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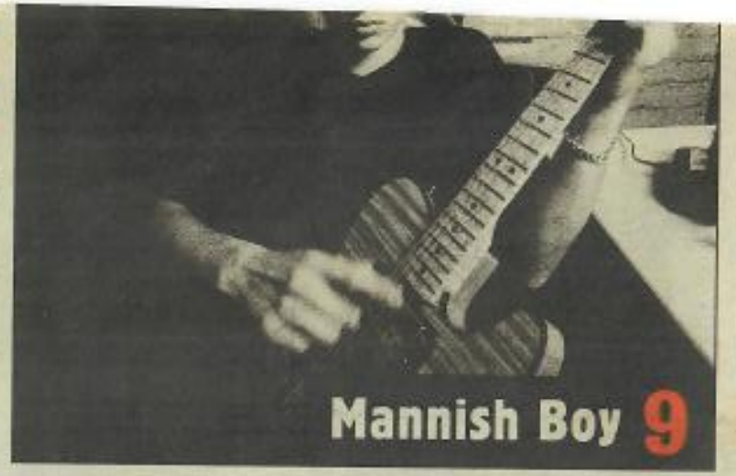
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Recent research into the travel patterns of sharks is yielding surprising results. by JOHN WYTHE WHITE

Shark Highway

PAGE 6

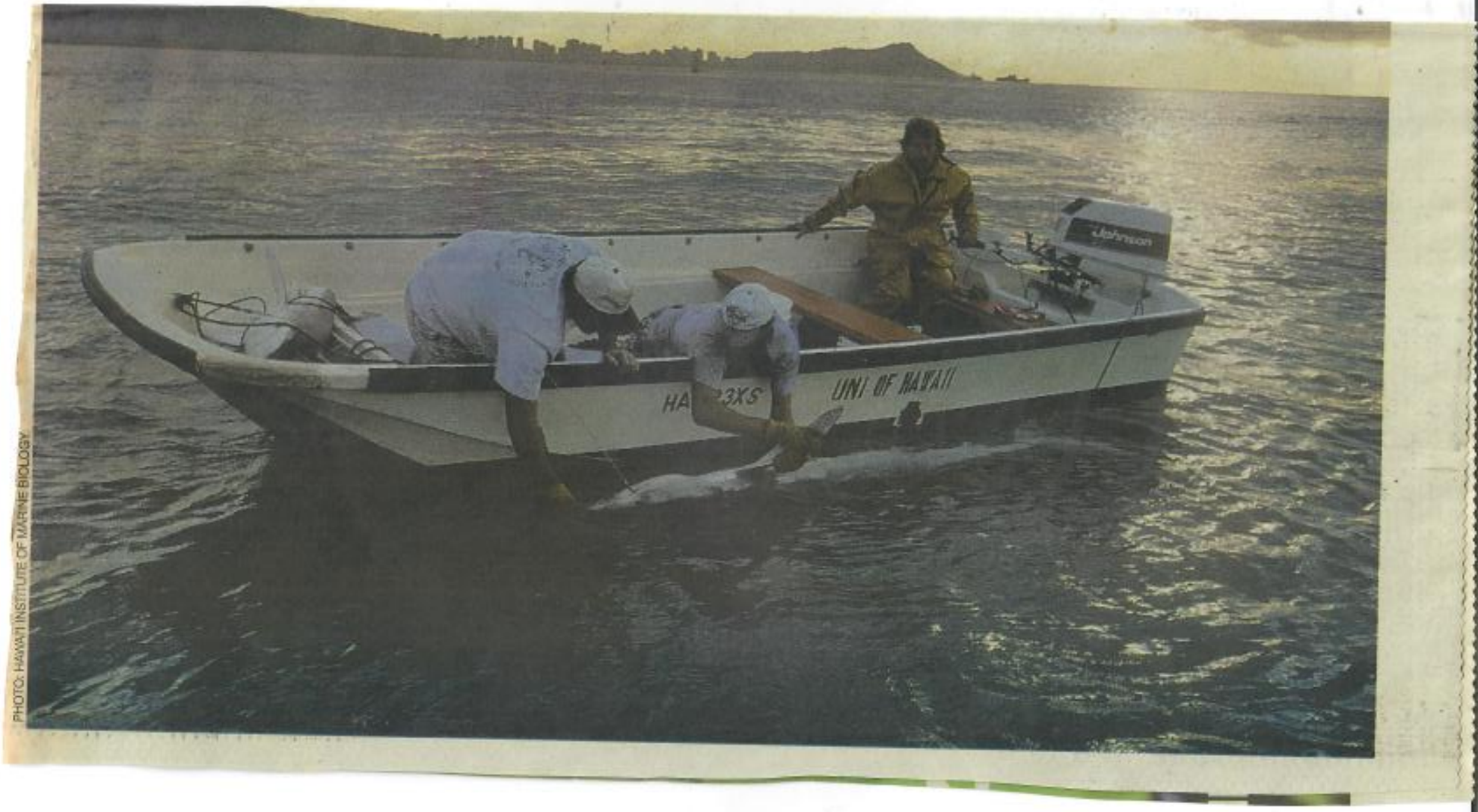

PHOTO: HAWAII INSTITUTE OF MARINE BIOLOGY

PHOTOS: HAWAII INSTITUTE OF MARINE BIOLOGY

Lab is electro-sensitivity in hammerheads. It's a fact that every marine organism generates an electric field. Sharks have a built-in sensory system called the Ampullae of Lorenzini, which lets them detect potential prey. On a boom suspended over an enclosed shark pen, Steve videotapes the responses of hammerhead pups to artificially generated electric signals. They attack the source of the signals, and Steve records the data.

The Ampullae of Lorenzini are located around the shark's head. Shaped like a round flask, they're connected to the surface of the skin by a tube. Cells lining the base of the flask measure the ambient electrical field outside the shark. The data is conducted down the tube, which is filled with a conductive jelly. By sampling the information coming from an array of these ampullae, the shark gets a picture of the status of the electrical world in the immediate vicinity of its body, a few inches at most — for example, the tiny electrical fields that may be broadcast from a nearby shrimp.

Apart from contributing to the scientific knowledge base of little-known sharks, this electro-sensitivity research already has a practical application. Oil companies are funding the research because it gives them some information they need to know. Specifically, can they find an electric field signature that's repellent to sharks?

