

Reasonable folks, like most scuba divers, recognize that the risk of a shark attack is extremely low unless one is careless or is diving in waters known to be infested with sharks, such as Eniwetok Lagoon for example. In fact, Dr. David Baldrige's analysis of more than 1,700 shark attacks indicates that scuba divers may have less chance of being attacked by a shark than other swimmers, snorkelers, and shipwreck survivors.

Imagine, however, living in a region with extensive coral reefs, a few low sand islands, plenty of lobster and fish, and teeming with twelve-foot tiger sharks. Imagine being dependent upon the ocean for food, and spending your entire life there — growing up, mating, and raising a family. This is exactly the situation with which the Hawaiian monk seal is faced.

This fascinating animal is one of only

HOW TO AVOID SHARK ATTACK (If You Happen to be a Hawaiian Monk Seal)

by
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in collaboration with
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three kinds of tropical seals; its Mediterranean cousin is very rare, and its Caribbean cousin is extinct. The Hawaiian monk seal, *Monachus schauinslands*, only occurs in the leeward Hawaiian Islands, that is, those generally low sandy islets and shoals lying between Kauai and Midway Islands. Although most of these islands are technically included within the City and County of Honolulu, they are all under the jurisdiction of the Hawaiian Island National Wildlife Refuge (Department of the Interior). The area was declared a refuge in 1903 by President Theodore Roosevelt in order to protect the nesting sea birds, rare land birds, green sea turtles, and the monk seals.

Access to these islands and their surrounding waters is tightly controlled by the United States Fish and Wildlife Service. Entry is only possible with special



Very few underwater observations of monk seals have been made and little is known about their behavior. Recent work indicates that the seal often enters underwater caves to seek shelter from sharks. (Leighton R. Taylor)

permits which are issued strictly for purposes of research that will benefit the animals. In addition, the monk seal has been declared an endangered species and receives special protection under the Endangered Species Act.

Shark-bite scars are common on many seals and it is well documented that sharks are their major predators. In the normal balance of nature such predation is beneficial to a healthy population of seals, but in the case of an endangered species such as the monk seal, with a population probably less than 2,000 individuals, extinction might be hastened by fatal shark attacks.

Working under a grant from the Marine Mammal Commission, my research associates and I have been conducting studies at one of the Leeward Island areas, French Frigate Shoals. Located about 450

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miles northwest of Honolulu, this region consists of about ten low sand islets, one

rock pinnacle and more than 175 square miles of reefs shallower than 120 feet.

My colleagues in this study were Captain Skip Naftel, master of the research vessel *Easy Rider*, his crew, and Timothy C. Tricas, a graduate student at the University of Hawaii. Skip Naftel is the perfect skipper for such a research project: he is an experienced commercial fisherman, an astute natural historian and an accomplished diver. Tim Tricas was also an essential participant in the research program. He has conducted behavioral research on gray reef sharks in the Marshall Islands and great blue sharks near Catalina Island in California. Working with Dr. Donald Nelson of Long Beach State University, he has become a specialist in the ultrasonic tracking of free-swimming sharks.

The objectives of our research project were three: first, to estimate the number of



The author sampling a bubble formed by seal exhalations in the ceiling of a cave some 30 feet below the surface. Analysis of the gas showed it to be high in carbon dioxide and depressed in oxygen but safe to breathe. (Timothy C. Tricas)

tiger sharks in the area by fishing with a standard long line; second, to determine what the tiger sharks were eating; and third, to assess the ranges of individual tiger sharks and possible interactions with monk seals. To accomplish this last task it was necessary to attach a ten-inch ultrasonic transmitter to a shark and track it with a boat-mounted, or diver-held, hydrophone.

In the course of eight days of fishing, the *Easy Rider* caught twenty-three tiger sharks off French Frigate Shoals ranging in length from six to thirteen feet and averaging ten feet. Three were found to have eaten monk seals, nine had taken green sea turtles (some whole and without teeth marks!), and thirteen had engulfed lobsters. Six had eaten sea birds such as albatross and shearwaters. One ten-footer had even eaten another six-footer already hooked, and still another had digested a porpoise. We succeeded in attaching a transmitter to a female tiger shark about thirteen feet long and tracked her continuously for forty-eight hours. During that time she swam over 50 miles per day and ranged from 60 to more than 500-foot depths, often reaching an estimated swimming speed of four knots.

