptical about their effectiveness in reducing the already very low risk of a shark bite.

Commercially-available shark repellents run the gamut from absurd to potentially-effective, but none are likely to be 100% reliable. Nonsensical repellents include wetsuits and surfboards with stripes and other disruptive patterns. The rationale behind these patterns is that they mimic the appearance of highly-venomous sea snakes and hence will be avoided by sharks. The genius who came up with this notion apparently overlooked the fact that sea snakes are a regular component of the tiger shark diet in many regions, plus when viewed from below against a brightly-illuminated sea surface, objects decorated with patterns still appear as dark silhouettes!

Electrical repellents, such as Shark Shield, have a more scientific foundation, and I've actually tested one in a very basic experiment with wild sharks. I attached the Shark Shield below a floating PVC frame at the site of a Galapagos shark aggregation off Hawaii. I first deployed the Shark Shield with the power off, and dropped chunks of fish next to it. Galapagos sharks approached to within 30 cm of the Shark Shield to consume the fish. I then switched on the Shark Shield and repeated the experiment. Guess what!? Galapagos sharks approached to within 30 cm of the active Shark Shield to consume the fish! I was actually very surprised by this result, because the manufacturer's website has videos of huge sharks flinching and turning away when the Shark Shield is turned on. However, I was unable to produce this response in Galapagos sharks.

I still believe electrical repellents may deter sharks under certain circumstances but I certainly wouldn't bet my life on one. More experimental work is needed to understand the limitations of these devices.



Carl Meyer, Ph.D.,  
The Hawai'i Institute of Marine Biology

## **Response**

The difference between sharks and lions is that poor livestock husbandry attracts lions, so most of us are trying to find ways to make pastoralists look after their cattle more carefully. Sharks are approaching human areas of recreation -- challenging problem!

Craig Packer  
Professor, Director - Lion Research Center  
College of Biological Sciences  
University of Minnesota

## **Response**

My thought is this, if it's strong enough to drive away Great Whites how good can it be for humans, and "everybody knows" you can get cancer from cell phones, and living near power lines (cancer cluster debate). The practical issue is the liability issue for the device's risk real or imagined and public perception.

We all know irradiating food would save thousands of lives from food borne epidemics, and how about nuclear power to save hundreds of thousands of lives each year from air pollution deaths alone. Gosh no!!! We can't have nuclear, or electromagnetic or cosmic rays!!! Don't the astronauts and flight attendants get more cancer over a lifetime???? But wait, there's hope to market this device!!! The earth's magnetic field holds all that bad stuff at bay in the Van Allen Belt!! There you go, that's the ticket!!! I'm sold! Great piece dude!

Claude Zanetti, MD

## **Response**

While the pursuit of shark repellents is a worthwhile one, I am afraid most of the products on the market or in development are not based on rigorous scientific testing and their effectiveness is inconclusive at best. At worst, they may provide surfers and other ocean enthusiasts with a false sense of security that could lead to them to engage in risky behavior, like being in the ocean alone, at night, near sea lion haul-outs etc.

Electromagnetic repellent devices may be the most promising, but these need more independent testing. The orca pattern on the bottom side of a surf board may or may not do anything. The same could be said for the striped pattern or even striped wetsuits. These may offer some camouflage effect, but animals are also attracted to novelty and if it is something the shark has not seen before, it may investigate (with its mouth). Orca sounds may or may not be a deterrent, if the sharks can even hear the sounds. Sharks hear very low frequencies and the machines needed to generate low frequency noise that travels far distances are large and expensive.

Lastly, tagging all the white sharks in the ocean is not feasible and very costly. It would also require a constant effort because newborn sharks would have to be constantly tagged as they grew as well as new sharks that enter from other areas. Even if you could tag most of the white sharks, how would the public respond when one was detected nearshore? Would they not enter the water? White sharks are all over, so there would be detections all the time. If there were no detections, would people assume

there are no sharks in the water? That would also be incorrect because there would obviously be untagged sharks out there. Given how few people are injured by white sharks every year off California, I'm not sure that the investment in time and money could be justified.

