



Institut
océanographique
Fondation Albert I^{er}, Prince de Monaco



Living with Sharks

**A Toolbox
to Combat Shark Risk**



"A better understanding of sharks, the technology available today and a collective effort to manage our activities, should enable us to share the ocean with sharks."

***H.S.H. Prince Albert II
of Monaco***

The Oceanographic Institute is pursuing its aim of bringing about a reconsideration of our relationship with sharks through the development of a toolbox.

The result of an animated exchange between international experts, This toolbox, result of an animated exchange between international experts, is designed for authorities and actors faced with the coexistence of human activity and potentially dangerous shark species, as well as all those affected by this risk or simply interested in cohabitation issues between humans and wildlife.

Reaching beyond the impasse we see in by the idea of confrontation between man and animals, it offers a wide range of solutions that are either already in existence or under development to address the risk and provide practical, proven or promising alternatives. It shows that an organised and peaceful cohabitation with sharks is now possible.

This effort to share the oceans with sharks must be at the forefront of a broader commitment to recognise the importance of these large predators and protect them through the strengthened supervision of their fishing.

Innovative solutions exist today to meet shark risk without decimating these animals that are essential to the health of the oceans.

Public authorities have a fundamental role to play to:

Develop our knowledge of the habits and peculiarities of sharks and enable a more relevant and appropriate analysis of the potential risk.

Clearly and transparently inform sea users of the risks they incur by implementing "shark forecasts" if possible.

Implement protection measures in certain areas (monitoring, human/shark separation, deterrent/repelling devices ...) to enable a peaceful coexistence with sharks.

Sea users for their part must adapt their practice and equipment to the natural environment in which they operate.

No solution can guarantee zero risk. The risk of sharks exists alongside other often more significant natural hazards (avalanches, diving, drowning ...). The risk should be taken into account when practicing activities in the sharks' environment.

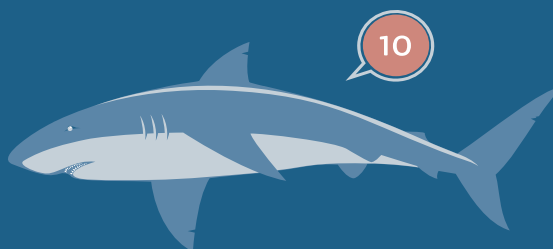
The real danger

The risk of a fatal shark attack is extremely low on a global scale, compared to other risks related to sports or other wildlife.

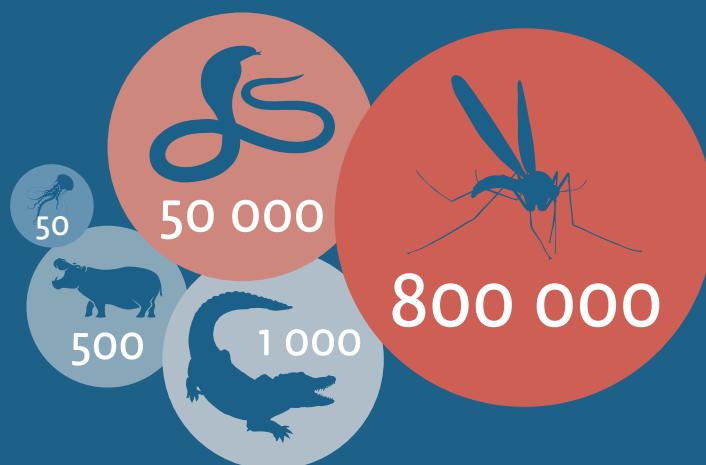
death too many and must impel us to find solutions to manage the risk.

Each attack however gets wide media exposure reinforcing the image of sharks as bloodthirsty monsters. Although this reputation is largely exaggerated, every death is indeed one

