



Edited by
Michael Symes

...the ability of water to transmit sound waves is of great importance for marine organisms enabling them not only to investigate their immediate environments but also to communicate.

Text by Michael Symes



detect movement; this includes both plants and fishes (see Xray-mag.com #10 for the detection of movement by fish). All these forms mostly function over short distances of the order of centimetres, although chemical signals, such as blood can also be detected over relatively large distances, tens of metres, by sharks, for example.

Water, as we have previously seen in this magazine, has many properties that have been utilised by terrestrial organisms. One of them, the ability of water to transmit sound waves, is of great importance for marine organisms enabling them not only to investigate their immediate environments but also to communicate.

Noise

Standing on the seashore one would never know the amazing amount of noise to be found below the

surface of even an apparently quiescent sea. Noise is created by the surf and winds, of course, but a large amount is created by humans with their boats such as the big oil tankers. In a minor way, countless divers going about their professions or hobbies also create noise. It is not generally appreciated, though, that fish, whales, and even crustaceans, create an amazing amount of noise underwater.

However, when we speak of noise we must be careful to distinguish between what we generally call noise, which is just what it says, an indiscriminate inharmonious muddle of sound, and a useful sound signal, which can be used for communication.

For those animals living above water, it is the sense of sight and,

to a lesser degree, hearing, that functions over great distances. Vision can be unlimited in its reach (we can see to the edge of the universe) while sound can be detected over several thousand kilometres after volcano explosions. And so it is with aquatic creatures, although vision can often be limited to a few metres by conditions in the water. Thus, it is mostly the sense of hearing that functions as a means of long distance communication under the surface of the oceans, whales appearing to be able to communicate using sound over distances of thousands of kilometres.

The aquatic organisms that use sound for communication, in its broadest sense, are the fishes and the aquatic mammals. These, however, emit, detect and use sound in fundamentally different ways. So, this article will only discuss the use of sound by the aquatic mammals leaving other marine creatures to be discussed in a subsequent article. However, before describing these ways, we must first look at what is meant by sound in water.

Sound transmission in the Ocean

Sound, as most people will know, consists of varying longitudinal pressure waves transmitted by a medium. Sound can be described by four parameters:

c - Speed	unit
λ - Wavelength	ms ⁻¹
v - Frequency	m
I - Intensity	Hz
	Wm ⁻² .

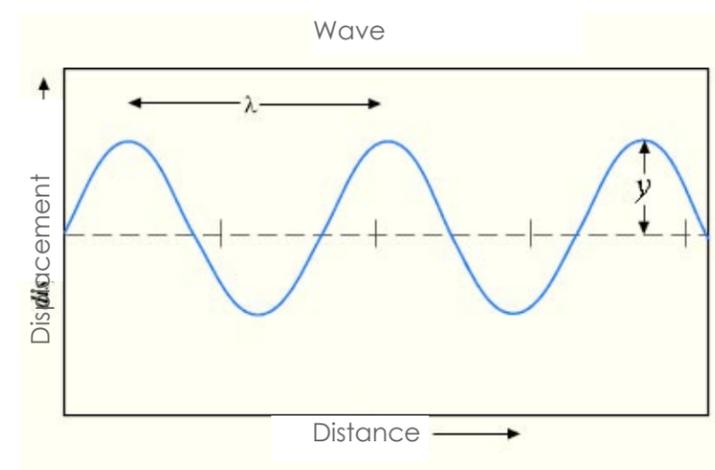
1 Hz is one cycle per second. The relationship between c, v and λ is given by the simple relationship:

$$c = v \lambda \text{ ms}^{-1}.$$

Loudness, a subjective perception, is a function of the wave intensity, which itself is a function of (amplitude)², (frequency)² and speed, and the sensitivity of the hearer to the given frequency.

The speed of sound depends on the medium through which the waves propagate. For example, the speed of sound in air at 18°C is about 331 ms⁻¹, and about 1524 ms⁻¹ in sea water at the same temperature i.e. about five times faster.

Due to the wave energy being converted into random energy in the molecules of an imperfectly elastic medium, the sound becomes attenuated. Attenuation is much less for water



λ = wavelength
y = amplitude

SOUND

Cetacean communication & the Harmonious Humpback



than air making water an efficient transmitter of sound. This makes it very useful as a tool for marine creatures.

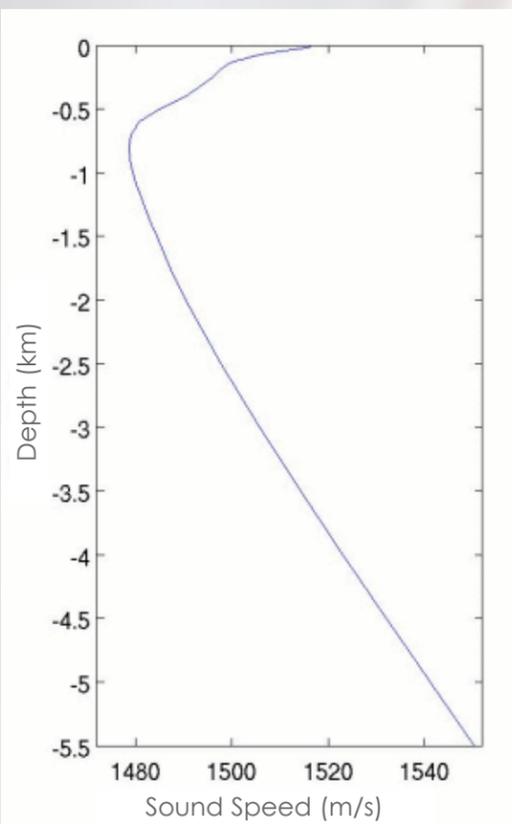
Humans can detect frequencies between about 20 Hz and 20000 Hz, with the maximum sensitivity being at about 1000 Hz, which is about two octaves above middle C on the piano. A frequency of 1000 Hz corresponds to a wavelength of about 33 cm in air and 1.5 metres in water.

The speed of sound in water, like that in air, is determined by a number of factors, such as temperature and pressure. As the temperature decreases so does the speed of sound in water. The propagation of sound in sea water can be affected by its salinity and also by particulate matter that can scatter or absorb the waves.

As pressure and temperature change with depth in the oceans so does the speed of sound. A temperature gradient exists when the temperature of the water decreases with increasing depth, called a thermocline. However, at a depth of about 750 metres the water temperature becomes essentially constant so that the speed of sound becomes more a function of changes in pressure due to depth. This can give rise to special effects when specific combinations of temperature, pressure and salinity occur. Among these are the formation of the SOFAR channel.

The SOFAR Channel

Because the transmission speed of sound is proportional to pressure, the speed of sound increases with depth, which is opposite to the effect of the thermocline. Therefore, at the interface of the thermocline and the depth at which the temperature becomes constant, a region exists at which the speed of sound is a minimum. From the equation $c = v\lambda$ it can be seen that for a constant wavelength λ the frequency v is proportional to the speed c .



Sound speed as a function of depth derived from the 2005 World Ocean Atlas. The SOFAR channel axis is at ca. 750 m depth

Therefore, at lower speeds the frequency is lower. A channel is thus created within the oceans, which permits the transmission of low-frequency sound over thousands of kilometres. This channel allows long distance sound fixing and ranging (SOFAR) and was discovered in 1943 by both the Americans and the Russians.

Being a function of the depth and of the extent of the thermocline the SOFAR channels are closer to the surface in the colder northern waters. Due to the shape of the

SOFAR channels sound waves can become trapped in them and, as they are travelling at minimum velocity, lose little energy as they progress. This permits them to travel distances of up to 25,000 kilometres. It is claimed that some whales utilise the SOFAR channels for mating calls over great distances (see figure).

As stated above, sound has been employed as a very useful tool by many aquatic creatures. However, it is the marine mammals that have made the great-



- (i) the **cetacea** i.e. the whales, dolphins and porpoises
- (ii) the **pinnipeds** i.e. the seals, sea lions and walrus
- (iii) the **sirenia** i.e. the dugongs, manatees and sea cows

All of these mammals produce sound signals, with the seals and sea lions producing great growls and roars. However, it is perhaps the cetacea that are of the greatest interest when discussing sound and communication beneath the waves as they can produce echolocation clicks, beeps and even songs.

est and most sophisticated use of sound as a means of communication.

Marine Mammals

There are three orders of mammals that have evolved independently and adapted to life in the sea.

The cetacea

There are over 80 species of cetacea which can be divided into two subgroups, those of the

In the past, the tree of life was constructed on the basis of similarity of morphological features. The more similar two species looked, the more closely they were thought to be. But looks can be deceptive. This became abundantly clear more than a decade ago, when molecular biologists began comparing small numbers of genes from various organisms and found that many species were not what they appeared. Hippos, for example, were once thought to be the kissing cousins of pigs, but genetic evidence revealed their closest relatives to be the cetaceans (whales, dolphins and porpoises).

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suborder *mysticeti* (the Baleen whales), a group of 12 species containing the great Blue whale, the Right whale and the Humpback whale; and the suborder *odontoceta* (the toothed whales), a group of about 70 species containing the Bottle-nosed dolphin, the Sperm whale and the Killer whale.

All of these aquatic mammals produce sound. For example, the Blue whales produce very low frequency sound in bursts of 10 to 15 seconds of about 40 Hz i.e. they are bass singers. On the other hand, the Beluga whale is known as the sea canary, having a much greater singing range from 1.5 kHz to 60 kHz. It could perhaps be considered the soprano of the aquatic world except for the fact that it is only the males who sing. Other aquatic mammals have different frequency ranges and melodies. For example, the Bottlenose dolphin uses a large range of frequencies between 7 and 15 kHz to emit clicks and whistles. And among the pinnipeds, the



vocalisations of the Weddell seal have a frequency range from 100 Hz to more than 70 kHz, emitting a large number of warbles, trills and chirpings.

It is the male Humpback whale, though, that is the most prolific singer of them all.

The Humpback whales

The male humpback whales sing the longest, loudest and most complex songs, with repeating themes, and they can last for more than half an hour. They are the most musical of the whales with a frequency range of from 20 Hz to 8000 Hz. These songs can be heard thousands of kilometres away, especially if a SOFAR channel is used.