I think what is most important is that we keep things in perspective. The chances of being injured or killed by a shark are vanishingly small. Perhaps that small risk is just something we have to accept when we enter the water for any purpose? This does not mean we shouldn't think about ways of further minimizing risk. After all, that's why we have seat belts in cars and why there is a growing push for self-driving vehicles. That is also why hikers carry bear spray in the woods. However, at this point, the best way to minimize risk of a shark bite is to always have a buddy nearby who can help in the event of a shark encounter (or other much more likely medical emergency), minimize water activities at dusk, night, and dawn, when sharks are most active, and to avoid places with lots of food like bait, marine mammals, and river outflows.



Andrew Nosal, Ph.D.  
Postdoctoral Researcher  
Scripps Institution of Oceanography

### **Response**

Human nature is designed to focus on the threats even when the statistical likelihood is low. For example. Most folks way overestimate the risk of dying from terrorist attack or plane crash. In fact the risk of dying from road accident is orders of magnitude greater. Ditto, sharks.

Paul D.

## Response

All of the expert responses bring up excellent points and I whole heartedly agree with most of it. To add my personal, non-scientific, opinion. I think most shark repellent products are a fairly crude attempt at affecting a complex animal in a complex environment. Most devices I have seen or heard of will only work on certain species, during certain circumstances and under specific conditions. It is a simplified idea to think all species of sharks will respond to a color pattern or electric field at all times when there is other stimulation in the water. How strong a deterrent has to be largely depends on how motivated the shark is. Most of the time sharks are not even interested in humans, so keeping them out of the area is not necessary. The slightest sound, movement or sight can either attract or spook a shark, depending on what they are used to, why they are in a particular location and what they may or may not fear. How often do sharks have to fear being hunted by Orcas if they live in a place where you never see Orcas? Small amounts of electric current can attract sharks. So does sound. How can you dose it considering the density of the water? Sound travels incredibly far. Electricity disperses quickly. To use electricity or sound to protect a whole area would require such a high dose that surely it would be damaging to a lot of other ocean life in the area. Trying to tag and track ALL Great whites, tiger sharks and bull sharks is simply impossible.

It really worries me that there seems to be this attitude that the sharks are encroaching on human's swimming areas or surf spots and that there is an increase in sharks. First of all - when seen in relation to how many people are entering the ocean, there is no increase in attacks. It has been proven that shark populations are decreasing all around the globe. Creating panic over the fact that sharks come closer due to climate change is also pointless. It is a natural reaction that predators will go where they find prey. That does not mean that there is automatically an increase in danger. We cannot expect fish to stay in their neatly designated areas that make it easy for us to keep track of them. That is not how it works. And secondly, sharks contribute to the health and balance of the ocean. Surfers and swimmers are there for recreation - what is more important?

The real problem is that sharks are being wiped out and that sightings have become quite rare, except in certain locations. It is unfortunate that sometimes these locations coincide with some of the popular surf spots. Maybe choosing locations for surf competitions should consider the wildlife as much as the perfect wave. Most surfers I know are perfectly happy to be in an environment that is still wild. Extreme sports have an element of danger, so sometimes I wonder who shark repellents are made for? Is it more hype than necessity? Are we trying to sanitize the ocean so more people can enjoy it without worry? Is that what we should strive for? People are more and more removed from the natural world and feel entitled to safely use the wild places as their playground. We have managed to wipe out nearly ever "slightly" dangerous predator on land, and now this attitude is extending into the oceans. We do not need shark or bear repellents. We need to be willing to learn about our environment and enter the wild with some knowledge and acceptance that we are only one of the animals that use that space and that we need to coexist.

Stefanie Brendl  
President  
Shark Allies

## Response

Fear of sharks is a fascinating and often debilitating emotion. I am always saddened to speak with people who let this irrational fear keep them from exploring some of our planet's most incredible ecosystems. The concern that it is the fear of sharks which limits the number of surfers and results in less people willing to stand up for ocean conservation is interesting. While surf groups certainly can help to promote ocean conservation, they are not alone in this fight. The assertion that people need to feel safe about going in the water to foster a strong connection with the ocean seems flawed to me. I would argue that many, if not most, of the people who have strong connections with the ocean understand thoroughly that it is not always a 'safe' place, and in many ways this understanding contributes to their fascination and drive to spend more time immersed in and learning about it.