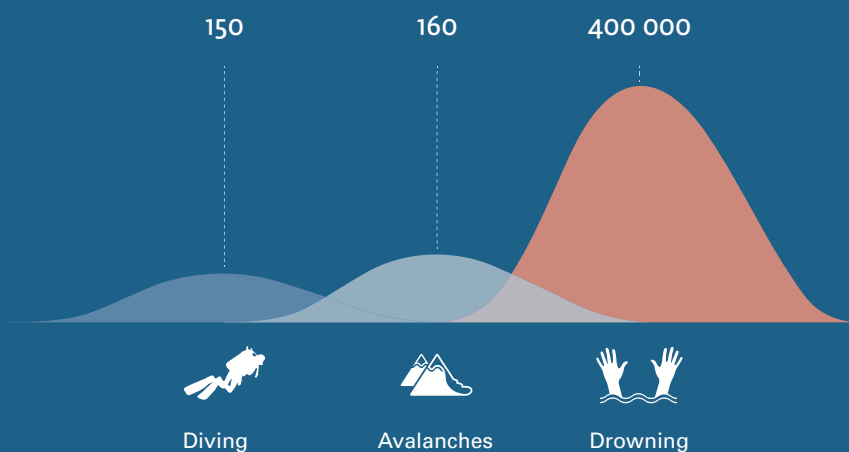
*Number
of deaths*



*Compared
to other animals*



*Compared
to other activities*

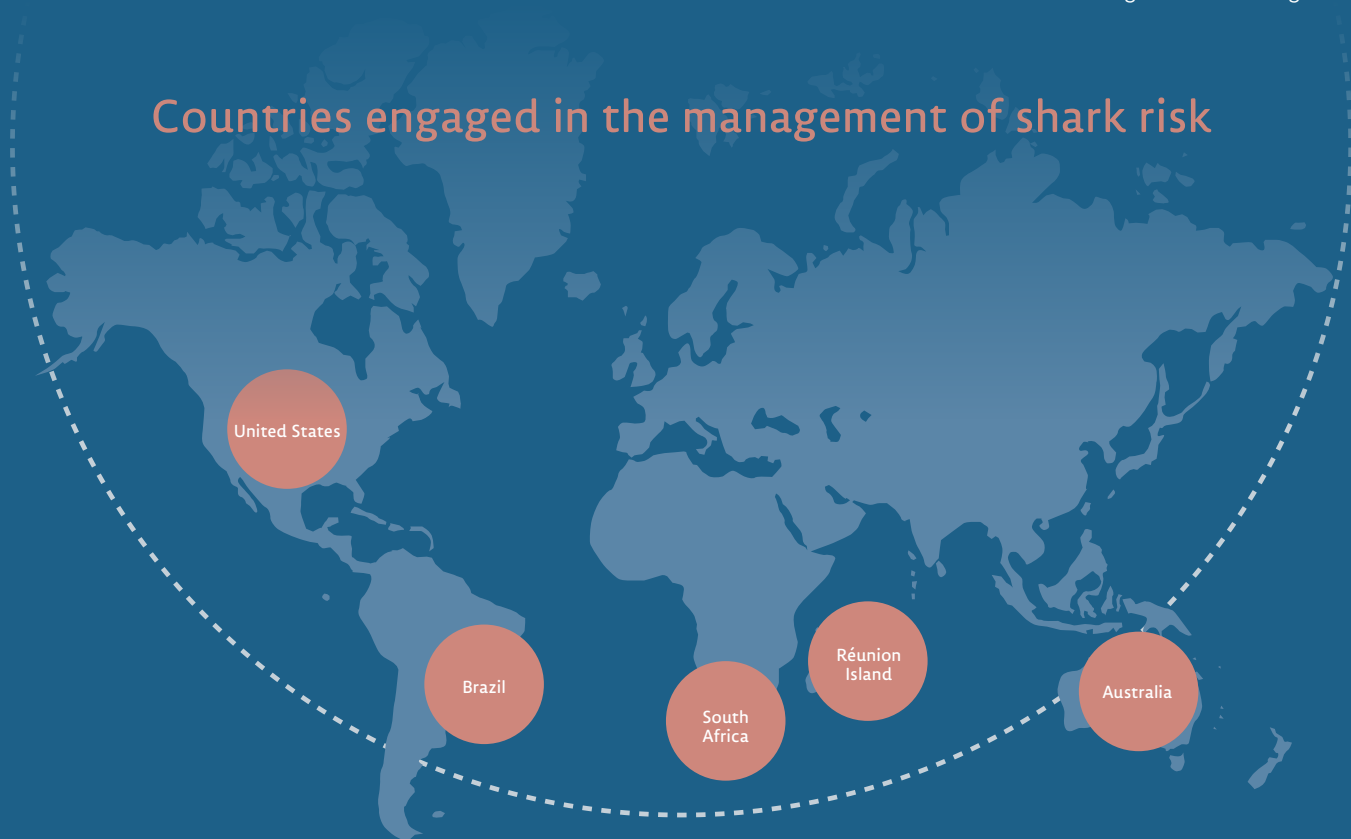


A localised risk

Most shark species do not pose a safety problem and are often tourist attractions, attracting divers. In most cases, humans and sharks live side by side in harmony.

However, in some specific areas, activities have developed where some species may present a risk. While the what specifically triggers attacks remains poorly understood, surfing is the most exposed activity, far ahead of underwater hunting and swimming.

Countries engaged in the management of shark risk



Great white shark



Tiger shark



Bull shark



Oceanic whitetip shark



Shortfin mako shark



Only five species of sharks out of almost 500 present a danger to humans, because of their size (greater than two meters) and their diet.

The great white shark, the bulldog shark and the tiger shark cause most accidents because they frequent coasts.

The shortfin mako and oceanic whitetip stay further offshore and rarely come into contact with humans.