The songs can be very different, depending on location, although they are only heard on the breeding grounds. For example, the whales of the North Pacific sing quite differently from those of the North Atlantic. And even within a given area, there can be dialect differences. The songs also change over time and are therefore different from year to year.

The production and perception of sound by Baleen whales

This is still an ongoing area of research. With regard to the

location of the source of the sounds, it is known that the nasal plug and nasal sac system move when sound is produced. Baleen whales do have a larynx but it lacks vocal chords, and furthermore, unlike humans, whales do not have to exhale to produce sound. However, the mechanisms of sound production are still unclear.

Like terrestrial mammals, whales have an outer ear, but this tiny opening closes underwater. However, there is a very sensitive reception of vibrations through the bones of the head. The perception of these vibrations is via the bone structure of the middle and inner ears. This structure is a modification of that of the terrestrial mammals, which of course the whales once were millions of years ago.

Other sounds

Not only do these whales use their "voices" to make sounds, they can also signal

by slapping their flukes and flippers on the surface of the water. It seems that this is also a form of communication between Humpback whales.

Otherwise, if you would like to hear some of the whale songs for yourself then *Songs of the Humpback Whale* is recommended. This is an audio CD available at Amazon.co.uk, costing GB£9.98. This has had excellent reviews. **Direct link**

What is this signalling used for?

It is reasonable to ask what is the use of this communication, if it is such. Seen from the point of view of evolution, it must obviously be an advantage.

As mentioned above, the songs are heard only on the breeding grounds, generally during breeding times, and it therefore seems to be safe to conclude that they are connected with breeding behaviour. The songs are apparently used to court females and to frighten off male rivals. As the oceans are so big, perhaps the songs are used to attract suitable females from afar; or perhaps, like the songs of birds in the Spring, they are to stake out a territory.

Interestingly, it has been observed that there is a clear resemblance between whale songs and, for example, some of the sounds produced by elephants. Obviously, we are still in great ignorance about the "languages" of animals and how they communicate.

Echolocation

When sound from a whale is reflected back from a solid object, an echo is created, which can be perceived by the

It is interesting to note that even aquatic mammals display the same right handedness as humans, of whom some 90 percent are right handed. To quote from a recent book, *Right Hand, Left Hand*, by Chris McManus, on the origins of asymmetry in brains, bodies, atoms and culture: "Humpback whales like to slap one of their two flippers on the surface of the sea, and for three-quarters of them it is the right one that they choose."

whale. The sound is emitted as a series of clicks, and the whale listens for the reflected echoes. The time it takes for the echoes to return tells the whale how far away the object is. Whales are able to resolve the sound down to 0.1 m/s which, at a speed of sound of 1500 m/s, corresponds to a distance of 15 cm. It is a useful

tool for when visibility is reduced in turbid waters.

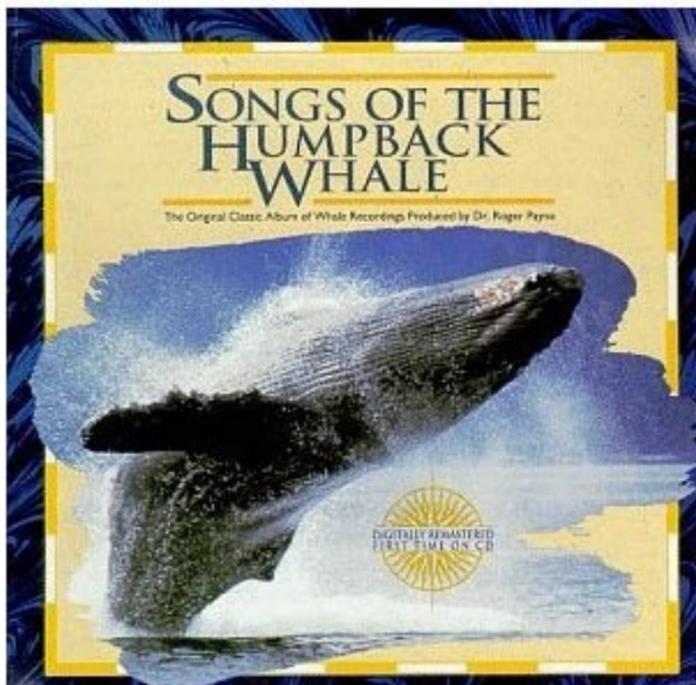
Some whales, the odontocetes, hunt prey using echolocation, with some species showing the ability to herd and capture their prey.

Effects of human actions on the underwater environment

It has been established that large noises in the oceans can seriously effect the health of the aquatic mammals. Just as very loud noises can affect humans and can cause not only pain but also disorientation, so also can the aquatic mammals be affected. Ship and submarine noises together with marine seismic surveys seem to be affecting the populations of the different whale species.

Has the Humpback whale a future?

Prior to their commercial exploitation, the population of the Humpback whale is estimated to have been about 115,000. Today, there appear to be no more than about 10,000 remaining, and they are now considered as an endangered species. It is horrifying to think that these fantastic creatures, due to their being hunted by egoistic humans, are rapidly moving towards extinction and the silencing of their songs. ■



Numerous CD's are available with whale songs

Links to Wav files with whale songs. If you have a computer with a sound card and speakers or headset, just click on the links

- Whale Song #1** (WAV) 324K
- Whale Song #2** (WAV) 345K
- Whale Song #3** (WAV) 259K
- Whale Song #4** (WAV) 291K

dive in.
explore.
discover.



Tailgating the lone dugong, KAT, on Cocos (Keeling) Islands. Photographed by Karen Willshaw ~ underwater.com.au member



focus

Just their name, their size, and their menacing looks can evoke feelings of terror, fear and instinctive rejection. However, if you have the privilege to be able to dive with big tiger sharks, as I have, you might fall in love with them, at least you will bond with them in a mysterious way. They are certainly not as “cute” as marine mammals or anthropomorphized clown fish, but they will have an impact on you that could change your perception of sharks, and marine life, forever.

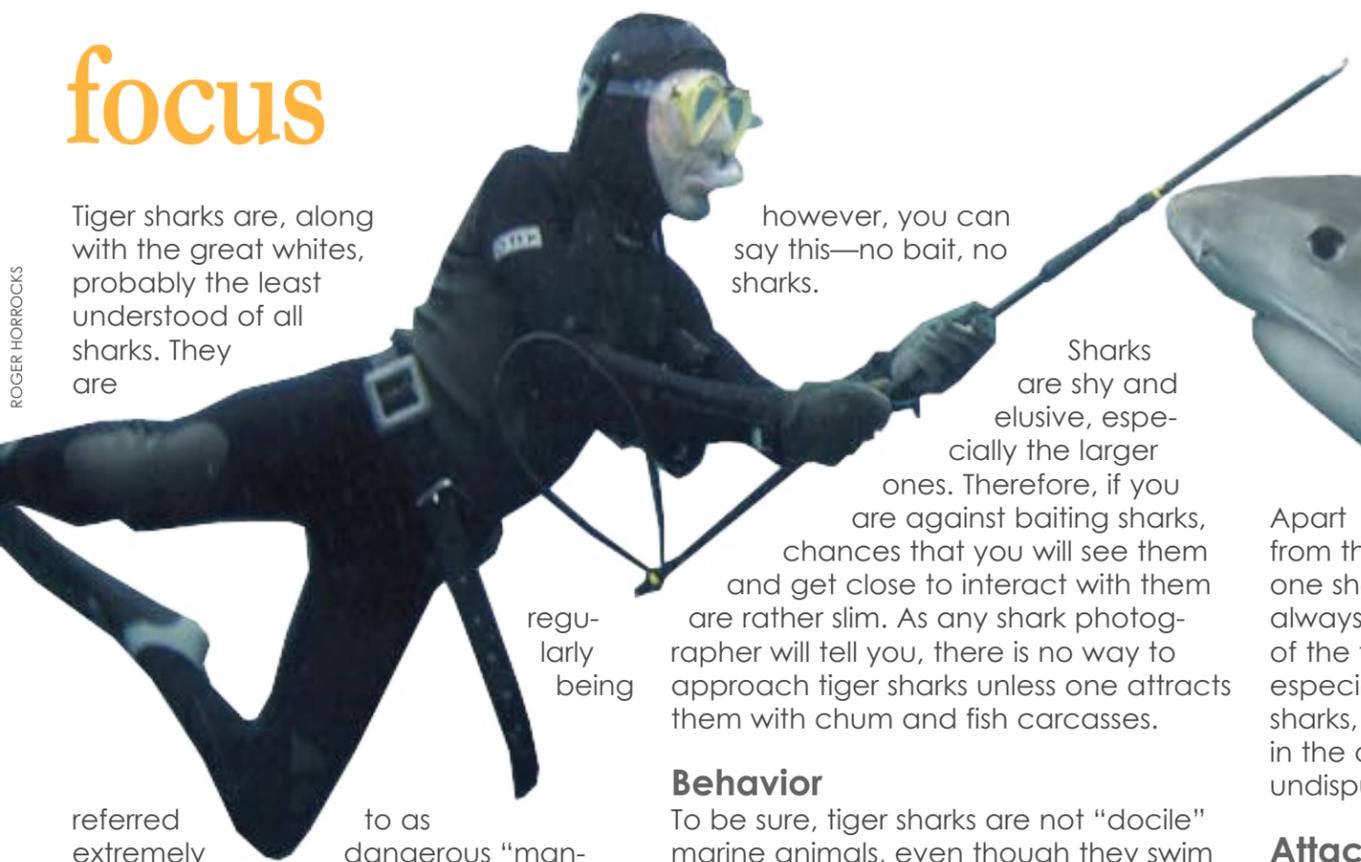


Freediving with Tiger Sharks

How safe is it?

Text by Wolfgang Leander
Photos by Wolfgang Leander,
Roger Horrocks and Sijmon de Waal

ROGER HORROCKS



Wolfgang blessing a large female tiger shark appropriately baptized "Dances with Wolf"

Tiger Sharks

Tiger sharks are, along with the great whites, probably the least understood of all sharks. They are

however, you can say this—no bait, no sharks.