The reason they need to know is because, when their vessels are out exploring for potential new sources of oil, they deploy an array of cables 5 kilometers long, containing sonar devices that map the geology of the ocean floor. Microphones on the cables pick up echoes and paint a picture of the ocean floor. The problem is, sharks attack the cables, bite the sensors and do millions of dollars worth of damage. The oil companies can't use sound to deter the sharks, because the array system is sonar-based. They can't use chemicals, because there are no identified chemicals that are noxious to sharks. Besides, sharks don't stick around long enough in any given place to imbibe the chemicals.

It's a fact that sharks use electromagnetic signals to detect prey, but do they also use them to identify potential enemies? If so, then the oil companies could generate signals which would repel the sharks from their sensitive, expensive equipment. They hope to obtain some helpful information from the Shark Lab.

Kim recently received an e-mail from NASA asking for information about hammerhead sharks. Despite the apparently ungainly shape and contour of the hammerhead, with its winglike protrusion emanating sideways from its head, it has been proven to be a highly maneuverable animal that moves efficiently through its environment. NASA wants the data to help it design spacecraft.

Another organization interested in HIMB's shark research is the state of Hawai'i's Division of Aquatic Resources. Data from its tiger shark research helps the agency determine public policy. For example: If a shark attacks a surfer, does it make sense to hunt for the killer? The answer is no. Thanks to the shark group's research we know that sharks don't "park" in a single locale. They travel long distances in straight lines, and may not return to a particular place for weeks or even months.

The electronic listening post off the shore of Sand Island indicates that more than half of the sharks come back, but there seems to be no pattern or rhythm to their revisits. Kim theorizes that this is because sharks are patrolling in response to their environment, all around the island chain, looking for food.