Solutions exist to combat the risk of sharks

1 - Information

2 - Shark forecasts

3 - Search and alerts

4 - Shark lookouts

5 - Shark spotters

6 - Shark nets

7 - Individual deterrents

8 - Detection buoys

9 - Shark barriers

10 - Shark repellent cable



Shark Forecasts

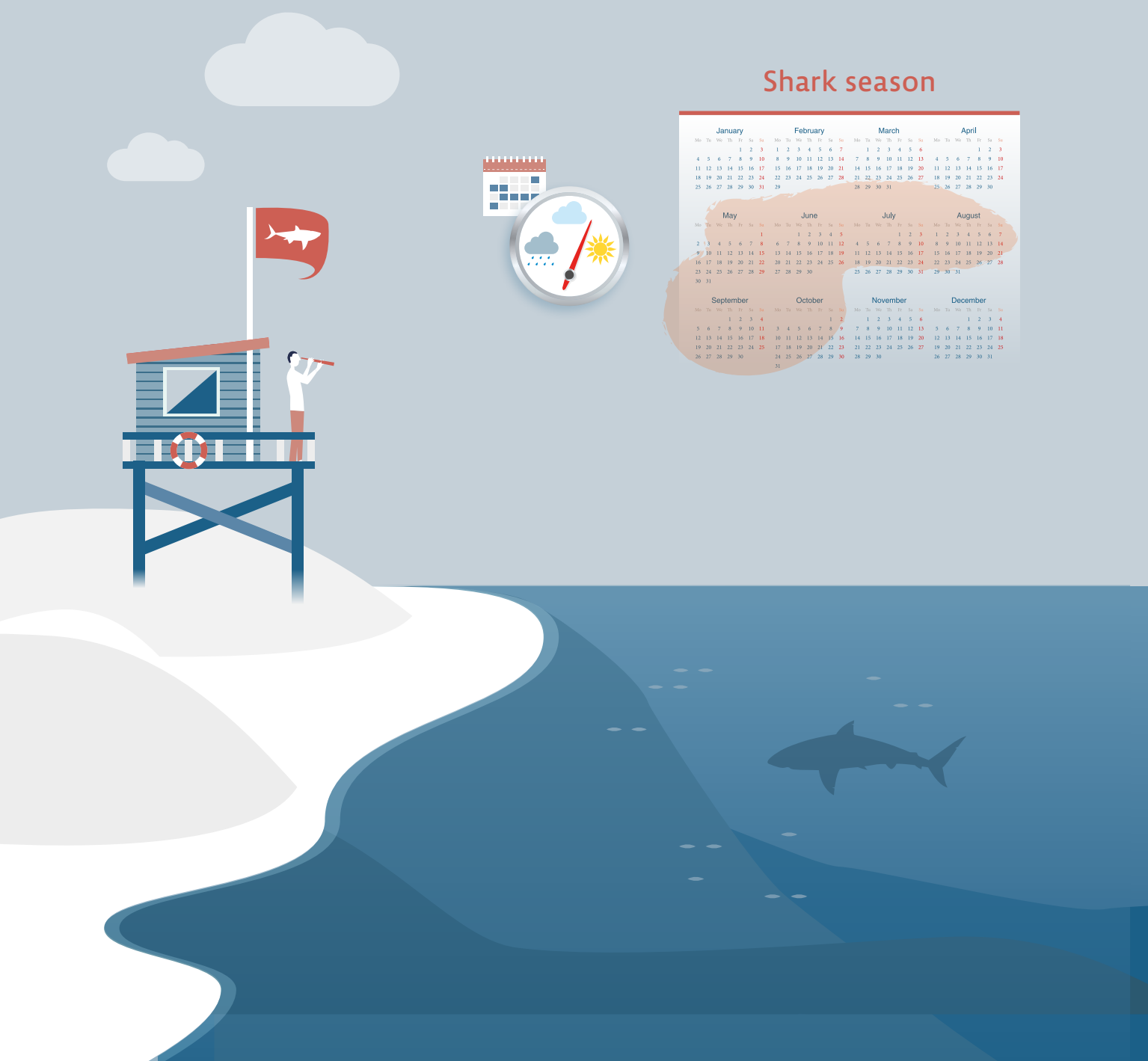
monitoring
and alerts

The principle

Strong winds, heavy rainfall, risk of avalanche ... Thanks to reliable and easily accessible forecasts, we are now accustomed to organising and even postponing our outdoor activities depending on weather conditions.

The risk of sharks could also be assessed locally, this would deter us from going into the water in the event of a particularly high threat. Knowledge of sharks is progressing and creating new perspectives.

Shark season



How it works

Research into the habits of sharks is very recent. However, some programs, such as CHARC, which focuses on bull sharks and tiger sharks in Reunion Island, are beginning to lift the veil by revealing some essential information: seasonal peaks, migrations as well as conditions favouring the movements of sharks near coasts (murky water, dusk ...). These factors help identify periods of increased risk, during which the most sensitive water activities (surfing, swimming) should be avoided.

"Shark forecasts" could be developed on the basis of these factors in order to trigger increased communication at particularly high risk times. Tougher sanctions against those who venture into the water at times of maximum danger in spite of the clear dissemination of information on beaches could be combined with this.

Even when conditions are "good", zero risk cannot be guaranteed - especially given the present state of our knowledge of sharks. "Sharks forecasts" should therefore only be used to raise alerts in case of increased danger.

As for security, this will only be significantly improved by collective protection systems or individual deterrents.

To function, such reports should be combined with local observations of the state of the sea (how choppy or turbulent it is ...) as well as observations on the presence of sharks. Such observations are the core of shark lookout services and can also be supplied by beacons detecting tagged sharks, emergency services and sea users. The setting up of such an observation and alert network will only

strengthen the effectiveness of this service.

The reliability of "shark forecasts" will then improve thanks to two factors: the integration of new knowledge on the behaviour of sharks and feedback from observations.

Shark Spotters

monitoring
and alerts

The principle

"Shark Spotters" is a program of visual detection of sharks and warnings, implemented to protect swimmers and surfers on nine Cape Town beaches (to date). The Cape area is known for its large

population of great whites, attracted by the colony of seals in False Bay.

The Shark Spotters service requires a high platform and clear water with a sandy seabed in order to identify sharks properly from

Flag warning system



High shark alert



Poor observation conditions



A shark has been spotted



Good observation conditions,
nothing to report



Shark Spotters

monitoring
and alerts

How it works

Thanks to the steep terrain of the coast, the lookouts are positioned on observation posts located 100 meters above the bay. They use binoculars to observe coastal waters during the day 7 days a week.

A flag system has been set up to warn sea users of the presence of sharks as well as a procedure to ask users to get out of the water and help them get out if necessary. The lookouts placed on the platforms communicate with other Spotters on the beach, who raise the corresponding flags and warn bathers. A rapid intervention team is on hand in case of accidents.



The observation conditions, which depend on the state of the sea, are specified to inform users of the reliability of the service.

The program was created in 2004 by surfers in the area: Greg Bertish, with the help of Rasta Davids and Monwabisi Sikiya and that of Dave and Fiona Chudleighwas, the owners of Surf Shack. It was then adopted by the City of Cape Town. This program is 80% financed by the local government, 15% by NGOs, and the rest by local companies and now employs 15 to 20 observers. Since its inception, it has helped record and monitor the status of the sea, the number of sharks and the number of users in order to improve understanding and knowledge of the behaviour of sharks according to weather conditions.

Important note: the Shark Spotters warning system has proved effective in Cape Town with hundreds of observations of sharks already recorded. However, it has to deal with hazards related to weather, the state of the sea or human error. Every individual user must understand and accept the risks associated with the activities they take part in in the sea.

Species concerned

Great white shark
identifiable in shallow waters as it swims close to the surface.

Location

**South Africa
Cape Town**



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Shark Sentinels

monitoring
and alerts

The principle

Shark Sentinels, a concept developed in Reunion Island, are freediver Sentinels who accompany surfers and secure a site at a particular time. By underwater monitoring, these shark sentinels can detect any shark presence and raise the alert.

In most cases, their mere presence in the water is enough to keep the sharks away from surfers.



How it works ?

The service helps secure a surf session (training, competition) for the time of the session.

Before the session, the sea conditions are strictly assessed, in particular vertical and horizontal visibility. If visibility is not sufficient to ensure the effectiveness of the service and the safety of the divers, the service is not used and the session is cancelled. If conditions deteriorate during the session, it is terminated.

The freediver sentinels are deployed in pairs around the spot to be protected. A boat serves as a communication relay and is on hand in case of emergency.

As bull sharks and tiger sharks are quite shy, the mere presence of freedivers under the water generally keeps them at a distance.

If a shark is spotted, an alert is immediately raised and relayed by the support boat. The session is suspended and the spot is evacuated.

The freedivers are supplied with a shark stick intended to keep away any sharks that are too curious.

The shark sentinels are also involved in prevention and awareness raising regarding "shark alert" among sea users.