Better research and education on shark sensory biology and behavior to limit shark-human interactions is needed for many reasons, both for human safety and for protection of declining shark and ray populations. This is why I have chosen to study this particular field and contribute to development of more effective methods, specifically aimed at shark and ray bycatch (unintentional catch) reduction from fisheries. There is a lot of misinformation about shark sensory capabilities and in many cases much more research is needed. Sharks and rays are a very diverse group and with the exception of a few well studied species, we know relatively little about them as a whole. In general, we know sharks can use all of the types of sensory information that we can, with the addition of the electrosensory system to detect electric fields and the lateral line system to detect water flow. Some information can travel long distances underwater, like chemical odors and some sounds, while others like vision are useful at intermediate distances (depending on water clarity and light levels), and still others are useful only at very close range like electric signals. As far as researchers have been able to tell, sharks are just as sensitive to odors as other fish, hear low frequency sounds about as well as other fish that don't have advanced hearing apparatuses, have large visual fields with good low light vision, though are likely unable to distinguish colors (though at least some rays can), and are highly sensitive to minute electric fields.

Shark repellents have been of interest since WWII, yet there is still no 'one-size-fits-all' solution. This is in large part due to the diversity- what works in one situation with one species may not work in another situation with the same species or in other species. While there is a very small number of shark species that have been involved in human deaths, these species are often difficult to conduct robust experiments with. Furthermore, in the development of commercial shark repellents, very few have been independently tested. Unfortunately, it is possible for a device to be profitable if it makes people feel safer even if it has no actual effect on deterring a shark bite- this is because shark bites are so rare. The purchaser is unlikely to ever be approached by a shark while using the device, so whether it would make a difference or not becomes irrelevant.

Most research on deterring sharks has focused on the electrosensory system using various metals, magnets, and battery powered electric devices. These have met very mixed results, showing promise with some species in some situations, but not consistently across species. The idea of using a largescale electric 'fence' sort of array is being studied, but is also very expensive and unrealistic in many areas. Using loud sounds has also been suggested, but these can be damaging to a range of marine life and evidence suggests sharks quickly habituate, or begin to ignore these signals. Using chemical odors is another area of current and past research but it is very difficult to control the spreading and concentration of these, and effects of the chemicals on sharks and other species must be thoroughly studied. The recent wave of visual deterrents such as patterned surf boards and wet suits is another

area of study, though any influence will depend highly on visual conditions - even white parts of patterns are likely to look dark from below against bright sun from above.

As useful as it might be to have all large sharks tagged, this is extremely unrealistic for many reasons, not the least of which is cost and the impossibility of actually being able to tag every large shark. Successful programs like the one implemented in Cape Town, S. Africa with Shark Spotters to give early warning and temporarily close areas seems to be one of the most effective and least environmentally damaging options to provide 'safer' beach areas for recreation.

Finally, it is unrealistic to expect any wild environment to be 'safe' but real knowledge of the actual risk of shark bites in the area of ocean you plan to enter is important. Human fatalities caused by shark bites are extremely rare, even with more people spending more time in the water than ever before in human history. If a bite does occur, it is less likely to result in fatality because of improved response times and emergency medical care. Research to prevent shark-human interactions is important and should evaluate species individually based on their biology and ecology because no single deterrent is likely to work in all species and situations. Using a multi-sensory approach (targeting more than one sensory system) is a particularly interesting area of research that I hope will result in more effective technology. Overall, of things to worry about on a trip to the beach, sharks are very low on the list.



Laura K Jordan, PhD  
Shark & Ray Sensory Biologist & Ocean Educator  
World Below the Waves

## **Response**

I believe that the ocean should not be a big safe bathtub.

