Demystifying the Shark

Some things 'Jaws' didn't tell you

BY JOAN AREHART-TREICHEL

Mote Marine Laboratory

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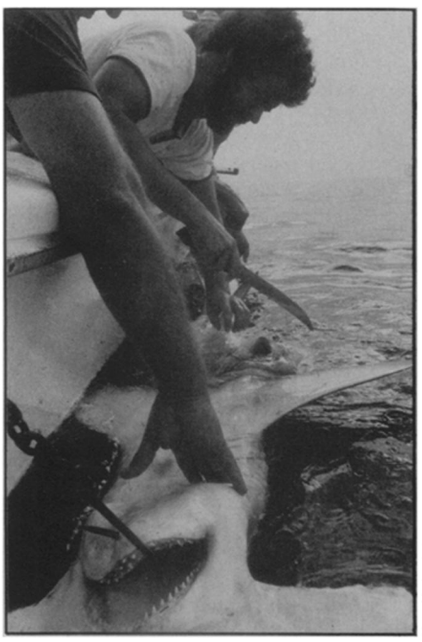
In the dark, icy waters of the world's oceans, hydrodynamically streamlined creatures dip, swim lazily and sprint as they've done for 300 million years. Primitive vertebrates that have fascinated and terrified man since he arrived on earth a million years ago, giving rise to rich and timeless legends. "Monsters of the deep." "Tigers of the sea." "Great fish." Yes, sharks.

In spite of sharks' ancient lineage and formidable reputation, only recently have scientists come to probe their physiology and behavior. Much of the information emerging on these subjects is coming from two of America's leading shark researchers—Perry Gilbert, professor of neurobiology and behavior at Cornell University and director of the Mote Marine Laboratory in Sarasota, Fla., and Eugenie Clark, professor of zoology at the University of Maryland. A large, sandy-haired man with disarming charm, Gilbert has studied sharks for 40 years. A petite brunette with a lilting voice, Clark too has dived throughout the world to study sharks, thereby earning the title of "Shark Lady."

Jaw dynamics, how sharks sense their prey, shark sex and reproduction and shark sleeping habits are some of the intriguing aspects of sharks that Gilbert and Clark have been studying of late.

The jaws of a shark, for instance, are as mighty as those portrayed in the movie "Jaws," Gilbert reports. He and his colleagues have measured the force that shark jaws exert. One shark tooth alone can apply a force of 60 kilograms over an area of two square millimeters, which is equal to three metric tons per square centimeter. In addition, the teeth in the lower jaw hold the prey while the teeth in the upper jaw tear it apart. Shark jaws can easily shred 25 to 30 pounds of prey in one bite. Perhaps because they're put to such strenuous use, shark teeth are regularly replaced. One of Gilbert's co-workers has found that young sharks lose their teeth so fast that one can almost see them roll out. Gilbert suspects, but has not yet confirmed, that even an adult shark gets a whole new set of teeth each year. So it's hardly surprising that thousands of shark teeth are tossed by the surf onto beaches, to the delight of beachcombers.

The way a shark senses its prey is also impressive. It is quite likely that a shark can detect an odor up to a quarter of a mile away. A shark's smell depends on how much an odorous substance is diluted



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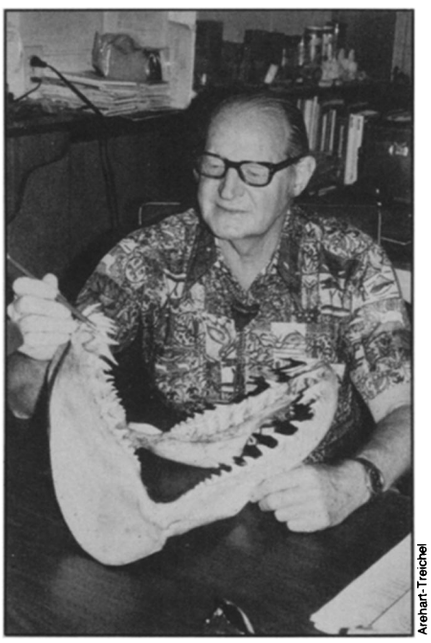
Shark hauled in live for experiments.