After catching so many tiger sharks, the question occurred to us: how do any monk seals manage to avoid shark attacks? Many individuals, particularly mothers with suckling young, spend extended periods hauled out on the small sand spits scattered throughout the Shoals and are probably safe, although we have seen large tiger sharks right off the beach in water less than five feet deep. Some biologists believe that the seals hunt mainly at night and may stay at sea for over a week. Skip Naftel has seen them at Brooks Bank, eighty-five miles from the nearest exposed land.

What kind of behavior patterns have the seals adopted to avoid attack, or at least decrease the risk of one?

We were diving at the base of La Pérouse Pinnacle, a rocky projection of French Frigate Shoals, about 100 yards long and 200 feet high. Colored a ghostly white from sea bird droppings, it looks, from a distance, like the very ship — its sails set full — on which the French navigator La Pérouse was sailing when he discovered the shoals named after his frigate. We were searching for a shark cage, abandoned by a film crew some two years ago, in about thirty feet of water. The refuge manager, Palmer Sekora, based in Honolulu, had asked us to locate it and report on its condition. We found it,

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or at least parts of it. Fragments were spread all over the reef.

During our search, I had noticed deep undercut areas at the base of the pinnacle and returned to investigate them. I stuck my head well back into one of the low but deep caves and as my eyes adjusted to the darkness, I was startled to see a monk seal, weighing over two hundred pounds, staring back at me with large brown eyes. At the top of the cave, I noticed a reflection of the seal's head in a bubble trapped in the ceiling. Most scuba divers who have gone into caves have noticed how exhaust bubbles from their regulators become trapped too. I had not yet entered the cave far enough for this to happen and my exhaust was visibly rising to the sea surface. None of the other divers had been near this cave, and French Frigate Shoals seldom sees divers at all. As I wondered how the bubble had been formed in the cave, the monk seal occupying the hole casually, or so it seemed to me, stuck her nose up into the bubble, exhaled, inhaled, and resumed her staring. Several moments later she did it again. Being careful not to disturb her, I slowly backed out and swam to get Skip so he could share the observation. We returned and again witnessed the same behavior. Investigating two additional caves, we found two other seals doing the same thing. A swim around the island revealed eight good sized undercuts or caves, six of which had ceiling bubbles.

At dinner that night aboard the *R/V Easy Rider*, we discussed the possible reason for the seal's behavior and the origin of the bubbles. We propounded the following hypothesis: a monk seal feeding in the area near a cave is threatened by a shark. The seal retreats into the cave where the shark cannot get at it. The shark continues to patrol the area outside the

overhang, barring the seal's escape. During the seal's presence in the cave it has exhaled some of the air it inhaled at the surface. Monk seals exhale underwater; so do California harbor seals and sea lions. The bubble formed by the exhalation reflects the seal's face in a manner similar to the ocean's surface where it normally takes a breath. This reflection stimulates it to stick up its nose and breathe just as it would at the surface. Of course the bubble does not actually contain air, but rather a mixture of gases much higher in carbon dioxide. However, there is still sufficient oxygen in the bubble to allow the seal to extend its breath-holding time and wait out the shark.

We decided to sample the gas in the bubble using a syringe to extract it and to transport it to Honolulu for analysis. We found that the ceiling bubble contained about ten times as much carbon dioxide and one third as much oxygen as is dissolved in air-saturated sea water.

We also decided to sample the bubble in our own, less scientific, manner as well. After locating a cave with a bubble and without a monk seal, I removed my tank, crawled into the cramped underhang and carefully took the gas sample with the syringe prepared the night before. I estimated the bubble to be about two cubic feet. Skip then entered the cave and took a more practical sample. I decided to follow his example. As my face entered the bubble, I was aware that its contents were warmer than the water or the air at the surface. A seal, with its high body temperature, must have recently exhaled the bubble. I exhaled my breath of scuba-tank air and inhaled a small portion of monk seal breath. It tasted slightly fishy, but really quite good. The bubble was certainly usable, at least in an emergency. Although continued use of the bubble would raise its carbon dioxide content, diffusion from the oxygen saturated water would soon bring it back into equilibrium during periods when the seal was not bubble breathing in the cave.

As I left the cave and took a fresh breath from my regulator, two striking thoughts occurred to me: Skip and I were probably the only humans in the world to breathe pure (?) monk seal breath; and if the bubble tasted fishy to me, would it taste like my luncheon onions to the next seal to use it?

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