Sharks are shy and elusive, especially the larger ones. Therefore, if you are against baiting sharks, chances that you will see them and get close to interact with them are rather slim. As any shark photographer will tell you, there is no way to approach tiger sharks unless one attracts them with chum and fish carcasses.

Apart from that one should always be aware of the fact that sharks, especially the "requiem" sharks, have no serious adversaries in the oceans, which makes them the undisputed lords of their habitat.

degree of corporal mobility, which in my opinion only apnea diving will allow you. But then again, this is my choice. Most other people will feel more comfortable diving with tanks—being relaxed underwater is really what recreational diving should be all about.

I began freediving 52 years ago in southern France, and to this day I can still fully relive the overwhelming sensation I felt

then being able to enter into another Cousteau's weightlessly

referred to as extremely dangerous "man-eaters", which, as many enlightened divers and experienced "sharkmen" know by now, is not the case; Tiger sharks are neither "extremely dangerous" nor do they eat men (or women).

"Dangerous" can be circumstances and wrong attitudes like harassing or provoking them, or else disregarding other basic safety rules such as not spear-fishing in their presence. Being with tiger sharks in a feeding situation where they might view you as an intruder or a competitor could incite them to display dominance, which, if not recognized and respected, could possibly trigger a bite.

Behavior

To be sure, tiger sharks are not "docile" marine animals, even though they swim slowly compared to other more nervy sharks and, thus, appear to be "cool". They are formidable and highly developed predators capable of hunting other sharks and biting through the shells of sea turtles. Not understanding and correctly interpreting their body language is probably the highest potential risk factor while encountering them in their environment.

Attacks

So, what about so-called shark attacks? I would venture to say that not more than five to ten tiger shark related accidents happen each year worldwide, of which perhaps one or two may result in fatalities. According to the Princeton-based Shark Research Institute (SRI), between 2000 and 2006 some 35 incidents involved tiger sharks; only eight of

these were recorded as fatal. The SRI lists the shark species in their shark attack files when they are 99-100 percent certain about it. Surfers, swimmers, and spear-fishermen appear to be at a higher risk of being bitten by a tiger shark than snorkelers and scuba divers.

These findings, although not complete as not every incident is being reported, simply confirm that tiger sharks—or any sharks for that matter—are not at all what ignorant and sensationalistic media people still call the "monsters of the deep" or "mindless killing machines".

That said, diving with sharks, even with fully grown tiger sharks, should not be regarded as a "hazardous" activity or an "extreme" sport. If you want to dive with tiger sharks, and assuming that you have some experience diving with other sharks, the question should not be: Is it safe or not? Rather, the question is whether to freedive or scuba dive with the sharks.

To freedive or not to freedive...

I prefer freediving for two very basic reasons. First, as a mammal, I find it unnatural to breathe underwater, and second, interacting with sharks requires a high

silent world—and swim in it.

Freediving with tiger sharks for the first time in my life and just four months ago in the Bahamas in a place called Tiger Beach, left me just as breathless, literally, as I was back in 1955. To swim with tigers spoiled me completely. I have to admit that all other sharks I have seen and



ROGER HORROCKS



WOLFGANG LEANDER

"Up close and personal"—this is what shark operators call tiger shark encounters

Large but graceful as a prima ballerina



WOLFGANG LEANDER



Freediver, Roger Horrocks, photographing "Dances with Wolf"

Tiger Sharks

Close encounters

As a freediver, I have had my close encounters of the "striped" kind mostly at the surface where the tigers look their best, photographically speaking. Nothing beats the sight of a tiger shark that comes up to the surface to check you out. Once the tigers feel good about you and move in perhaps a bit too close for your taste, don't panic—just place your hand on their heads and push them down very gently.

Never, never hit a shark on its nose as some "experts" advise. Handling sharks roughly is asking for trouble. Sharks are sensitive and responsive. They can tell a klutz from a tactful person.

Location

Which place is "better"—Tiger Beach or Aliwal Shoal? This is a tough question, which I have been asked many times after I returned from South Africa. Both spots are great. To my knowledge, these locations are the only ones in the world where you are (almost) guaranteed to see tiger sharks on every dive.

Tiger Beach in the Bahamas is what you'd expect from first class tropical diving in pristine waters—the visibility is superb, and the sandy bottom as background makes for "clean" photographs and videos. The diving is easy, and as you can get there only on a live-aboard (Jim Abernethy of

swum with—even large specimens—pale in comparison.

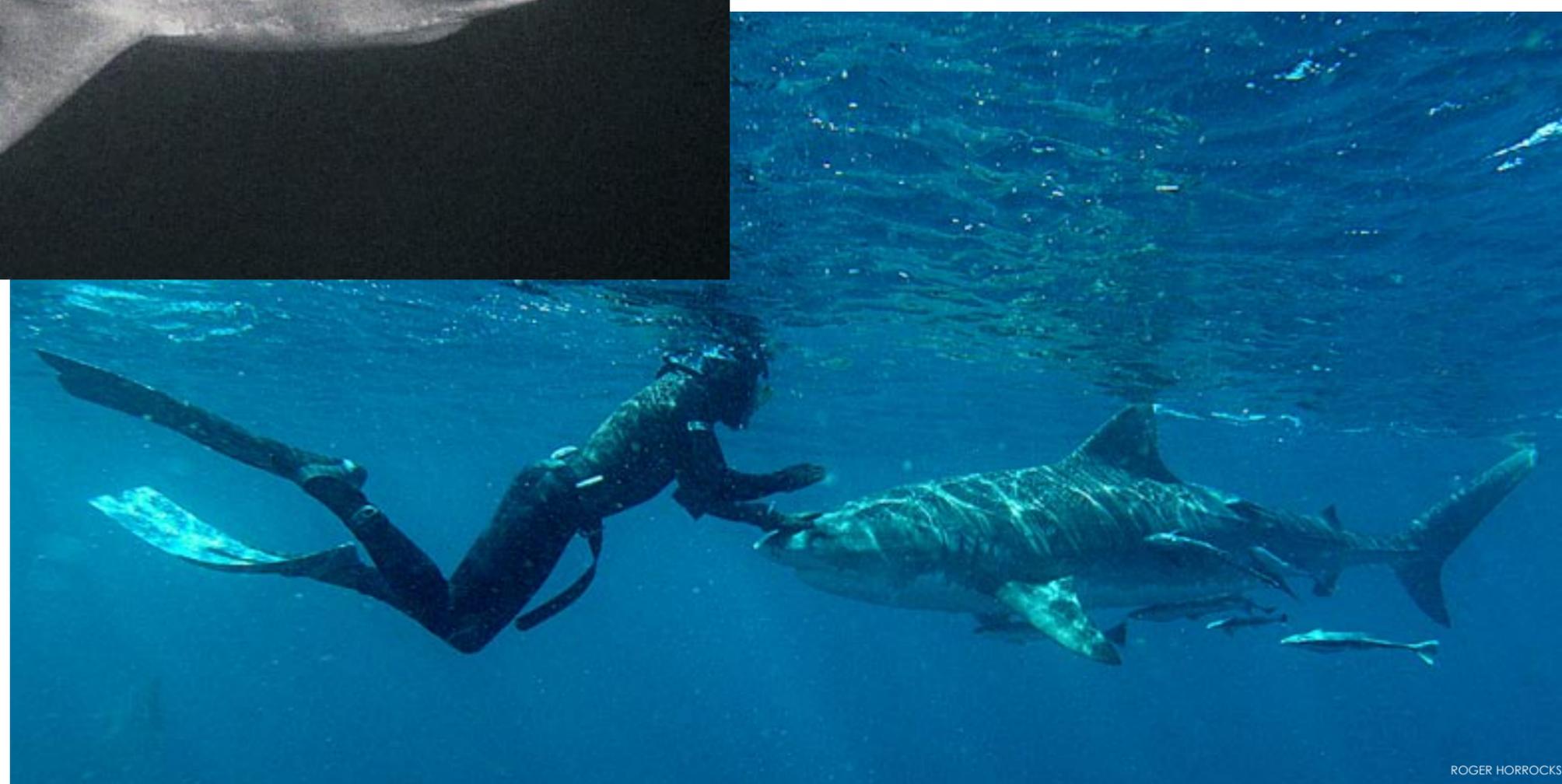
No other sharks have a stronger expression of character than tiger sharks—the square head, the wide, blunt front, the comparatively huge mouth—often tightly shut when they get very close—and those inquisitive, intelligently looking black eyes.

When I saw the first tiger shark swimming out of the blue mist of the Bahamian sea—which struck me as the quintessential shark—I felt reborn, miraculously invigorated by the spell of a perfect animal that has already been

around long before the dinosaurs roamed our planet.

A few weeks after my first encounter with tiger sharks in the Bahamas, I flew to South Africa to freedive with the tiger sharks of Aliwal Shoal. Here, I was able to experience the most incredible interaction with big tiger "girls". Swimming up very close to these gentle creatures was what I would call the climax of a lifelong love affair with the ocean and its sharks.

LWolfgang interacting with one of his tiger girls



ROGER HORROCKS



Scuba Adventures and Scottie Smith of the Dolphin Dream Team are the guys to go with), you have unlimited dives while anchored at Tiger Beach.

Aliwal Shoal, in contrast, is for the hard core shark divers—darker waters, usually less clear than in the Bahamas, at times rough launches from the beach as the skippers have to get past the surf.

However, if what you are looking for is close and intense interaction with tiger sharks, I'd recommend that you go all the way to Umkomaas, about 25 miles south of Durban, and book at least 7-10 dives with the operator I consider the most experienced, and whose team members are all excellent, enthusiastic shark divers, with or without tanks—Blue Wilderness.

Mark Addison of the Blue Wilderness team pioneered tiger shark diving in South Africa and is the guy people like David Doubilet and Doug Perrine go with if they want to photograph the tigers or dive the by now famous Sardine Run. Perrine shot his award winning image of the copper shark coming out of a cloud of sardines there.

What's next...