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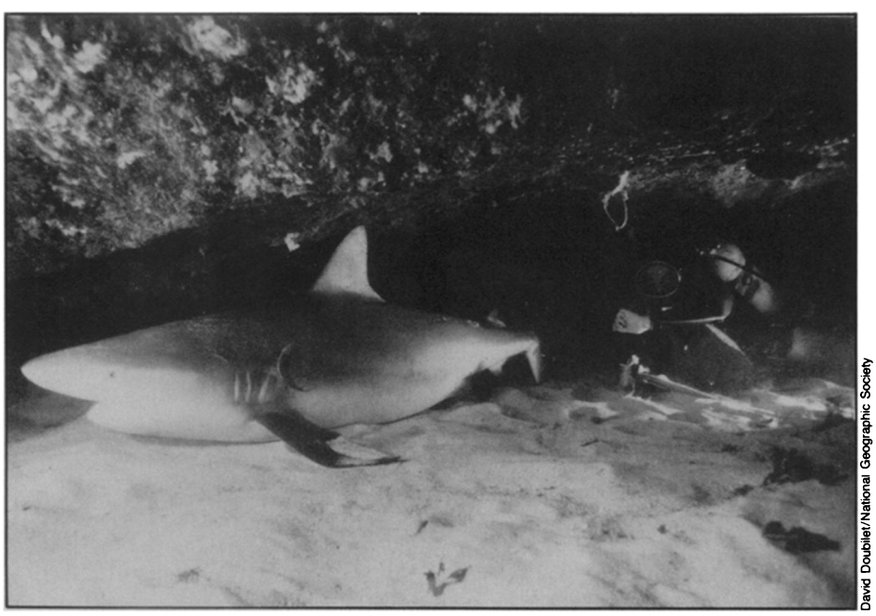
Gilbert with shark jaws: The big crunch.



David Doubilet/National Geographic Society

Clark approaches one of the many "sleeping" sharks to be found in caves off Mexico.

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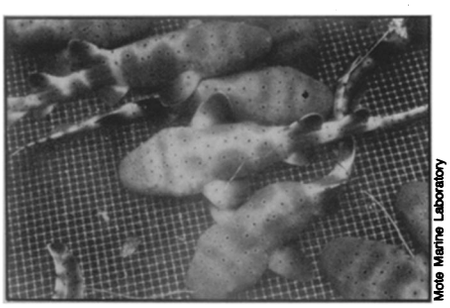
in water. Says Gilbert: "We have seen lemon sharks detect small fluid samples of freshly caught tuna (one of the strongest shark attractants we have found) placed upcurrent at a distance of 75 feet." A shark can also see its prey up to 50 feet away. And even if it is deprived of its smell and sight, it could still feel the presence of its prey with its lateralis system—nerves that extend along the sides of a shark and converge in its brain. No one is sure how far away a shark can detect a prey with this system, Gilbert says. But he notes that the erratic low-frequency vibration of struggling fish is one of the sounds that the system picks up best.

Shark vision is particularly interesting, Gilbert and his colleagues are finding. When a person goes into a dark theatre, it takes his pupils 20 to 30 seconds to enlarge enough to see well. A shark entering the dark can see within only 10 seconds because the shark's pupil expands more rapidly than a human pupil. A shark can also see in ocean depths and dim caves where a human cannot. In humans, in dim light, light passes through the retina of the eye and is absorbed by the choroid, a vascular membrane in the eye. But in the shark, the light passes through the retina and is reflected by thousands of tiny mirrors in the eye—the *tapetum lucidum*—then bounces back to restimulate the retina.

How a shark focuses its eyes is currently receiving attention from Gilbert and his team. When the human eye focuses on an object, the curvature of the lens changes. Sharks, however, have a rigid lens. Some, but not all, sharks have a muscle in their eyes that can move the rigid lens both toward and away from the light-sensitive retina.



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Nurse shark pups, hatched inside mother.