We are seeing globally the consequences of human activity that is changing and threatening all life and future life in our planet. One aspect is the loss of the top predators in our ecosystems, on land and in the ocean. I refer you to this study. <https://scripps.ucsd.edu/news/1925>

"The decline of apex consumers has been most pronounced among the big predators, such as wolves and lions on land, whales and sharks in the oceans and large fish in freshwater ecosystems. But there have also been dramatic declines in populations of many large herbivores, such as elephants and bison. The loss of apex consumers from an ecosystem triggers an ecological phenomenon known as a "trophic cascade," a chain of effects moving down through lower levels of the food web."

We Humans need to temper our needs and desires for unbridled consumerism with consideration for these consequences. That is the challenge of our times, to preserve the world for future generations of life.

Carmen Ramírez  
Mayor Pro Tem,  
City of Oxnard, CA

## **Response**

Surfing is an inherently dangerous sport. Anyone that decides to pursue this undertaking has to accept responsibility for personal injury and any potential environmental effects. The only action I would consider are measures that are paid for by the responsible human parties, and have zero impacts on shark populations, that are already threatened due to human related activities such as habitat encroachment, overfishing, and pollution.

Karen Crow-Sanchez  
Associate Professor  
Department of Biology  
San Francisco State University



## Response

My personal opinion is that we (humans) are entering the shark's home.



Ryan K Walter  
Dept of Physics, Cal Poly

## Response

I do not believe shark behavior has changed, I think we are in the water more and shark numbers are recovering. We are not a prey item or we would be bitten far more frequently. We will see what this year's numbers say, but one year does not make a trend. The Media is reporting almost every incident now, so reporting is putting it out there far more than in the past. I think what has changed is perception and not really the numbers. Typical psychological bias. There may be local differences or changes like Reunion, but I am not sure even there. Of course, the discussion is pointless unless we look at species specific information as well. As you know that not all sharks behave the same way and not all incidents are created equal.

A lot of incidents in the US are fishing related and that is pretty much left out in the media. For me, those do not count as it is like saying oh look a lion on the savanna eating something someone killed or came in to investigate a slaughtered animal.

Grant W. Graves  
Marine Biologist

## Response

The ocean attracts people to it for many reasons, one of which is that it remains one of the last readily accessible places for most people to have a true adventure in a world that has become increasingly tamed and modified for the purposes of human progress and the 'greater good'. The intersection of human and shark in the coastal/oceanic realm is one of the things that makes life more interesting and adds a bit of mystery and unpredictability back into the lives of those who choose to spend time in, on, or under the water. This is, of course, despite the fact that there are unfortunate instances where it does not go as planned (occasional shark-attacks). Those who chose to make a living or recreate in the ocean must be aware that once they set foot in the water they are entering an environment that is home to creatures that have evolved over millions of years to be very successful and efficient at what they do, whereas we (humans) have not. This humble realization should not serve as deterrence, but rather as a reality check and a healthy dose of respect that helps people make informed decisions about where they pursue their activities and the manner in which they go about them. And, at the risk of sounding spacey, this humble realization and respect can also be used as a way to find a deeper connection with the ocean and ultimately add to the context of how we view our own place in the world and the other creatures that are riding around the sun with us.

This may come across as an unpopular or inflammatory statement to some, but perhaps the presence of sharks and the occasional shark attack can help to keep the oceans from being completely overcrowded and saturated with weekend warriors and thrill seekers out to conquer the ocean on their own terms. If the oceans are somehow made completely safe for everyone that would likely mean that an even greater percentage of our ever-growing population would end up spending time in the water, equating to more surfers crowding popular surf breaks, more scuba divers spearfishing and depleting limited fish stocks or damaging sensitive habitats, more crowded beaches, and so on. I certainly do not want to suggest that we should not strive to make our coastal areas safe and accessible for all to enjoy, but we should be careful what we wish for.