My next diving plans? In December 2007, I will be back at Tiger Beach, with the Dolphin Dream Team, and in March 2008, you'll find me with my son Felix in South Africa where we have some great friends waiting for us—Roger Horrocks (www.rogerhorrocks.com), the Blue Wilderness team, and, of course, "my" girls, of which one I will take out for a dance to renew our special relationship...

I am hopelessly hooked on tiger sharks. I love them. They are to me the paradigmatic sharks—the sharks of sharks. If somebody would ask me what I feel for them, for all sharks, this is what I would state:

We have stripped them of their dignity, we have vilified them throughout the ages, we feared them irrationally out of ignorance, and now we persecute them mercilessly, exploit them as if they were a commodity. We have likened their innocence to the worst of human traits,



not wanting to admit that the darker side of our nature is not bestial but human. We have refused to realize in our hubris that our God is the God that also created them, not a lesser god, a god of sharks—peace to them, finally. ■

Editor's note: The opinions expressed by Wolfgang Leander in this article reflect his own assessment of diving with sharks. While we believe that diving with them is relatively secure if and when generally accepted safety rules are observed, it should be stressed that sharks are wild animals and accidents could happen





Edited by
Gunild Symes

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**POINT & CLICK
ON BOLD LINKS**



Art of the Sea

Arts & crafts inspired by the ocean & the underwater world

All photos are courtesy of the individual artists

Waterscapes

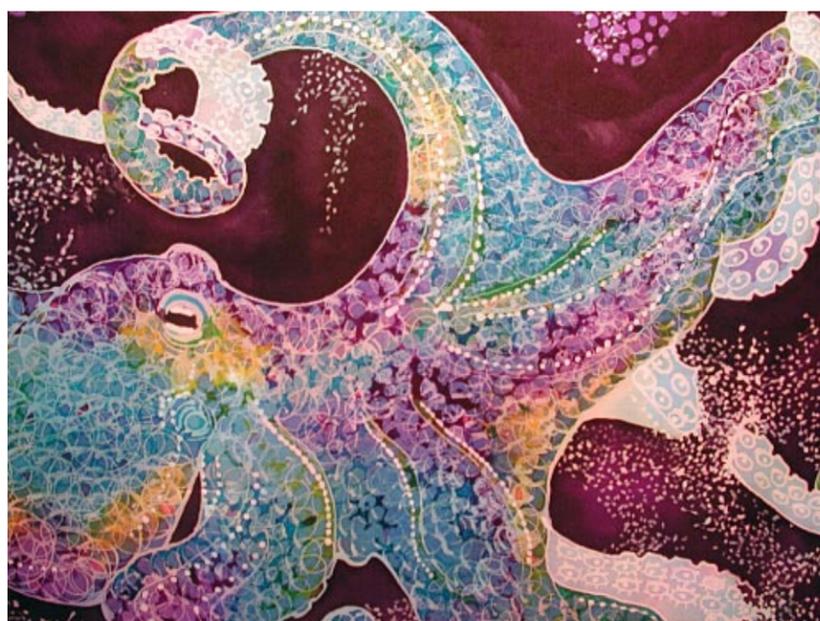
Linda Bolhuis is an art glass and graphic designer who works with watercolor or dye on silk and pastels. She creates images on silk that capture the moment when light hits water or "the shifting qualities of light found within the intimacy of a water garden." She believes in the healing power of art and strives to incorporate it into her work. lindabolhuis.com



Silk Stream by Linda Bolhuis, dye on silk, 40 x 28 inches. Available as a giclee print, 27 x 19 inches, US\$375



Baja Storm by Linda Bolhuis, dye on silk, 19 x 11 inches



Detail of *Octo* by Helen Goldberg
dye on silk, 34 x 34 inches, private collection



Seascape by Helen Goldberg, dye on silk, 34 x 34 inches, US\$550.00

Seasilks

Modern dance professor and diver Helen Goldberg combines her fine art skills with her scuba diving experiences to create colourful paintings on china silk, or silk habotai. These silks are hand painted using Dupont silk dyes. The artist uses various layers of dye and gutta, which corals the dye, as well as various wax, salt and application techniques which ensure minimal fading or running of colors. seasilks.com



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ocean arts

The Sea in Abstraction

Call of the Open Ocean

Anita Hochman is an Australian artist living near Byron Bay, who creates evocative sky and waterscapes that have a sweeping sense of space. Her fascination with luminosity and movement can be seen in her richly layered semi abstract paintings of landscapes in flux.

www.anitahochman.com



Simplicity & Spontaneity

Anna Grethe Aaen creates oil paintings and neo-pastels, many of which are exhibited in Greenland and Denmark. Most of her paintings come from her

memory "of a piece of nature" or from an experience of nature. She seeks out the simple expression that forces her to reflect. "The power of telling a small part

is greater than telling all. In my paintings, I deal with reality, but they are not about me. Perhaps one can read some states of mind, but I'm not interested in pouring

out my soul. What is interesting is the image and what is happening on the surface, in the structure, the shapes and the colors." www.annagretheaaen.dk



Stormy Weather, by Anna Grethe Aaen
oil on canvas, 100 x 100 cm



Hekla As A Neighbour, by Anna Grethe Aaen
oil on canvas, 100 x 100 cm



Iceberg and Orange Stripe by Anna Grethe Aaen
oil on canvas, 100 x 100 cm





Edited by
Edwin Marcow

Music to Watch Girls Go By

Love songs for sharks! Songs by Lionel Ritchie and Diana Ross to get you in the mood for making whoopee!

This is not for some star-struck lovers in their twenties, but for the sharks housed at the ten Sea Life aquariums across Germany. Why? Because the centre's staff fear that not enough offspring have been produced throughout the country's aquariums. "We tried everything else, and it didn't work, so we are taking a new approach. It has been tried with pandas and primates and we have nothing to lose by trying the music."

If the sharks do get into the swing of things the public will be treated to a special experience. The mating ritual of sharks, with the male biting the female's fins as he pursues her is quite something to witness.

As Andy's Williams sang... "Eye to eye, music to watch girls go bye." ■

The Plight of the Whale Shark

A twelve year study at the World famous Ningaloo Reef Western Australia has shown a decline in Whale Shark population numbers. Originated about 60 million years ago, and attaining a length of 20 metres and weighing in up to 30 tonnes, these gentle giants migrate 12 thousand kilometres around South East Asia, and the Indian Ocean.

Within the Pacific Rim, for the exception of Taiwan and Australian waters, these gentle giants do not enjoy the protection they need. Over harvesting, coupled with a slow growth rate and infrequent reproduction leaves this leviathan vulnerable to exploitation.

In the Far East, in particular Taiwan, Whale sharks are considered a delicacy known as the "tofu shark" locally because its delicate meat is said to taste like tofu.



—In 2001 in Australia, the Whale shark was listed as nationally threatened under the Environment Protection and

Biodiversity and Conservation Act 1999. Taiwan legislators have now implemented a ban starting next year that will make it illegal to catch or sell the meat of Whale sharks. Across the Globe in Atlanta Georgia, the Georgia Aquarium, a 500,000 square foot vessel housing more than 100,000 fish including several Whale Sharks brought in from Taiwan, has lost two more Whale Sharks. The sharks, Norton and Ralph mentioned in Sharktales, were brought in from Taiwan in 2005.

Sadly Norton and Ralph died recently most likely from pesticide poisoning. This pesticide was introduced into their tanks to treat parasitic leeches. The aquarium has had its detractors and has come in for criticism for trying to be the first aquarium outside Asia to successfully display and house a Whale Shark, a feat yet to be attained.

Criticism from the Captive Animals Protection Society labelling the display as dangerous, and the Shark Research Institute on the aquarium's decision to exhibit these gentle giants, has been offset notably by the world-renowned Oceanographer, Dr Sylvia Earle. "Sharks that are at the aquarium in Georgia today would be dead if they hadn't been transported and lovingly cared for, and given a home for the rest of their natural lives with people looking out for their every need." ■

Man – Will We Ever Learn?

"There are none so blind as those who do not want to see."

Local populations of Thresher, Mak and Blue Sharks have dropped by more than 80 percent in the waters of Montauk, a small fishing village on the East coast of the United States. Australia has less than 500 grey nurse reef sharks remaining in the waters on New South Wales. These countries, continents apart, are joined by the indifference they share to the plight of the shark populations in their waters.

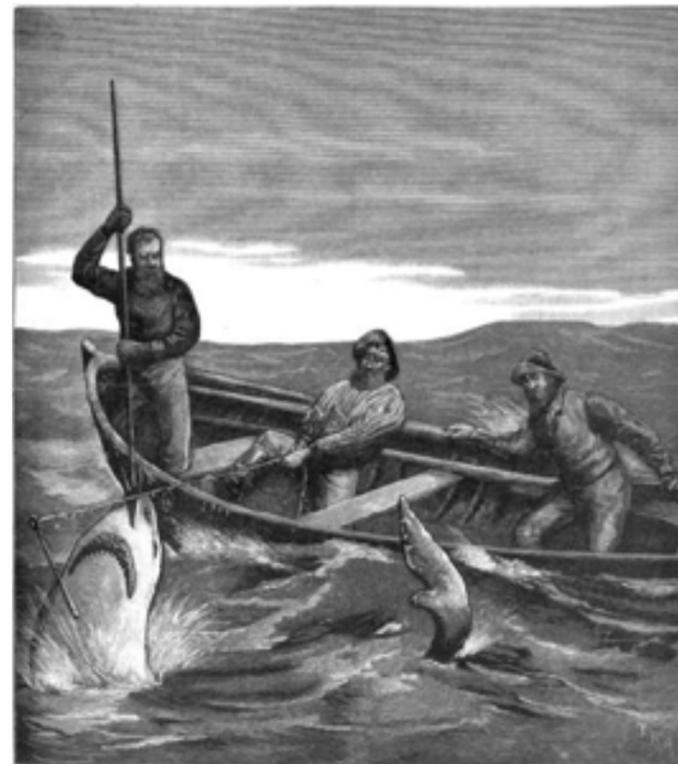
If not stopped, this indifference, fuelled by the greed of various entrepreneurs and commercial fishing companies, will prove to be the downfall for the sharks. In their rush to make a profit today, tomorrow's profit and effective husbandry of the marine environment has been overlooked.