Since spring 2015, tens of training sessions have taken place with the protection of shark sentinels. No sharks have been spotted to date during these sessions. This suggests that strict constraints regarding sea conditions, including good a high degree of luminosity and very good visibility combined with the presence of divers moving under the water, can prevent the presence of sharks. This must, however, be confirmed over time and the shark sentinels mission

remains vital.

However, the level of human resources required limits this service to occasional use. To date, it has only been used for youth training schools Reunion Island competitors. It should eventually allow competitions to be organised again under safe conditions.

Species concerned

- Bull shark
- Tiger shark

Location

Reunion
Surf spots on the west coast.

Contacts

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Nicolas Berthe
Head of the FFS regional technical team

Detection Buoys

monitoring
and alerts

The principle

New technologies now allow us to raise alerts in real time. Detection buoys are placed along the coast to identify the presence of sharks.

The information is then instantly transmitted to the emergency services and directly to the public via mobile applications (texts, applications, social networks, etc.).



Detection Buoy

How it works ?

Buoys are placed along the coast in the areas to be monitored. A detection system, using sonar or otherwise, placed on the buoy or attached to the seabed, recognises the shape of a shark swimming nearby.

A signal is then sent directly by mobile network to the local authorities, who can inform the public (via a flag system for example) as well as directly on social networks.

Such systems are currently under development (Clever Buoy for example).

Submerged receptors already exist for detecting nearby sharks that have been tagged previously. These devices are generally used for studying the behaviour of sharks and recording detections.

An Australian experiment carried out by Surf Life Saving in Western Australia, aims to communicate real-time detections on Twitter.

Sea users are thus informed instantly of the presence of a shark (including its size and species). However, to date, only tagged sharks are recognised.

Species concerned

- Great white shark
- Bull shark
- Tiger shark

Location

Bondi beach, Australia
Clever Buoy Test

Western Australia
Twitter alert

Electrical Deterrents

individual
solutions

The principle

Electrical deterrents are individual devices that emit an electrical field that is unpleasant for sharks, thereby keeping them at a distance.



How it works ?

Electrical shark deterrents are small devices that can be fitted on sports equipment. They consist of a box containing the electronics and two electrodes which diffuse an electrical field in the water.

Sharks are sensitive to electric fields thanks to their Ampullae of Lorenzini, special electro-receptor organs, located in the muzzle. The electric field transmitted is very unpleasant to them and deters them from approaching.

The first electrical deterrents, called Shark Pods,

were developed in South Africa at the end of the 1990s.

Today different versions exist. They can be attached to the ankle of an underwater hunter, scuba equipment or surfboards.

Note

The fields generated by several individual devices can be combined to reinforce protection. Electrical barrier systems are now being tested to create collective protection of zones.

Manufacturers

Shark Shield Pty Ltd

Lindsay Lyon, CEO

Aquatek Technology Shark Repelling System

Yves Eeckhout, CEO

Outsmarting Sharks' Senses

The principle

Sharks have seven sharp senses. For example they sense vibrations and electrical fields in the water, precious indicators which give them information on their prey.

The techniques tried in the past were not proven effective or practical, but recent attacks have triggered a new wave of research and development.

Many ideas have been considered and tested since the mid 20th century to foil these senses and escape their attention through concealment or the disruption of their senses to divert their attention.



Biomimetic camouflage

Various products are in development or launch phase, but their effectiveness is still difficult to evaluate given the variety of species of sharks, the conditions noted at the time of accidents and the low rate of attacks.

Suits or boards reproduce colours and patterns, such as sea snakes, that naturally repel sharks, or colours that make surfers or divers inconspicuous in the waves.

Chemical repellents

Chemical repellents tested at the beginning of the 20th century by the US Navy were inconclusive and probably disrupted the marine environment.

Sharks do not like the smell of their dead fellows. Since 2001 Shark Defense Technology has been developing repellents that reproduce the smell of death synthesised, from the chemical analysis of dead sharks.

This technology can be used by individual divers, in the form of repellent sprays, or during fishing operations, attached to the longline, producing a 75% decrease in catch rates of sharks in some cases.

Magnets

"Improved" hooks represent another line of enquiry to prevent bycatches by fisheries. Galvanic currents generated by the soluble metal of hooks affect sharks' Ampullae of Lorenzini (bony fish do not have them).

Electropositive metals could also be used in combination with systems which separate sharks from swimming areas.

Sound and light

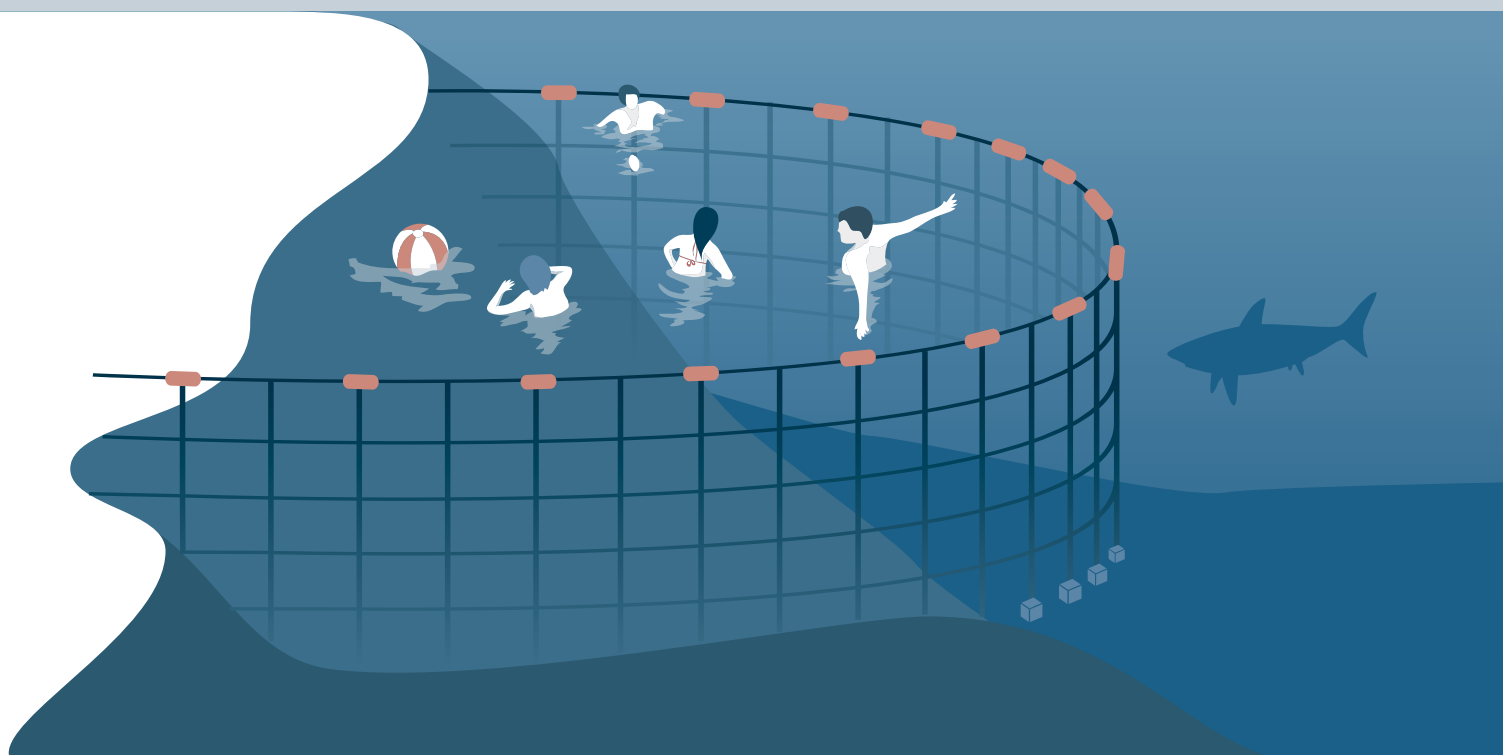
A pistol that uses ultraviolet flashes and noise to scare sharks is undergoing development by Deardeck. It is designed for individual swimmers, divers and surfers.