Orca/zebra patterned boards or suits: Sharks hunt for their prey using a combination of sight, smell, and electro-receptive abilities. Smell and electro-reception are used for long-distance detection and location of food resources, whereas sight is used in the approach and final moments leading up to capture and consumption of a prey item. The effectiveness of disruptive coloration or patterns applied to the underside of a surfboard or a wetsuit could potentially be affected by several things: the time of day/angle of the sun/cloudiness, underwater visibility/turbidity, and whether it is choppy or calm. For example, on a calm day with the sun overhead, the dark shape of a surfboard will be silhouetted against the contrasting lighter sea surface regardless of what pattern is underneath. And on other occasions where water clarity is an issue it is quite possible that the pattern might not be visible to a shark until it gets very close. And even then, the shark might not lock in on the uniqueness of the pattern in the moments leading up to an attack. Sharks roll their eyes back and/or protect their eyes with a nictitating membrane to protect them from damage during feeding, effectively and temporarily blinding them during the actual moment of attack. However, disruptive coloration/camouflage is used with great success by both predators and prey in the marine environment, and the idea could still hold great potential. The basic concept is that the animal employing the disruptive pattern is attempting to either blend in to its surroundings and/or to break up its outline to make it less distinct. One thing is certain, utilization of patterns such as these is much cheaper and simpler to employ than an elaborate electromagnetic field.

Tagging Great Whites: In recent years much has been learned about the movements and long-distance migrations of this and many other shark species. Numerous individual sharks have been documented as traveling hundreds to thousands of miles in a relatively short period of time. There are sharks that are sometimes considered as residents of a particular area and those that are transient that may only be associated with a specific location on a temporary basis. It is likely that during a shark's lifecycle it may lean more heavily towards one or the other at different times depending on its age, its dependence on a particular food source, and/or its reproductive state. To place tags on enough of the population to be relevant to the purpose of protecting people in the water at any one location, or for multiple locations for that matter, would be quite an ambitious undertaking. In addition, any tag that has an electrical component to it, whether it is a GPS tracking tag or something designed to apply a deterrent stimulus, will be limited by the finite life span of its power source. Even the most advanced satellite tags used to track sharks over great distances have a limit to how long they are useful. Therefore, unless better batteries are developed, the tags would need to be replaced too frequently to be useful on a long-term basis. Furthermore, even if this hurdle were to be overcome, there could still be a problem with how the shark reacts to the deterrent stimulus. Suppose a shark has been fitted with a tag that delivers an electrical shock when it approaches a strategically placed safety beacon. Assuming the shark reacts with an immediate escape response, what guarantee is there that the shark would reverse course and head away from the beacon? In its panicked flight, it might end up swimming closer to the beacon unless the stimulus is strong enough and continuous enough for the shark to sense that things are becoming increasingly uncomfortable if it continues traveling in a certain direction. And even then, if it does decide to turn around and head in another direction, if it is still within range of the beacon it will still be receiving the shock, which could further confuse its direction of travel.

Electromagnetic Fields: Our lab has recently been involved in a project assessing the effects of EMFs on the marine community in southeast Florida. A system of cables that have been in place on the sea floor for many years was used as our experimental test range. The focus was on the reaction of reef fishes that live in the immediate vicinity of the cables to EMF fields of varying intensities. Field strengths tested were on par with those produced by existing and possible future marine hydrokinetic devices (MHKs), such as offshore wind turbines, solar farms, ocean thermal energy conversion devices, or anything else that uses submarine cables to transmit electrical power. Sharks and rays were encountered occasionally during this project, although in numbers too small to be relevant for a robust statistical analysis. However, anecdotally, our observations indicate that they were neither attracted nor repelled by the EMFs we were evaluating. However, it is entirely possible that utilization of EMFs of specifically enhanced/selected strength and/or frequency could be used as an effective shark deterrent on a small-scale basis. As Tom Garrison pointed out already (inverse square law), the strength of the field dissipates significantly as you move away from the source. I also agree with Claude Zanetti (response above), in that anything that is strong enough to deter an apex predator will likely have undesirable effects on the surrounding environment and other animals, including humans. But perhaps there is a "magic number" out there somewhere...an EMF of sufficient strength to deter the electro-sensitive sharks that is innocuous enough to be used in close proximity to human activity. The inverse square law could be quite useful here - the EMF producing cable (or cables – perhaps a curtain of multiple suspended cables hanging from buoys) could be located far enough offshore to prevent its effects from reaching the surfers in the lineup. More research is needed, but this idea has potential.

Kirk Kilfoyle, M.S.  
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