Seventy million plus sharks are killed annually worldwide. Shark fishing competitions further compound this decimation of shark numbers.

The Shark Fishing Tournament organised by Sam Gershowitz, owner of the Star Island Yacht Club, has promised prize monies of more than US\$400,000 for the winner.

"Fishing has been an important part of Long Island's heritage and economy," he said. Note how Mr Gershowitz has stressed the importance of this fishing event to the heritage and local economy of this small fishing hamlet, but no mention of the sharks or the environment.

"This isn't about sport, it's about big money and big suffering of endangered animals," said John Grandy of the Humane Society. "This is recreational slaughter done



'Fight with a shark in Geelong Bay.' Engraving by Julian Rossi Ashton (1851-1942),

for cash prizes."

Mr Gershowitz expects 35 sharks big enough to be caught to be killed in this year's competition. Local character and shark fisherman Frank Mundus, 81, believes it. Mundus, who has written a recently published book said that he was the inspiration for Quint in the first *Jaws* film. He said, "Twenty years ago they would have brought in 100 sharks."

With a further ten percent drop in numbers due to fishing nets in the last five years and already listed as endangered, the future of the grey nurse reef shark in

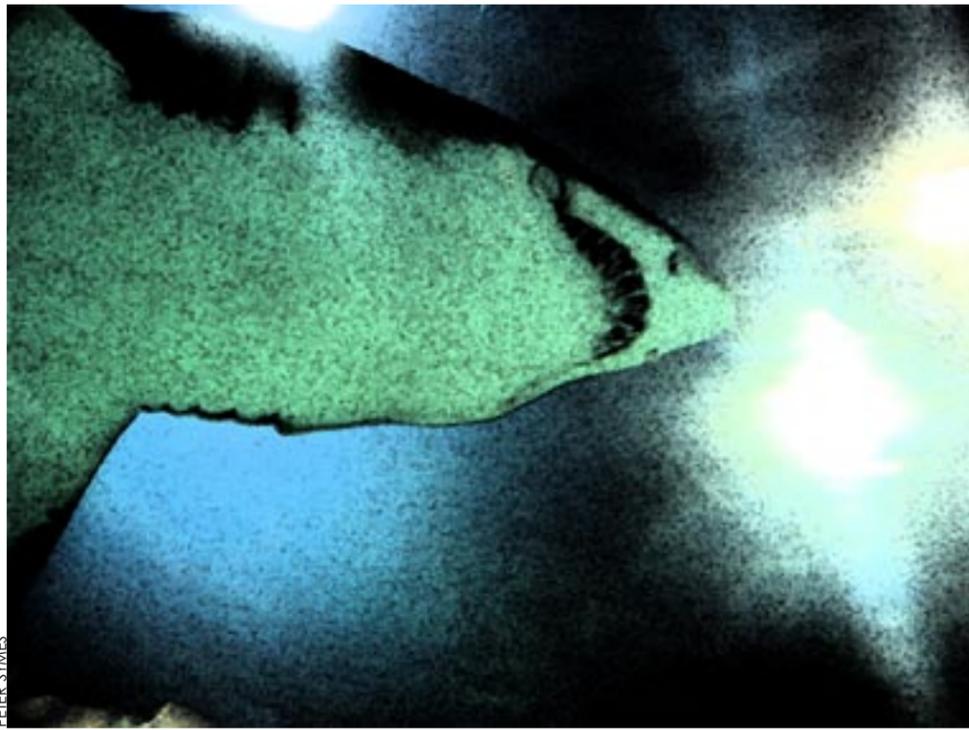
New South Wales (NSW) waters looks desperate. With only a pitiful 500 remaining in these waters, the Nature Conservation Council (NCC) of NSW resumed legal action, requesting 18 no fishing zones to be brought in along the NSW coast.

The NCC has petitioned the Appeals Tribunal to order the Federal NSW Government to legislate these 18 sanctuaries notably in and around Sydney.

The NCC has also petitioned the tribunal to overturn an earlier decision made last year to sanction a large commercial fishery to operate in grey nurse shark habitats along the NSW coast.

The Department of Primary Industries (DPI) estimates that as many as 50 grey nurse reef sharks have been killed by fishing hooks, spears and nets in the last five years. Some believe that this figure of 50 may only be a quarter of the grey nurse reef sharks that

have been killed in this period. The NCC believes with all the available evidence that failure to establish no-take zones would bring the grey nurse reef shark population to extinction within a lifetime. With the pressures of business, big monies have not only blighted the marine environment from Australia to the United States, but will rob our children of a healthy marine environment. What will big businesses and Sam Gershowitz do when there are no sharks to fish for and kill? ■



PETER SYMES

Opposites Attract!

Shark Defence is the trade name for a series of highly unusual and successful family of chemical repellents identified, isolated and synthesised by the Oak Ridge Shark Lab, founded by Eric and Jean Stroud in September 2001.

Working closely with Dr Samuel Gruber and the Bimini Biological Field Station, the team has come up with some very exciting research.

Their goal is to keep sharks away from both fisheries and bathing beaches without frightening the fish or harming the sharks. After years of disappointing research into a viable shark repellent, utilising materials like decayed shark tissues, the team discovered that most species of shark are repelled by electromagnetic fields created by rare earth magnets.

These magnets are not practical to fit in to your BCD or attach

to your surfboard, though these magnets could be lined up on the sea floor to create an effective shark-free zone. The miles of netting used to protect beaches could become a thing of the past, as well as the indiscriminate killing of sharks, dolphins, turtles, etc., which could be saved from dying a senseless death.

The rare earth magnets, Neodymium and Samarium-cobalt (Neodymium being the most widely used, cheapest and strongest rare earth magnet used today), are commonly used in computer hard drives, audio speakers and even bicycle dynamos, have been found to be very effective in repelling sharks. All species of sharks have demonstrated the unique ability to identify weak electrical fields known as electroreception—see box..

Sharks have further demonstrated the ability to detect the Earth's magnetic fields. ■

Magnetoreception via Electromagnetic Induction

Elasmobranch fish have demonstrated the ability to detect the earth's magnetic field.

The most widely held view is that when a shark passes through the Earth's magnetic field, a natural phenomena of electromagnetic induction generates an electric field as charged particles move through this field thus creating an electric field around the shark.

Differences in the Earth's magnetic field at different locations result in minute changes in the induced individual electrical fields, which are likely detected by the shark's electroreceptors.

Research by Shark Defence has discovered that rare earth magnets in particular Neodymium, Iron Boride, and Barium Ferrite magnets correspond or match very closely with the detection range of the sharks.

Ampullae of Lorenzini

By choosing a magnet with the matching specifications of the sharks' sensitivity range, and further hypothesising this magnet to over stimulate the sharks' Ampullae of Lorenzini, one has an effective repellent.

Magnetoreception via electromagnetic induction is the widely accepted view of how sharks detect and navigate the open oceans.

One wonders if these rare earth magnets work similarly to the Shark pod to create an electrical field, which hampers the shark's electroreception ability thus scaring it off. ■



No Male Required

In the last edition of Sharktales, we ran an article on Parthenogenesis or asexual reproduction—the incredible phenomena when, in the absence of males, female sharks can switch from a sexual to non-sexual mode of reproduction. Well, there were no male Blacktip Reef Sharks in the Virginia Aquarium and Marine Science Centre and no cross breeding between the

different shark species. Imagine the shock when veterinarian Bob George dissected Tidbit, a female Blacktip Reef Shark after she suddenly died at the Aquarium in Virginia Beach, USA, to find a perfectly formed pup ready to be born! How did she get pregnant?

Could Tidbit's pup be a hybrid?

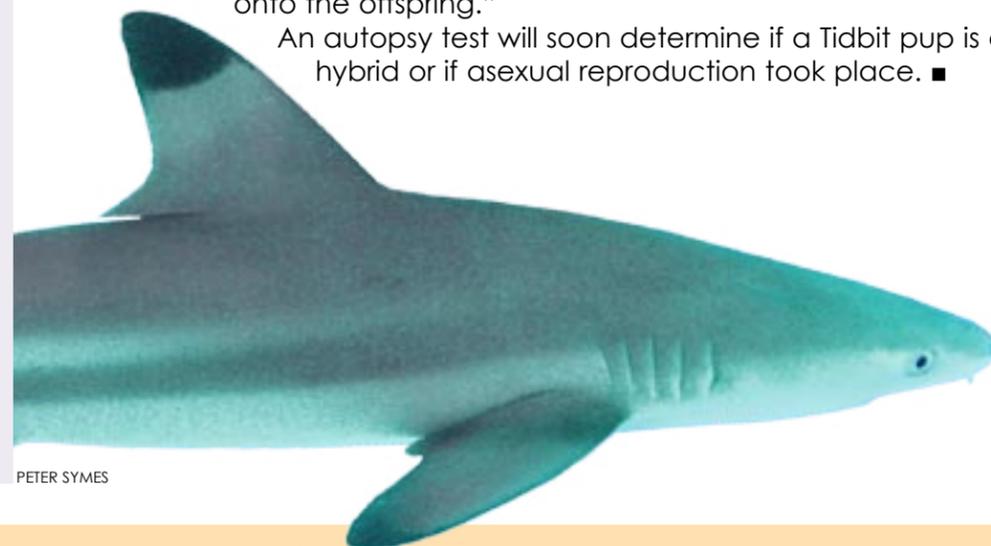
A recent study has confirmed the first case of asexual reproduction or parthenogenesis among sharks at the Nebraska Zoo in the US.

In normal reproduction, an egg is fertilised by sperm producing an embryo that contains a set of chromosomes. Half the chromosomes come from the mother, and half of the chromosomes come from the father. In asexual reproduction, the egg splits in two. DNA contributed from the mother doubles so each egg has a full complement of chromosomes from the female. The eggs then fuse producing a single embryo with no DNA from a father, hence, no male required. Asexual reproduction, though common in some insect species and seen in some reptiles and fish, has never been documented in sharks till now.

Asexual reproduction in sharks is more likely to happen in captivity than the open ocean, though this discovery does raise concerns. As shark populations drop, will female sharks turn to asexual reproduction which in-turn raises questions on the reproductive and genetic health of the offspring produced?