Opposite page: Turned belly up, a hooked tiger shark becomes immobile, allowing researchers to insert an electronic sensing device into the shark's stomach (this page). Left: A hammerhead patrols for food.

"You can't catch a single tiger shark or set nets for it," says Kim. "They move around too much. Tiger sharks regularly travel from O'ahu as far as the Penguin Banks off Moloka'i. It's a shark highway out there."

Besides, he says, attacks on humans are extremely rare events: "Sharks are usually conservative and cautious. We will never, ever know why a specific incident occurs. To know why a shark attacks a human being, we need to know the experience of the shark minutes or hours before the attack. It may have been feeding and its prey got away, and the shark goes after it and sees a dangling foot. It may just be hungry and unlucky. There may be a beached whale in the vicinity that aroused its senses. All we really know is that most attacks occur out of nowhere."

On a recent episode of National Geographic Explorer's *Animal Planet*, "Shark Gordon" followed Kim's group out on a shark hunt. The episode began with shots of sharks attacking floating gooney birds and then recounted several attacks on humans. Gordon noted that tiger sharks are man-eaters that can weigh up to 3 tons and measure 20 feet long.

But Kim says that tiger sharks only rarely attack people. That's something his research is trying to prove: that sharks visit the same place infrequently; that they are very selective in what they eat; that, therefore, hunting killer sharks is pointless.

"Sharks patrol a huge territory to make a living," he says. "They go 30 miles away with no regular return. You can't cull a local population to catch a single shark. The tiger doesn't deserve its reputation as a man-eater. We get along very well every day, and there's no way to adjust the situation without doing a lot of damage." ■

JOHN WYTHE WHITE

When we leave Snug Harbor on Sand Island, it's still dark. As we head into open ocean, a fiery red sun rises from behind Diamond Head, making it look like an erupting volcano.

Six of us — professor Kim Holland of the Shark Research Group of the Hawai'i Institute of Marine Biology, four graduate students and one journalist — are riding in two vessels, an old Navy surplus captain's boat outfitted with lots of electronic tracking equipment and an 18-foot Boston Whaler. They're fishing for tiger sharks. I'm just along for the ride.

Yesterday at dusk, the students floated hundreds of yards of longline with side lines attached, baited with marlin and 'ahi heads, provided courtesy of Tamashiro's Market in Kalihi. Today they're pulling in the line, hoping to have caught a tiger or two.

Everybody works hard while I ask questions and take notes. Kanesa Duncan keeps the big boat steady while Steve Kajiura pulls in the line. The sea is choppy, with the current flowing in one direction and the wind blowing in another. Kanesa has her hands full trying to keep the line from going under the boat, while at the same time recording information shouted at her from the rest of the crew.

Standing on a small platform at the stern, hauling in the longline, only Steve's sea legs keep him from swimming with the fishes. As he pulls in the line, Tim Fitzgerald removes the side lines from it, unhooks the fish heads (if they're still there) and throws them back into the water. He yells to Kanesa, who writes the information down in a log book, telling her what kind of hooks are on the side lines and whether or not the bait has been removed from them. (Tim is also responsible for the group's Web site at www.hawaii.edu/HIMB/sharklab; check it out for more information and lots of photos.) Aaron Bush lays the line carefully into a big plastic tub. Kim is hovering nearby on the Whaler. Later on, he changes places with Aaron and Tim.

Here's the procedure: If a shark is hooked on one of the side lines, the line is marked with a buoy and set adrift. The Whaler goes after it and pulls it in. Hook in mouth, the shark is brought up to the surface beside the small boat and lassoed around the tail. Pinned fore and aft, it thrashes around until it gets tired. Then the two people on the boat turn it belly up. And a strange thing happens.

Turn a shark on its back and it just floats there, calmly, as if in a trance. The technical term is "tonic immobility," but by any name it's a big break for somebody who wants to get up close and personal with sharks.