Shark Nets

The principle

Shark nets are not fishing nets, but form a physical barrier to prevent sharks entering a secure area for swimmers, surfers and sea users.

They close off the area completely, preventing sharks from entering. They are designed to prevent sharks and other marine animals from getting entangled and prevent damage to the environment.



How it works ?

Shark nets surround the swimming area entirely, from the sea floor to the surface. These nets have a wide mesh that mean sharks and other marine species are not captured or trapped as they often were in old anti-shark nets (turtles, seals, dolphins, rays ...).

They mark out a fully secured area, without damaging the environment. However, the protected area is typically limited and it can be difficult to use this system to protect deeper surfing sites that are subject to waves.

The nets are subject to the movements of the sea and must be checked regularly. Maintenance and implementation costs can therefore be significant.

In areas subject to harsh weather conditions, they are generally used every day as in Cape Town, for example; in more stable areas, they are regularly inspected (weekly) by divers as in Hong Kong. The deployment of shark nets remains dependent both on weather conditions and whether there are large marine mammals in the area (they can get tangled up in the nets or disorientated by them).

Species concerned

All shark species

Small mesh nets are also used against stinging jellyfish (mauve stingers - pelagia noctiluca - in the Mediterranean, for example) or jellyfish with fatal stings (notably box jellyfish in Australia in particular).

Locations

- Hong Kong
- Seychelles
- Fish Hoek Bay, Cape Town, South Africa

Shark nets have been set up on some beaches and surf spots in Reunion Island since late 2014 / early 2015 (Saint-Paul).