Head of Shark Research at the Pew Institute for Ocean Science, Dr Chapman added: "Not only does it experience reduced genetic diversity because it has no father, but around half of the genetic variation present in the mother is not passed onto the offspring."

An autopsy test will soon determine if a Tidbit pup is a hybrid or if asexual reproduction took place. ■



PETER SYMES



Shark Trust Tenth Anniversary Gala Ball

Featuring Sharks in Focus gallery exhibition

Date: Saturday 17th Nov.2007

Venue: Crown Moran Hotel, Cricklewood, UK

Download a programme and ticket reservation form

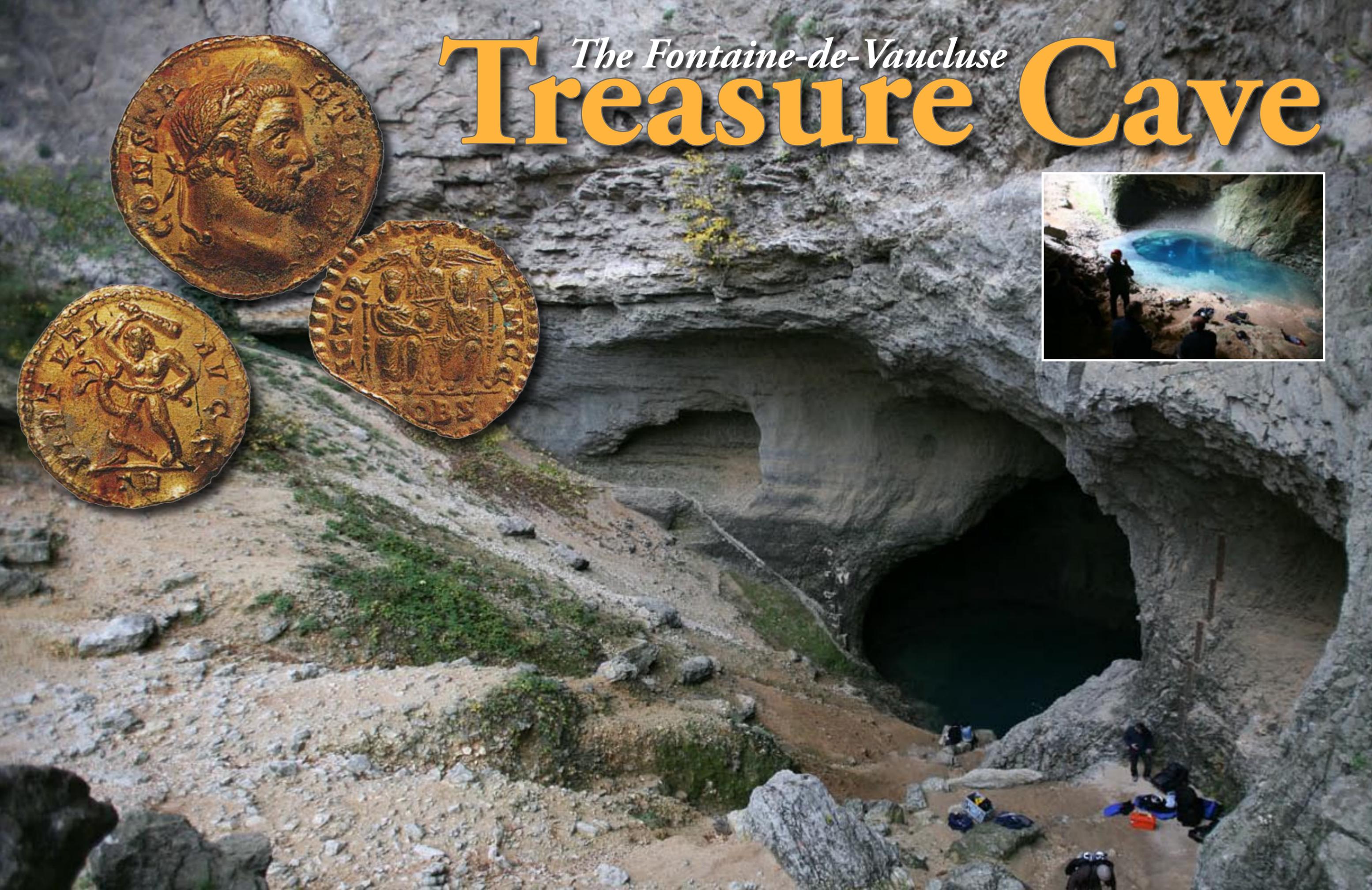
The Tenth Anniversary Gala Ball is the focal point of the Shark Trust's tenth anniversary celebrations. Generously supported by the Crown Moran Hotel, London, the Gala Ball presents an opportunity for the Trust to acknowledge its achievements, celebrate the magnificence of sharks and raise awareness as to their ongoing plight.

The fundraising evening boasts a packed agenda with talks, awards and activities as well as dinner and dancing to a live band.

A feature of the evening will be the Shark Trust and Diver Magazine Sharks in Focus Gallery and the auctioning of bespoke items of jewellery crafted specifically for the evening by Reef Jewelry.

Each guest will receive a ball programme which will include a limited edition shark print by Marc Dando. ■

The Fontaine-de-Vaucluse
Treasure Cave



Text by Andrey Bizyukin, PhD
 Photos by Andrey Bizyukin, Alexander
 Andrianov & Etienne Champelovier

“There is something in a treasure that fastens upon a man’s mind. He will pray and blaspheme and still preserve, and will curse the day he heard of it, and will let last hours come upon him unawares, still believing that he missed it only by a foot. He will see it every time he closes eyes. He will never forget it until he is dead and there is no way of getting away from a treasure once it fastens itself upon yours mind.” — Joseph Conrad

This amazing tale begins with the selection of a group of divers who were asked to participate in a technically complex dive expedition—to explore one of the deepest caves in Europe. Soon enough, we, the divers, found ourselves in a frenzy of activity and planning. There were so many preparations to make and things to consider—equipment for deep water photography, CNS and OUT values, which gas blends to use, how to put together a support team, management of the group and the quantity and size of the biggest cylinders and what not. But one can only plan for so much, then fate, as it would turn out, ended up giving us a surprising adventure for which no technical dive planning could have prepared us.

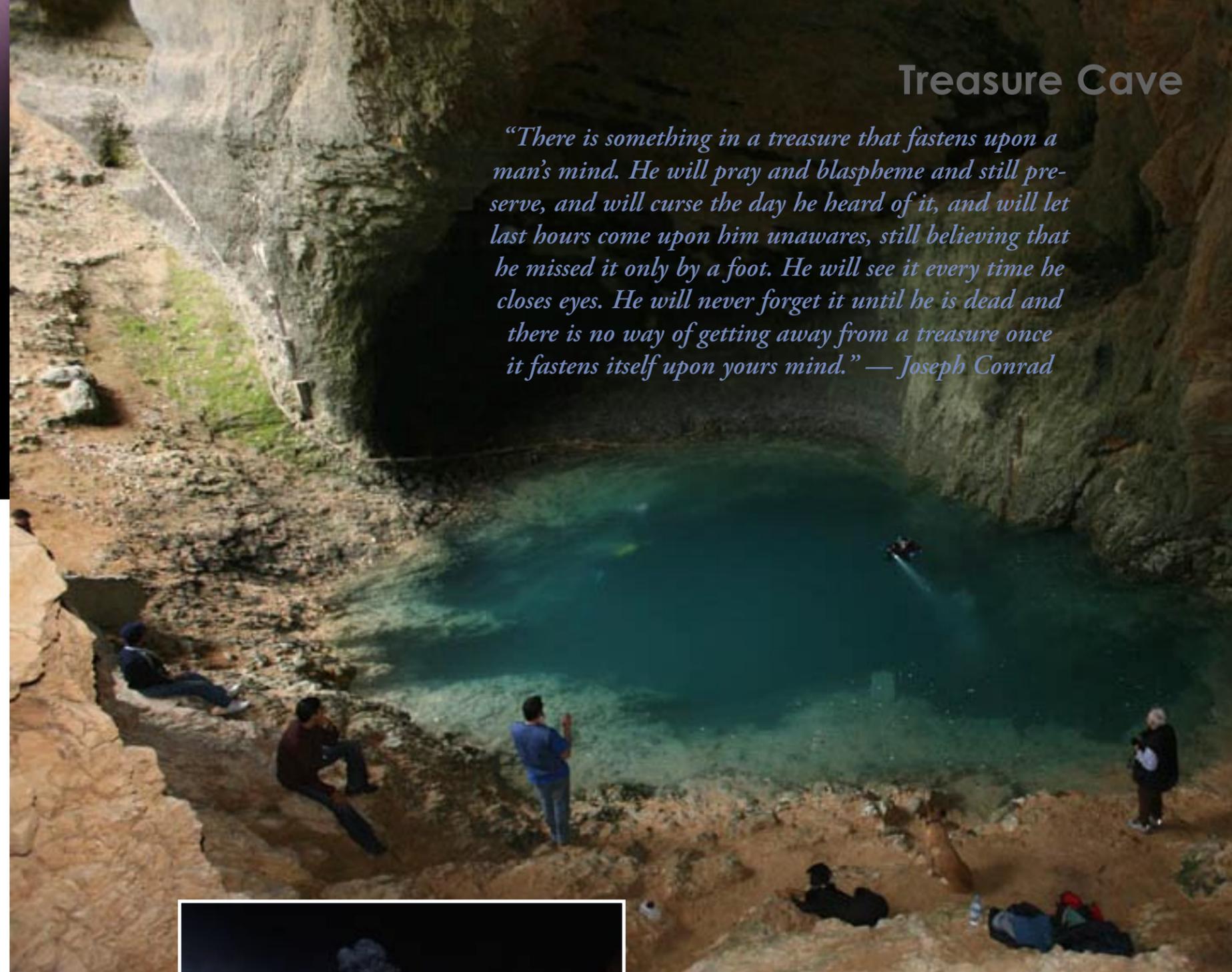
A jump on an Air France jet saw us off to Paris. Here, the more modest blue Fiat of our French patron, Joel Enndewell, almost squatting under the load of a roof of cylinders and weighy equipment, somehow managed to slalom itself out through the insanely busy Parisian traffic and onto the A6 heading out towards Lyon. To avoid congestion, we took the scenic route steering clear of any bigger cities. The tranquil French countryside was full of aromatic smells from the forests and fields we passed, as we journeyed through the landscape of wine and cheese. Wonderful places.