Unlike bony fish, where the females shed eggs in the water and the males fertilize them there, sharks (cartilaginous fish) copulate. The male shark has an extension on each pelvic fin known as a "clasper." He has the singular gift of being able to use either to copulate. He inserts the clasper of choice into the female shark's oviduct, located between her pelvic fins. A siphon sac connected to the clasper fills with sea water and contracts, washing sperm from the clasper into the oviduct. The sperm then fertilize eggs in

An appreciation of the shark

In 1960, a teenager and her dog gamboled along the wild, white beaches of Siesta Key at Midnight Pass, an alluring nature haven near Sarasota, Fla. The girl knew the haven well; her family had vacationed there for many a spring. But this year something was different. A large, shallow pool had been dug near the tip of the key, a barbed wire fence had been erected around it, and a sign had been posted: "Shark research facilities. Keep out!"

The fence was only makeshift, however. So the curious teenager and her dog slipped through to get a better look at the pool. Large black sharks circled round and round inside it, their pectoral fins bristling and advertising death to anyone foolish enough to lose his footing. The sight filled her with both awe and dread. The next year the wire fence had been replaced by high walls and permanent research facilities.

Now, 16 years later the teenager turned science writer—yes, it's me—has finally had the chance to visit the shark research center on Siesta Key. It wasn't a disappointment. The compound has served two of America's leading shark scientists—first Eugenie Clark, and now Perry Gilbert. It has become the finest shark research center in the world, drawing investigators from many countries who are not only interested in sharks per se, but in using them to solve problems in human physiology, immunology and virology. The pristine beaches have been usurped by condominiums and marinas, but the research center is still nestled in a pine cove and washed by waters teeming with sundry marine life, including sharks. Nearly every other day the researchers catch a shark on their baited lines 10 to 20 miles offshore, then tow them back alive for research purposes. The 13-foot tiger shark that appeared in the movie "Jaws" was caught six miles off Siesta Key at Midnight Pass.

Sharks may not continue to thrive off the coast of Florida and off other coasts throughout the world, however. " 'Jaws' was a fun and wonderful movie," says Clark, "but it created this horrible reaction in people to go out and kill sharks." While I was in Venice, Fla., a small town near Sarasota, sports fishermen were hauling in large dead sharks every several days. One was a 15-foot pregnant tiger shark, the most formidable shark species after the great white immortalized in "Jaws." Divers are now visiting the Mexican caves that Clark explored and killing sleeping sharks for the fun of it. "Being shot in your sleep is not fair, even if you are a shark," Clark protests. "Sharks have their place in this world like other things."

It's hard to disagree. First, sharks have been living on earth 300 times longer than humans have, so they deserve an ecological niche. Second, shark attacks on humans have been grossly overestimated and are scarcely an excuse to slaughter sharks wholesale. "Sharks attack people only under extraordinary conditions," Clark insists. Gilbert agrees: "The chances of being struck by lightning are eight times greater than those of being attacked by a shark while swimming in the ocean, and one is far more likely to be hit by a car while crossing the street than being struck by either lightning or a shark." Only 30 of the 250 shark species are dangerous to people. The 50-foot whale shark and the 40-foot basking shark, for example, feed exclusively on small fish and crustaceans.

What's more, sharks, like mountain lions, wolves and other carnivorous predators, provide us humans with a much-needed edge to our modern soft living. Isn't the joy of swimming in the ocean just a mite keener because of the minuscule but nonetheless real risk of grappling with a shark? I say that after having encountered two sharks while swimming off the coast of Venice and having made a triumphant sprint for the beach. Finally, don't sharks remind us of our modest role in the natural scheme of things? Even if we vanquished all the animals in the world that are potentially dangerous to us, we would still be prey to sickness and death.

I'll never forget the documentary movie I recently saw where Peter Benchley, author of "Jaws," agreed to encounter a great white shark in its natural environment. When a great white was finally located off the coast of Australia, Benchley was lowered in a metal cage to greet it face to face. The gargantuan beast attempted to gobble both the cage and Benchley with the same primitive lust that the mechanical great white had displayed in "Jaws."

Benchley was scared. You could see it in his face. But the cage held together. His face relaxed into a grin of respect and admiration for this, one of the last menacing creatures on earth. It circled back, again tried to devour the cage and him. He swiftly stuck an arm through the bars of the cage and gave its flank an appreciative pat.