Shark Repellent Cable

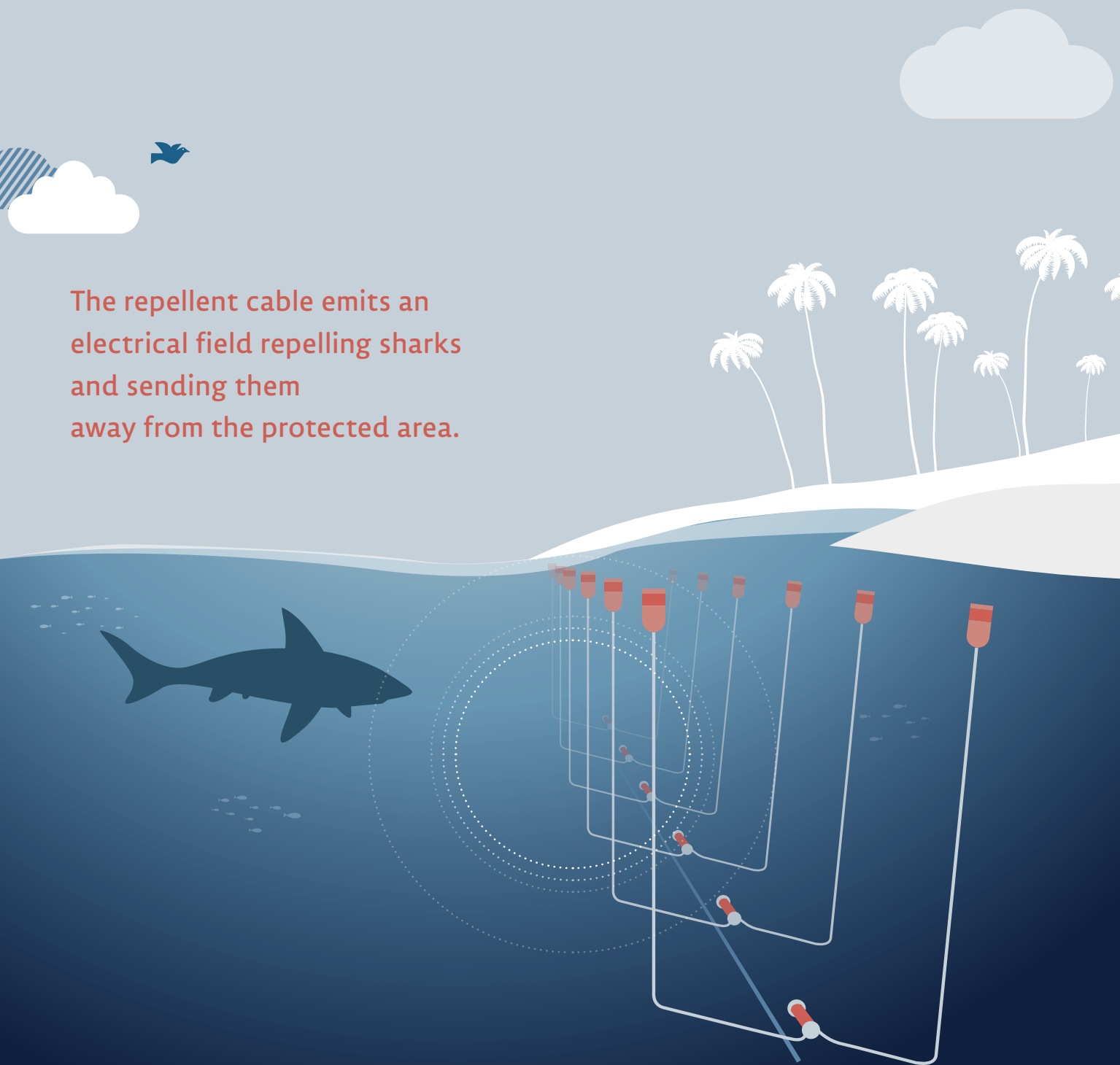
collective
protection

The principle

The repellent cable emits a radiation field of electrical pulses that repel sharks (without harming them) from areas frequented by bathers. The cable is usually run in the sea in front of the beach or place to be protected.

This solution is currently undergoing development and testing in South Africa, by the KwaZulu-Natal Sharks Board.

The repellent cable emits an electrical field repelling sharks and sending them away from the protected area.



Shark Repellent Cable

How it works ?

The cable includes several risers that emit low frequency electrical pulses which affect sharks' electro-receptor organs (Ampullae of Lorenzini).

This uncomfortable feeling repels them from the protected area.

This solution, based on experience acquired with individual electrical field devices, works more particularly well on great whites and can create a collective protection bathing or surfing areas.

Such a cable could become an alternative to shark nets to ward off sharks from recreational areas without harming marine life.

Tests are currently being conducted in calm sea to verify the effectiveness of this solution. The feasibility of this system in more turbulent surf spots has yet to be established.

Species concerned

- Great white shark
- Bull shark
- Tiger shark

Location

South Africa

(in Cape Town the current test site for great whites).

It will also be necessary to carry out tests in tropical waters to test for effectiveness against bull sharks and tiger sharks.

Contacts

KwaZulu-Natal Sharks Board

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Cable technology: Claude Ramasami

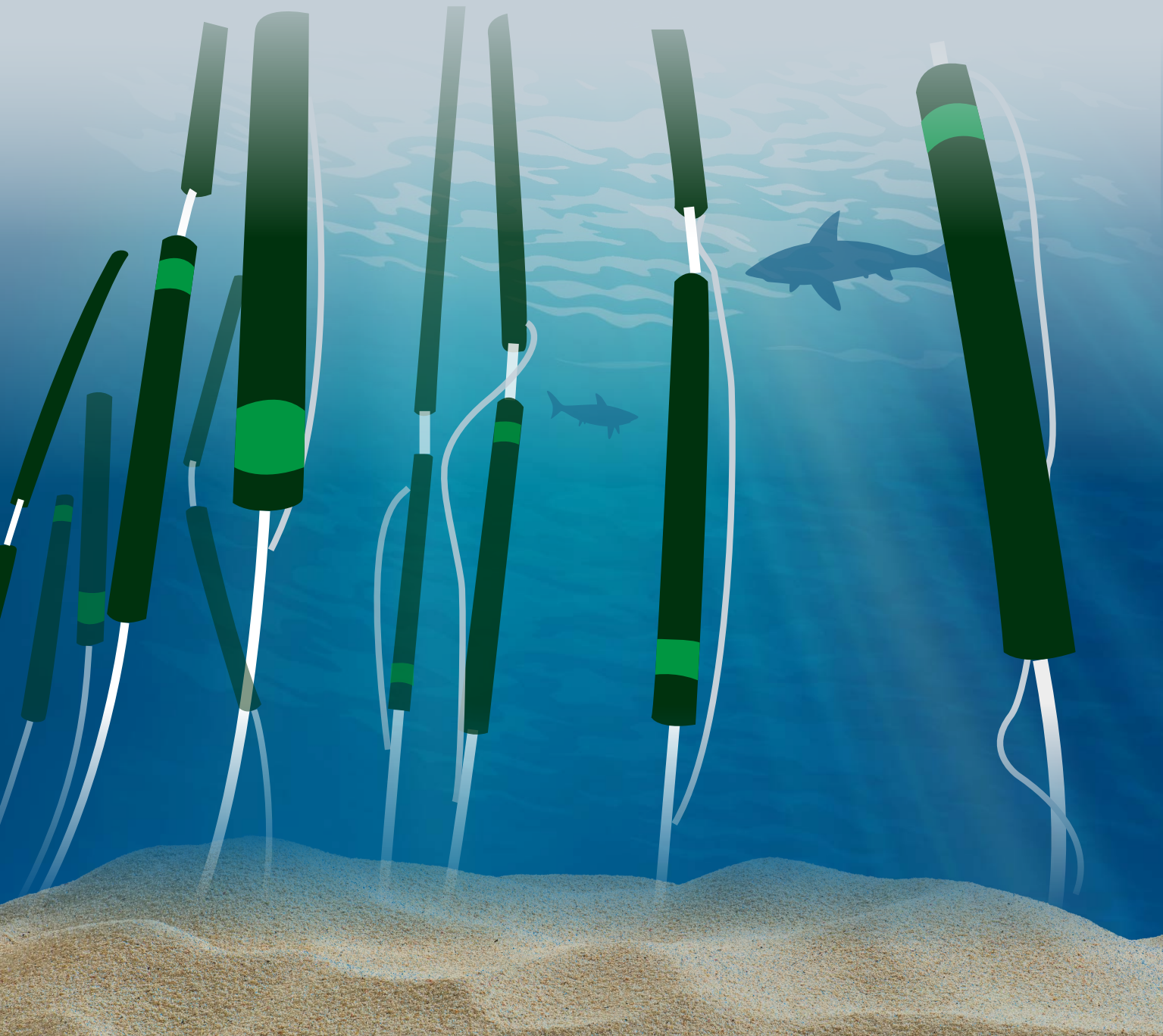
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Shark Barriers

The principle

Shark barriers simulate orests of kelp (a large vertical laminar seaweed), which great whites do not like to enter.