Our destination was the village of Chateauneuf du Pape, a city—famous for the making of the Pope’s wine over the centuries—that lies very close to the deepest underwater cave in Europe, the Fontaine-de-Vaucluse.

Diving in the cave is very prohibited. Both the city council and the county have imposed a prohibition of diving into the



The central square of Fontaine-de-Vaucluse. Everyone passes here to get to Treasure Cave. PREVIOUS PAGE: Gold coins from the 3rd or 4th centuries A.D. discovered in Fontaine-de-Vaucluse by Roland Pastor and Tomas Soulard



Magic lake of Fontaine-de-Vaucluse cave

cave. It is so strict that trespassers will surely be thrown in the slammer. What is the reason behind all these strict measures? Well, we heard that, basically, the French divers wanted the place to themselves and keep foreign divers out. Grilling one of our hosts, Yves Billaud, on the issue he looked at us with astonishment and gave us a mischievous smile. Yves is one of France’s most famous cave divers—it is what he does for a living. He is an acknowledged scientist and expert from DRASSM (Departement de recherches archeologiques subaquatiques et sous-marines-Anncy),

Archeologist Yves Billaud maps the location of the coins



Members of the speleological society, Societe Speleologique De Fontaine de Vaucluse (S.S.F.V.), explore the deepest cave of the Europe

which searches for underwater historical artefacts in karstic areas of the country.

"There are two versions of the answer to your question," was his enigmatic reply. "There is the official version and an un-official one. Which one do you want to hear?" he asked while pouring the first aperitif of the evening. "Is it possible to hear both versions?" we wanted to know.

"Well, as every secret some time becomes obvious, I will explain everything," he said. Yves explained: "The official explanation behind the ban on diving into Vaucluse is that drinking water is drawn from the cave river, and they want to preserve the purity of the water. But the real reason behind the prohibition of diving into Vaucluse has something to do with a centuries-old secret..."

Vaucluse was a place of worship for Gallic tribes who lived here during antiquity, more than two thousand years ago, when Provence was a Roman province. Astonishing evidence came to light, when in 2001, two divers—Roland Pastor and Tomas Soulard—from the speleological society Societe Speleologique De Fontaine de Vaucluse (S.S.F.V.), dived into Vaucluse and at the depth of just 22 meters and had their attention drawn to some flickering reflections on the cave walls. There was a boat wreck down there—the *D'Otonelli*, and once they moved closer, the divers realized that all those small green spots reflecting the light from their lamps were hundreds of coins lying in the cracks of the wall. "We immediately realized that we had made a significant discovery," Roland Pastor later explained.

Historical information

The first dive into Vaucluse was done by Nello Ottonelli at 1878. The diver wearing the heavy hard hat diving

Bronze coins from 138-161 A.D. were discovered in Fontaine-de-Vaucluse cave

equipment of the day reached the depth of 23 meters. Then a small diving boat that was providing the surface tendering also wrecked in the lake in the cave. The small vessel came to rest on the bottom at 24 meters becoming an unique shipwreck and the oldest cave wreck in the world.

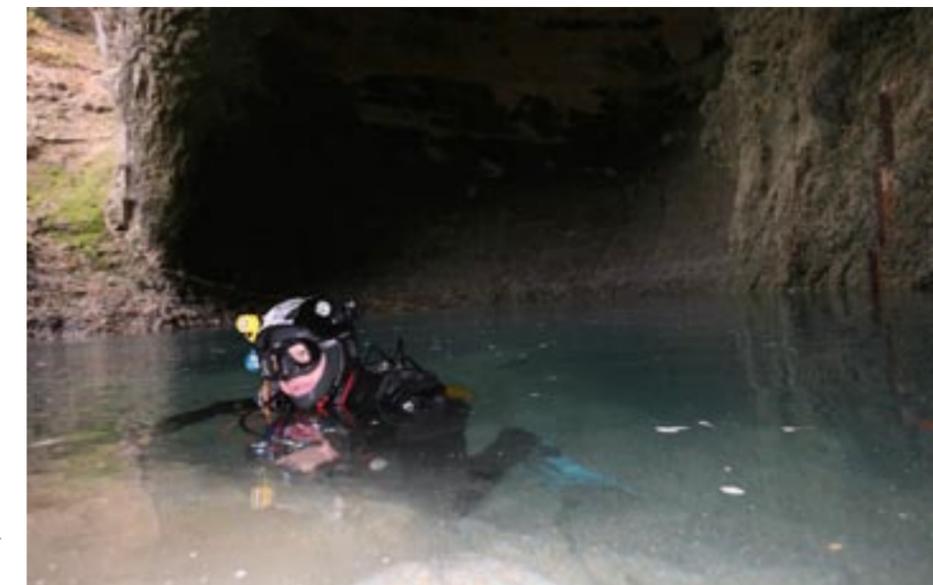
In antiquity, it was a commonplace ritual to throw coins into lakes and rivers as an offering to the gods. It is a tradition that still lives on to this day—just think of the many fountains in cities around the planet in which people throw coins.

Caves were places of special worship for the ancient Gauls. In the ancient cultures caves were often considered the abodes of invisible mighty divine entities. It is likely that the high waters and filling of reservoirs were perceived as act of gods.

In August 2002 and 2003, the first underwater excavations took place in the cave under the direction of underwater archeologist, Yves Billaud, and under the auspices of DRASSM in support of the regional archeological service, the PACA region and city council of Fontaine-de-Vaucluse. The expeditions, which took place during these two seasons, brought to light 1624 coins, iron nails, bronze bracelets and antique hairpins for a dress. Most of the coins were found in cracks of the vertical cave wall at a depth of 25 meters. It was quite straight for-



ward just to collect them from the cracks and crevices in which they were lodged, number and pack them.



Joel Enndewell, the famous French cave diver and the leader of our team, after an exciting dive



A subsequent analysis showed, that, despite poorly mineralized water, only 40 percent of coins were in a good state of preservation. Paul-Andre Becombes, an expert on Roman coins, dated the oldest of them to 70-30 B.C., and youngest to the fifth century AD. These findings have provided very valuable information on the periods when there was worship at the cave, the migration of populations and the circulation of coins in the Roman Empire.

A part of the coins obviously had cult value, not monetary, meaning that they had been produced not with trade in mind, but especially as gifts to the gods. Portraits of emperors, images of military fights and scenes of hunting on the back side of the coins have made it possible, with a fair deal of certainty, to tie them to specific historical events.

The gold coins from the third and fourth centuries AD shows that Fontaine-de-Vaucluse in this period was visited by the elite of the society who came here to offer gifts to the gods. By the same token, the abun-

dance of the much less valuable bronze coins show that also the poorer inhabitants of the province paid visits to the cave for long periods. It is surprising, however, that no coins from the Middle Ages have been found, indicating that the interest in this wonderful cave suddenly evaporated, to be forgotten for many long centuries.

Yves' story-telling captivated us. It completely made us forget all about diving and the often mindless technical discussions surrounding the dives. We were struck by the sobering realization that this cave was really an historical monument with ancient artifacts, and that this was why the French ministry of culture did not want uncontrolled amateur diving there. We began to appreciate how valuable and rare our special permit to dive this cave really was.

The treasure cave

The cave Fontaine-de-Vaucluse is located close to the town of the same name. On the central square, a roman column stands, and as we

French scientists and members of S.S.F.V. club collect the unique cave coins

head for the cave by foot, we pass the café, The Petrarca and Laura, where we held several briefings and debriefings. At the time of our visit, we found the idyllic provincial landscape draped in autumn colours, with fallen leaves blowing around the trunks of the trees contrasted by the deep green colour of the stream coming out of the ground. It is an intimate place for romantic couples, while on a noisy Sunday, there can be tourists picnicking on the bank.

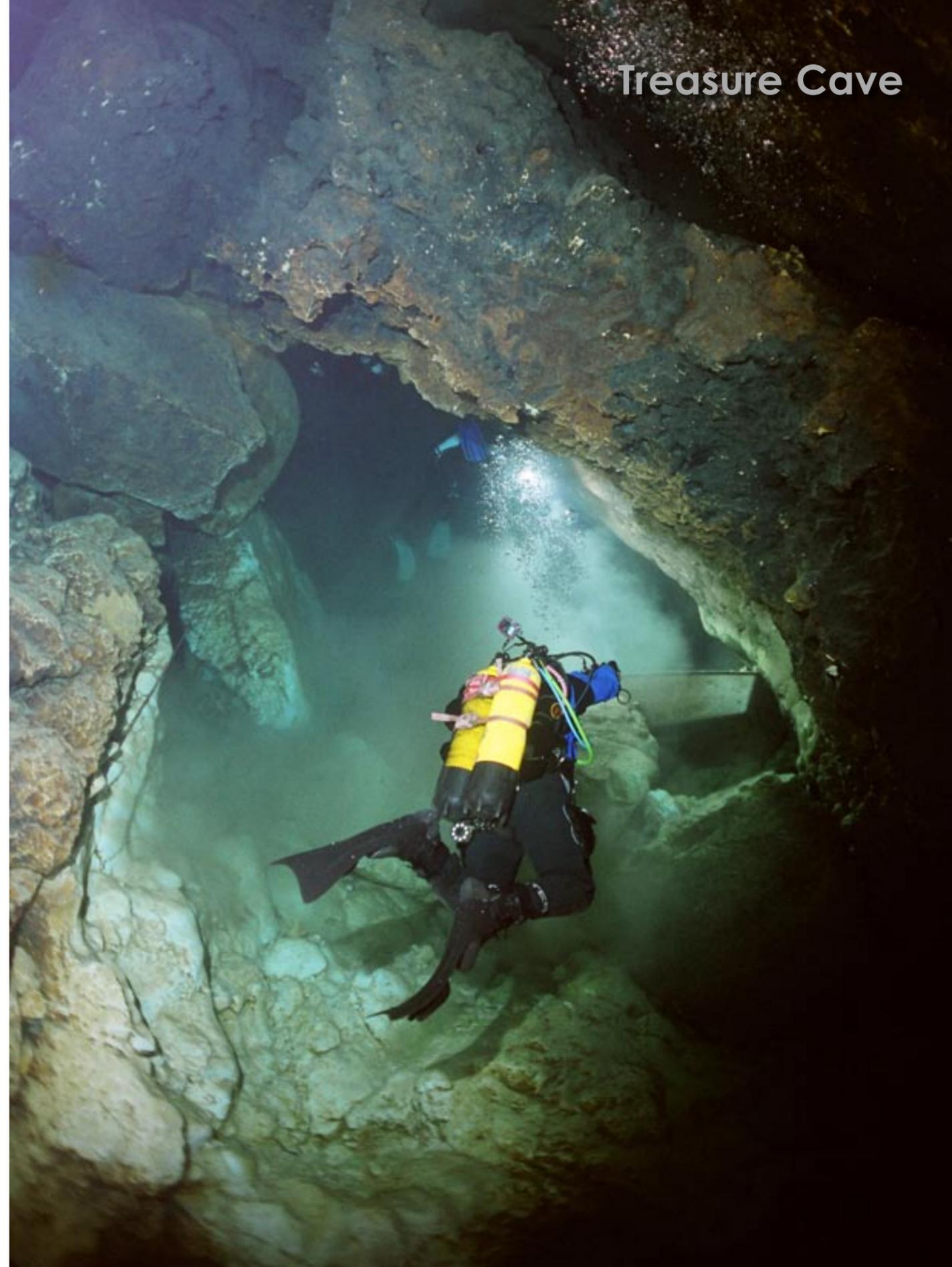
More than a million tourists visit Vaucluse each year, but only the rare cave diver can venture down into this secluded place. For this reason, we were met with rather surprised expression from the other visitors when we were hauling cylinders and heavy equipment uphill to the site on an early Sunday morning.