Once the shark is upside down and cooperative, Kim makes an incision in the blubbery part of its stomach, inserts a cylindrical electronic device and sews it in. The device is called a CHAT (for Communication Histogram Archiving Transmitter), which is coated with beeswax and paraffin so that the shark's immune system won't know it's there and reject it. Inside the CHAT are electronic sensors that measure depth and temperature. The CHAT receives and compiles data which is later transmitted via an infrared port to a data-collecting computer on the ocean floor. All the shark has to do is swim around near the "listening post" and his internal computer automatically downloads up to six months worth of data that reveals where he's gone and what he's been up to. The students go scuba diving to pick up the sunken computer and transfer the data to their own computers in the lab.

Tough and resilient, the shark's mouth will heal quickly from the hook wound. Once the CHAT is in place, the shark is de-hooked and set free. But the procedure described above happens only under ideal conditions.

"Not much surgery today," says Kim, pointing to the Whaler pitching about in the whitecaps. No matter: We catch no tigers, anyway.

Instead, we pull in two sandbar sharks. I'm in the Whaler with Aaron and Tim when they pull the first one up. Aaron has a hard time roping it around the tail, so he asks me to grab onto the shark's pectoral fin to keep it still.

Holding a shark by a fin is an amazing feeling. It has no bones, only cartilage, so it wriggles and twists like no living thing I've ever held onto. The scientific word for sharks, skates and manta rays is *elasmobranch*, meaning "soft-armed," referring to the fact that they have no spines in their fins. This makes them very elastic, but it also gets them into trouble. Some people really love their shark-fin soup.

The sandbar sharks are tagged, not implanted, and I get to do the honors on this one. Holding the tag-securing device in one hand and a pectoral fin in the other, I try to attach the thing where Aaron tells me to. But the shark is still occasionally thrashing.

"This is not what I would call 'catatonic,'" I complain. The creature I'm tenuously grabbing is so flexible it could probably bend itself in half just to bite off my hand. But I manage to tag it anyway. And I'm grateful for the chance to know what this infamous animal actually feels like.

The Hawai'i Institute of Marine Biology's home is the 28-acre Coconut Island in Kāne'ohe Bay. Its marine science research laboratory focuses on biodiversity and biotechnology. Sixty-four acres of surrounding coral reef have been designated by the state of Hawai'i as the Hawai'i Marine Laboratory Refuge. Its enclosed lagoons and fishponds contain hammerhead, sandbar, black tip and white tip sharks being studied by the HIMB's Shark Research Group, led by Kim Holland.

Kim is a chemo-sensory physiologist who studies the physiology of the chemical senses, i.e., smell and taste. He's interested in how fish use their sense of smell and taste to find food, mates and homes. He's also concerned about how sharks use up their so-called "energy budgets."

An energy budget, Kim explains, is how an animal divides up the energy available to it, coming in in the form of food that has to be used for a variety of functions: maintenance of body metabolism, growth, locomotion and, in the case of mature animals, producing sperm or eggs. If there's not enough food coming in, the animal will eventually waste away. So the animal has to "decide" how to spend its fuel. In the case of constantly swimming animals like sharks, locomotion is a necessary part of the budget.

Possibly because sharks are second only to dinosaurs as animal-world media darlings, Coconut Island's Shark Research Group has been the subject of several television documentaries. Publicity aside, Kim Holland is exactly where he wants to be.

"We're sitting in the middle of the sharks' pupping ground," he says. "The female hammerheads come in the summer to have their babies. The pups stay here for a year learning to fish and hunt, then go out into the deeper water outside the bay. For such a research facility, this location is one of a kind. We've got a tropical island that's just a few minutes away from a major city. It's a killer combo that gives us the drop on everybody else.

"You never know where research is going to lead you," Kim continues. He's telling me about the fact that, by keeping hammerhead sharks in shallow ponds, they have noticed that they get suntans. Humans and pigs are the only other animals known to tan, so the HIMB can provide an additional animal model for studies on what has become, thanks to the depletion of the ozone layer and subsequent ultraviolet ray penetration, a hot topic.

Another hot topic at the Shark Research

From Page 1

The Hawai'i Institute of Marine Biology's Shark Research Group is changing the way we look at sharks.

Eyes of the Tiger

JOHN WYTHE WHITE

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