The objective is to create an ecological barrier between sharks and sea users, by placing these barriers around frequented beaches.



How it works ?

Scientific research indicates that some shark species, including great whites, generally avoid entering kelp forests.

The shark barrier mimics the vertical structure of these forests. It consists of several columns, made of tubes attached to each other, floating vertically in the water.

These columns are made from a material that is easily colonised by various organisms. The plastic tubes contain high density foam to ensure flotation.

Magnets are also arranged over the entire length of the column to add another repellent effect to this barrier. They specifically disturb sharks' electro-sensory systems.

Other marine animals (e.g. seals) can swim through without getting tangled.

This measure is currently being tested. It was deployed for the first time in 2012 in "Shark Alley", in Gansbaai in South Africa.

Species concerned

Great white shark

Location

South Africa - Cape Town / Gansbaai

Contacts

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Dr. Conrad Matthee and Sara Andreotti

Stellenbosch University

Michael Rutzen

Shark Diving Unlimited

Eliminating Sharks

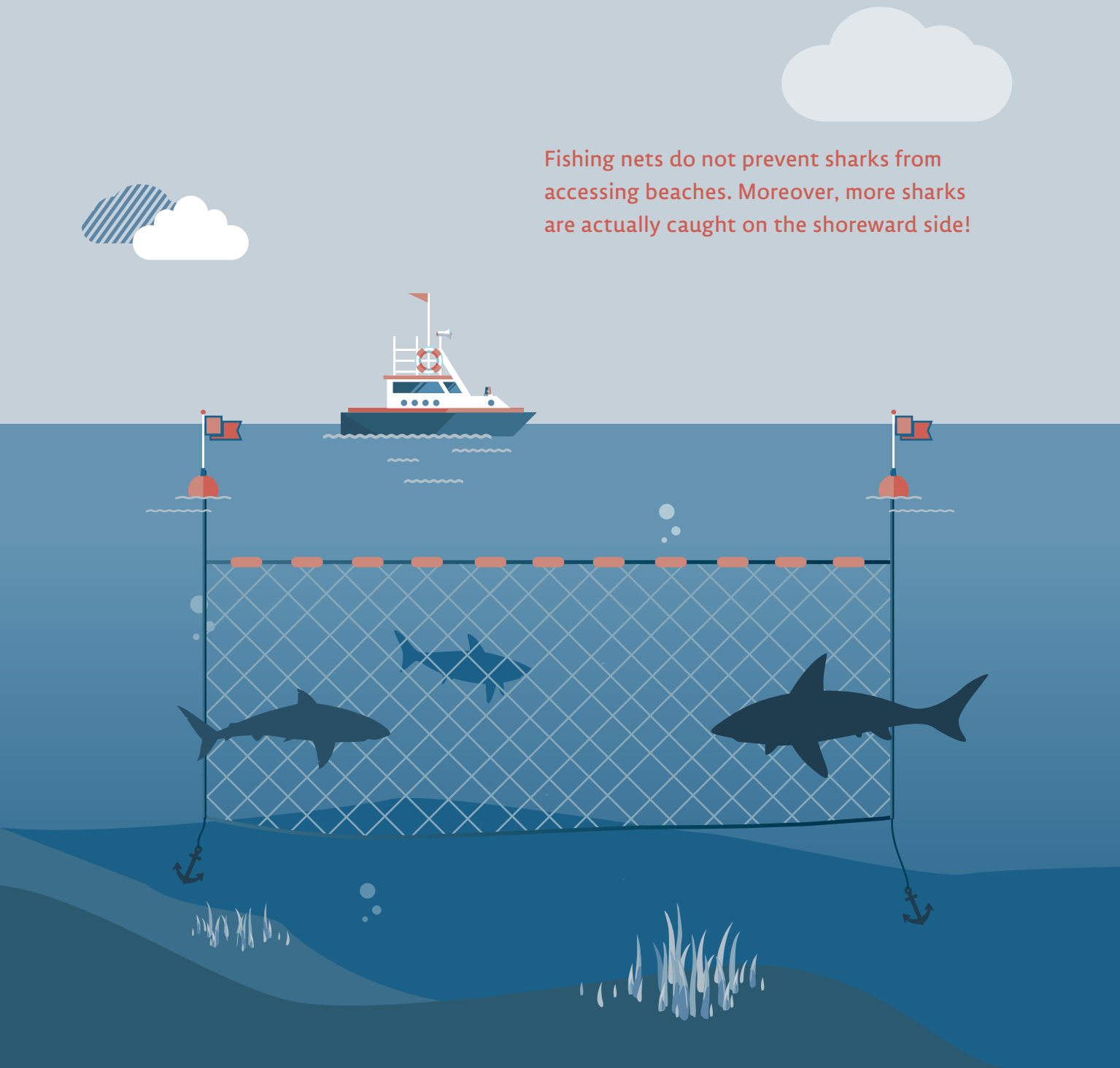
TO BE
AVOIDED

An outdated objective

In the early 20th century, the development of tourism was accompanied by a few shark attacks in some tropical regions. In response, various countries, such as South Africa set up local permanent shark fishing systems to eliminate dangerous species in areas frequented by man. Two techniques were used: the gill net and baited line.

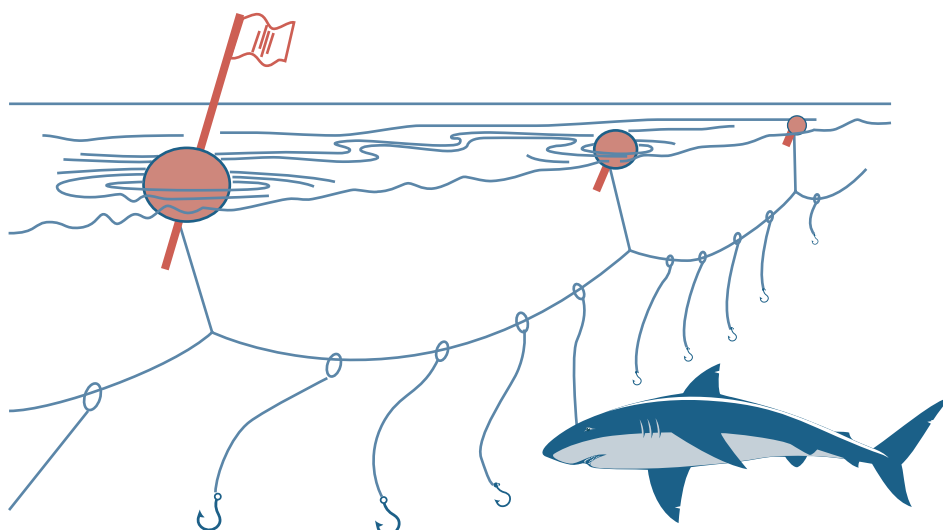
They had a significant environmental impact. Bycatch was frequent, including catches of vulnerable or endangered species: harmless sharks, but also turtles, rays and marine mammals were decimated.