The entrance to the cave is a huge grotto in which there is a small, approximately 25-meter wide, lake. It is precisely this lake that attracts tourists here. For centuries, its deceptively still oval surface has beckoned visitors to take a cool dip on a hot day. On a rainy autumn day when the muddy stream can discharge a powerful 22 cubic meters of water per second, it is a little less enticing. In spring, it turns into a roaring waterfall drawing admiring spectators from afar. Among geologists across the globe, *vaucluse* has now become a term for a large karstic source with big variations in water discharge.

The Fontaine-de-Vaucluse represents an output of the huge underground river collecting water from a watershed approximately 1100 square kilometers in size between the hills of Ventoux and Lure in the north and the Vaucluse Mountains to the south. The huge limestone pit was considered bottomless for a long time, because no diver had ever measured its depth until recently.

The brave divers who had dove here, told, that they literally felt like

Treasure Cave



The place in the cave where the largest number of the coins were discovered



falling into a black infinite void inside of the cave. It was only in August 1989, that an ROV (a remotely operated vehicle), the *Spelenaute*, operated via a cable from surface, finally landed on the sandy bottom of the Fountain-de-Vaucluse at a depth of 308 meters.

The expedition

We were a mixed group of Swiss-Russian-French lucky beggars who together with the teams from the speleological society of the Fountain-de-Vaucluse (S.S.F.V.) started preparing our first dive at the cave. Roland Pastor gave the last instructions: "The top part of the cave is full of loose boulders which have fallen down during recent tectonic movements. Some of these, which weigh several tons, appear to have come to rest in unstable positions. Be very careful around these. If you touch them, you might cause a rock to tumble down—and if worse comes to worst—the rock will take divers and coins with it in the fall."

All this being said, we were lucky. The conditions were excellent, with crystal clear water. It was imperative, however, that we didn't touch the walls that were

covered by a limey layer of particles that could be easily kicked up by a careless fin stroke clouding the visibility.

The head of S.S.F.V club wished us good luck as he saw us off. With all our rebreathers, cylinders, heavy photo equipment and other technical complexities to bear, we needed luck, too, as we descended into the netherworld in search of more treasures in Vaucluse.

In the cave, the water clarity is so good, that one can see the trees growing in the hills outside the cave from underwater. At the entrance, the walls are cracked, there is a stone talus at the bottom, and a huge rock separates the entrance from the rest of the cave.

It requires delicate maneuvering not to touch the walls as we squeeze ourselves under the block to plunge into the eternal darkness below. We can only rely on our bright lights to extinguish the blackness. Our beams fall across the wreck on the *D'Ottonelli*, which has come to rest on a ledge to the left of the entrance. On the right there is a big opening leading further down. We hover directly in the center of the body of water enjoying the sense of weightlessness. Directly

below us is another ledge and a slope of clay. It is a new shaft.

It was funny to recollect that, on past speleological explorations, I have been in similar caves that also had 300-meter pits with shelves, vertical slopes and huge vertical shafts. But these were dry vertical caves, not water-filled, as was the Vaucluse cave I was in now.

In the past, when I was a regular dry cave explorer, I would, in such places, put the safety rope on tightly and clasp onto to the walls to survive. I would have to hammer hooks and anchors into the walls, one behind the other, to attach the ropes, and I would progress to the next ledge in this manner. It would demand a lot of effort and time, but cave explorers always fancy the wide, deep wells for the sake of access to the bottom. It is interesting to compare the almost opposite sensation of exploring caves in air as opposed to underwater. Underwater, we, like fishes, simply hover in the emptiness above the mouth of a well, and we can float from ledge to ledge. This unforgettable sensation of controllable flight leaves no one untouched. Vaucluse, being so deep, fascinates and entices us.

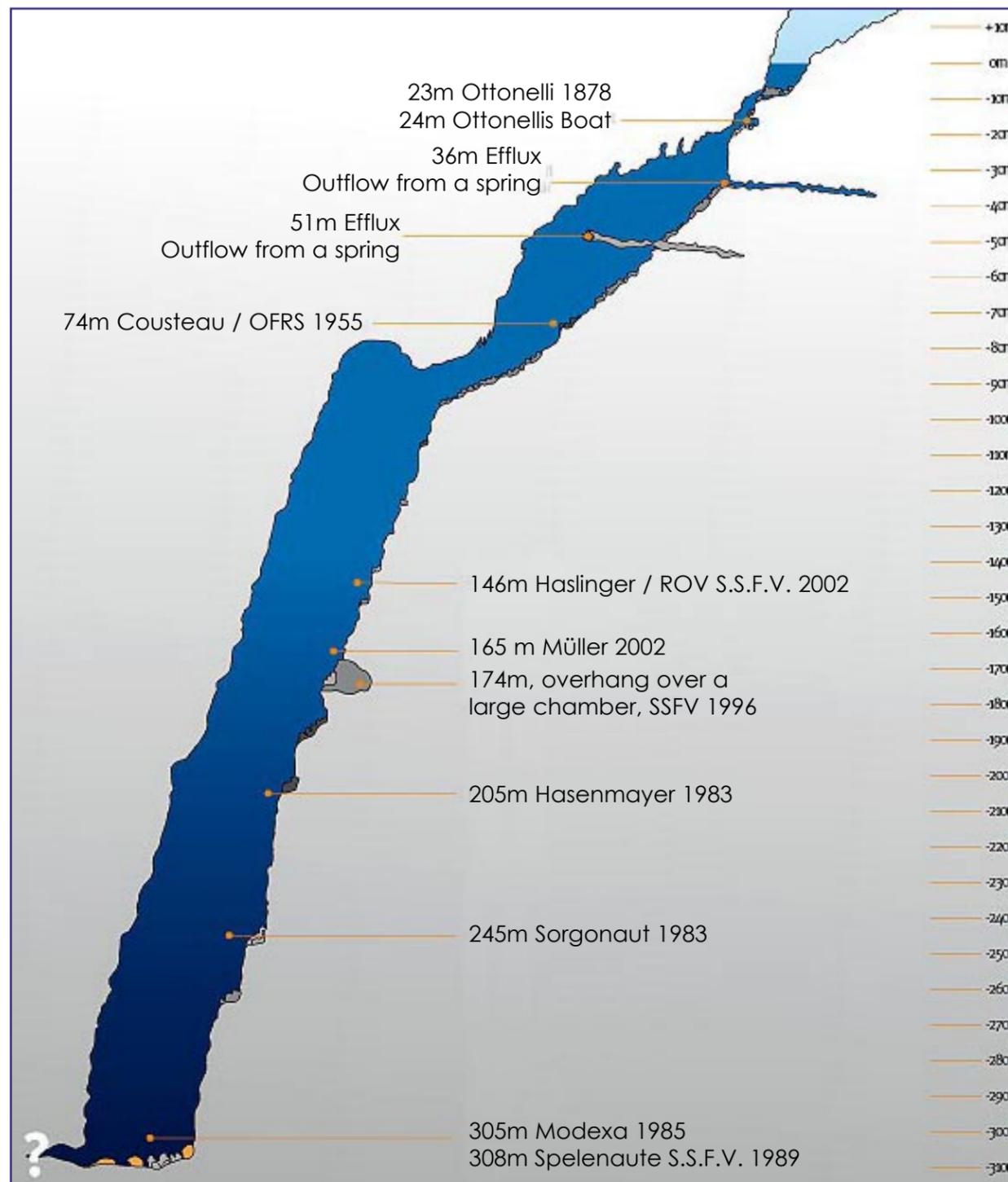
The only known cave wreck in the world (24 meters depth)

Treasure Cave

Somewhere in depth of our brains, natural instincts prompt us divers to realize that it is time to stop. Already weary from carrying too many big cylinders, we hover above the black opening of the next bottomless well. We ponder and admire the mighty cave full of treasures, for a few last moments. It has been a

long day already. Vivat Fountane-de-Vaucluse!

The author would like to give special thanks to the three great French cave divers: Joel Enndewell, Roland Pastor and Yves Billaud. Without their help and expertise this article could not have been written. —Andrey Bizyukin ■



Map of Fontaine-de-Vaucluse, the Treasure Cave