Viva the monsters of the deep, the tigers of the sea, the great fish—*Carcharodon carcharias!*

—Joan Arehart-Treichel

the upper reaches of the oviduct.

The eggs are usually fertilized there. After fertilization a thin shell is secreted around each egg, or in the case of the spiny dogfish off the East Coast of the United States, around all five or six eggs. Some females, such as the horn shark off California and Australia, deposit their eggs in rocks in the ocean. These eggs have thick shells and stay there until the baby sharks hatch. Other females, such as the spiny dogfish and nurse shark, retain the eggs, but the eggs hatch inside the mother, and the embryos are nourished solely by their egg yolks until the young are expelled. Most female sharks, such as the tiger and great white, give birth to live babies. The yolks in their eggs become attached to the mother's uterine wall, forming a placenta. Then nutrients from the mother's bloodstream can nourish the developing embryos.

Gestation in the spiny dogfish is longer than that of any other vertebrate—22 months. Most sharks have a gestation of 8 to 9 months. And none of the shark species provide parental care to their offspring. "If the old man is around, he'll often eat his young," Gilbert says. Fortunately, during the pupping season, male sharks usually stay offshore, and the pups are hatched or dropped near shore.

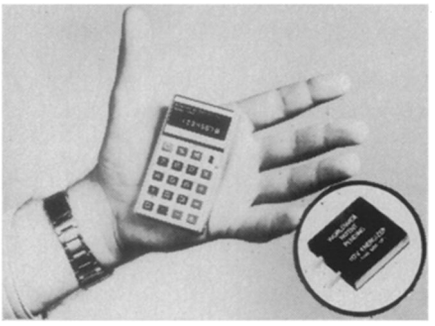
Meanwhile, Clark has been diving in waters off Mexico and Japan to explore shark behavior that scientists never suspected until recently—sleep.

In 1970, a Mexican fisherman and local diver, Carlos Garcia, was looking for spiny lobsters when he discovered lethargic sharks in caves. At first he thought he had found a shark graveyard, where sharks come to die. Then he realized that the animals could be awakened and become active and normal. The next year, Garcia led the underwater naturalist Ramon Bravo to the caves. Sure enough: lethargic sharks were there. They were requiem sharks, a member of the shark family that includes many of the man-eaters. Bravo had never seen requiem sharks immobilized before and unfrightened when divers approached them. Bravo reported his find to Clark; it excited her immensely. Zoologists had thought that these sharks, like other fish, remain in constant motion except when sick. The reason is that they expend more energy pumping oxygen-containing water through their gills while stationary than breathing through their mouths while in motion.

From 1973 to 1975 Clark studied these sleeping sharks, diving in Mexican caves 33 to 65 feet underwater. She found that the sharks, rather than entering into a true state of sleep, seemed to be tranquilized—stationary, but with their eyes alert and sharp. Their trance-like state seemed to come from the environmental conditions in the caves. Specifically, the caves may serve as cleaning stations—sort of health spas—for sharks. Chemical analysis revealed that, at certain times, the salt content of cave water decreases, and when this happens, parasites lose their grasp on sharks. The caves' waters may also give sharks a "high" because of excessive amounts of carbon dioxide and acidity.

Subsequently, Clark heard about sharks sleeping in caves off Japan. So from January to June of this year, she dove off Japan to see whether this was true. It was indeed. She often found three to eight sharks sleeping in a cave. Once even 20 to 30 sharks were piled on top of each other in a cave. The Japanese sharks enter a deeper sleep state than the Mexican sharks do, she reports, and they sleep anywhere from 20 minutes up to several hours at a time. "We could even push them around," she says, "and they're a cinch to catch by pulling a lasso around the tail."

During the forthcoming months Gilbert and Clark will undoubtedly provide still more insights into shark physiology and behavior. Gilbert will try to learn more about sharks' ability to quickly accommodate their vision to changes in lighting. Clark is now off to Israel to study more sleeping sharks. □



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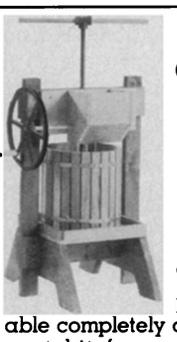

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