Fishing nets do not prevent sharks from accessing beaches. Moreover, more sharks are actually caught on the shoreward side!



Eliminating Sharks

TO BE
AVOIDED



A baited line that attracts and catches sharks.

Towards targeted removal

Today, the eradication of dangerous sharks is still practiced to reduce the risk of attack statistically. Faced with growing environmental concerns, research has focused on elective removal, targeting potentially dangerous species and even individuals.

Longlines or baited lines are now preferred to gill nets because they allow greater selectivity.

Many bycatches do however take place, which has led researchers to develop “intelligent” longlines: when an animal is caught, a surveillance team is alerted and quickly arrives on site to decide whether to release the animal or remove it from the sea. This system is being applied in the CapRequins programme in Reunion Island. In its latest version, it allows bull sharks and tiger sharks that are too small to be dangerous to be released after being tagged. The objective is to remove only the individuals of both species that are large enough to be directly harmful.

Where to draw the line?

Even the improved and selective removal of sharks disturbs the balance of marine ecosystems. It is based on a principle of confrontation with nature and the elimination of any dangerous animal, while many other dangers, including those of human origin, are much more significant for man.

And the principle itself raises questions:

Is it possible to take local action against sharks? Recent research highlights the mobility of sharks. So localised fishing in a watersports area risks take a toll on a much wider population of sharks.

What would be the corresponding shark population and intensity of fishing that would need to be applied? There's a strong temptation to push fishing regulation as far as eradication.

It is difficult to envisage applying this approach to an endangered species like the great white. Even when it comes to species of shark that are not threatened at world level, can regional decimation be accepted?

Programme Cap Requin 2

<http://www.info-requin.re>

Expert Workshops Organised by the Oceanographic Institute

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1st Sharks Workshop

Expert Workshops Organised by the Oceanographic Institute

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Participants in the 2nd Sharks Workshop with H.S.H. Prince Albert II of Monaco



2nd Sharks Workshop: major outcomes

20 international experts gathered together with H.S.H. Prince Albert II of Monaco at the end of 2014 to discuss, compare and evaluate existing measures or pending developments to meet the risk of sharks.

Solutions combining improvements in safety and respect for the environment do exist

1. Many innovations have proven their effectiveness in the long term. An in-depth knowledge of sharks is always critical to their proper implementation.
2. Technological advances are opening new perspectives in the reduction and management of shark risk: individual repellents, zone protection, detection and warning systems. There is still significant potential for innovation.

3. There is no single transposable solution. Systems used must be adapted to the local situation (geography, species present and their habits, as well as the social context).
4. A steady, continuous effort must be made over time, regarding both information and protection measures. Discontinuity in terms of measures taken affect short-term safety and undermine the credibility of these measures.

Inform in order to engage

1. The public must be clearly informed of the presence of sharks and any preventive actions put into place. This access to information will allow all every person to measure the danger and take responsibility, as they do in any activity deemed to carry risk.

2. Appropriate information is more likely to be heeded. A better knowledge of sharks may help to refine the evaluation of risk, to the point of allowing us to set up shark forecasts, taking into account the season, climatic conditions, the state of the sea and recent observations.

Building solutions together

1. Local stakeholders are important contributors to risk prevention policy.
2. The issue of sharks often reveals different perspectives on the relationship between humans and nature, and can also be exacerbated by social concerns which go far beyond the issue of sharks (e.g. economic crisis, tensions between communities ...)

3. The dialogue between public authorities, sea users and scientists must take place as early as possible to promote dialogue and the involvement of all.
4. The message must be adapted to different groups and preferably passed on from the scientific community and policy makers by local intermediaries.

A collective commitment

1. Shark risk management is an overall strategy and requires teamwork: research, prevention (risk assessment, collective protection systems, monitoring, alerts), rescue, communication, education, community action ...
2. Risk prevention and shark research should be conducted jointly.

3. To better manage shark risk, we can learn from the long experience acquired with other natural hazards (avalanches, drowning, etc.).
4. Strategic and technical collaboration must be reinforced at an international level, between the experts and the authorities of the different regions.

Sharks, So Misunderstood!

For two years, the Oceanographic Institute's "Sharks, So Misunderstood !" programme has been trying to change the public image of sharks by reminding us that:



Participants in the 2nd Sharks Workshop with H.S.H. Prince Albert II of Monaco

1. Sharks are not the bloodthirsty monsters our popular culture them as. There is a risk, but it's very limited.

2. Sharks today are under threat worldwide through overexploitation. Nearly 100 million sharks are caught each year and 90% of sharks have already been eliminated.

3. Sharks are essential to the balance and vitality of ocean ecosystems by regulating the populations of many other species.

The Oceanographic Institute seeks to promote a peaceful coexistence between men and sharks, including in the rare event that sharks present a risk to humans.

"We have to explore all lines of enquiry to combine the safety of inhabitants and the preservation of sharks"

Robert Calcagno
CEO of the Oceanographic Institute

For over 100 years, the Oceanographic Institute has been working to increase awareness of the richness and fragility of the oceans and promote their sustainable management and protection. To do so, it mediates between scientific and socio-economic actors on the one hand, and the general public and key decision makers on the other with the aim of increasing "knowledge" love and protection of the oceans".

Its major programmes question the relationship between man and the environment through the case of emblematic species or environments: the Mediterranean, the deep sea, sharks, jellyfish and turtles.

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