Stinging SEAS

Tread Softly In Tropical Waters

Text and photographs by GARY C. WILLIAMS

I WAS IN THE OCEAN, IN WATER about waist deep, at the popular swimming spot at East Point Reserve, Darwin, when I felt a severe sting on my thigh. I climbed back into the boat, and, thinking it was a box jellyfish, looked for welt marks. There were none. After about five minutes my back around the kidneys started to tighten up and a mild pain began. By the time I got to the boat ramp ten minutes away, it felt like I was being stabbed. My chest was tightening and breathing was becoming strained. I poured vinegar over the sting area, but that did nothing to relieve the pain, and I still couldn't locate any stinger marks. Twenty minutes later, vomiting and in agony, my heart racing, I arrived at the hospital. The doctors gave me three injections of pethadine before the pain subsided.

—Geoff Bishop

ALONG THE NORTHERN coastline of Australia, water sports are virtually off-limits to all but a few foolhardy risk-takers and those oblivious of the local fauna. An Australian tourist industry that promotes spectacular beaches doesn't highlight the two things that keep most people out of the water—15-foot-long saltwater crocodiles and the much less conspicuous cubozoans, venomous sea creatures related to jellyfish. Often only a few inches long, the deadliest species deliver a sting that could swiftly leave you dead. Most victims don't even see what hit them.

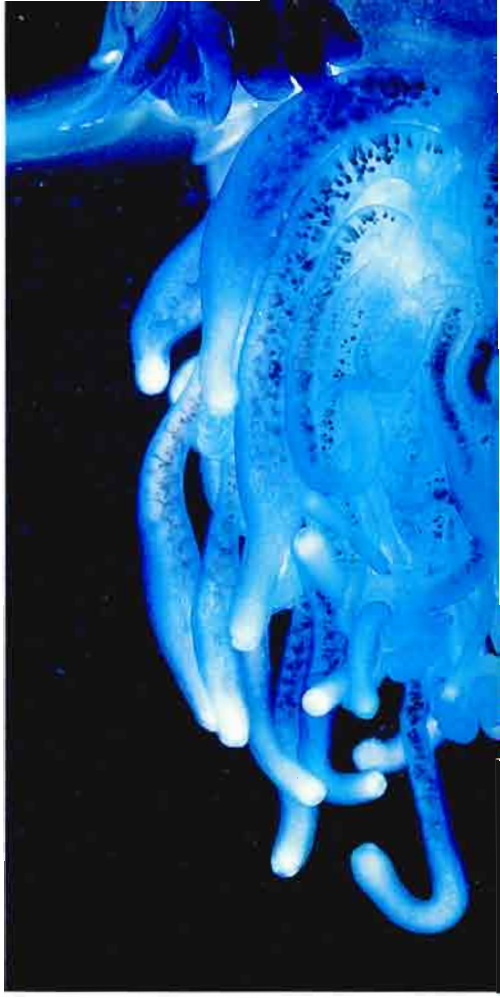
About 70 documented deaths from cubozoans—more than those caused by sharks and crocodiles combined—have been reported from Queensland and the Northern Territory since 1884. Three dangerous kinds of cubozoans, or box jellies, inhabit the warm waters of Australia's eastern and northern shores: the common box jelly (*Chironex fleckeri*), the sea wasp (*Chiropsalmus quadrigatus*), and the Irukandji (*Corukia barnesi*). It was an Irukandji that wounded bank manager Geoff Bishop. Unlike the more dangerous common box jelly, it leaves no welt marks. The Irukandji was considered new to science in 1961 when Cairns physician John Barnes identified it in a medical case. Although the species was named for him, he chose the common name for the Irukandji Aboriginal people of northern Queensland.

Not until 1955, when a young boy was killed at Cardwell, Australia, did biologists first identify *Chironex fleckeri*. It's now considered to be the world's most venomous marine animal, able to kill a human in three to 15 minutes of excruciating pain, ending in heart and breathing failure. (In contrast, other cubozoans, such as *Carybdea marsupialis* from southern California, have a sting almost undetectable to humans.)

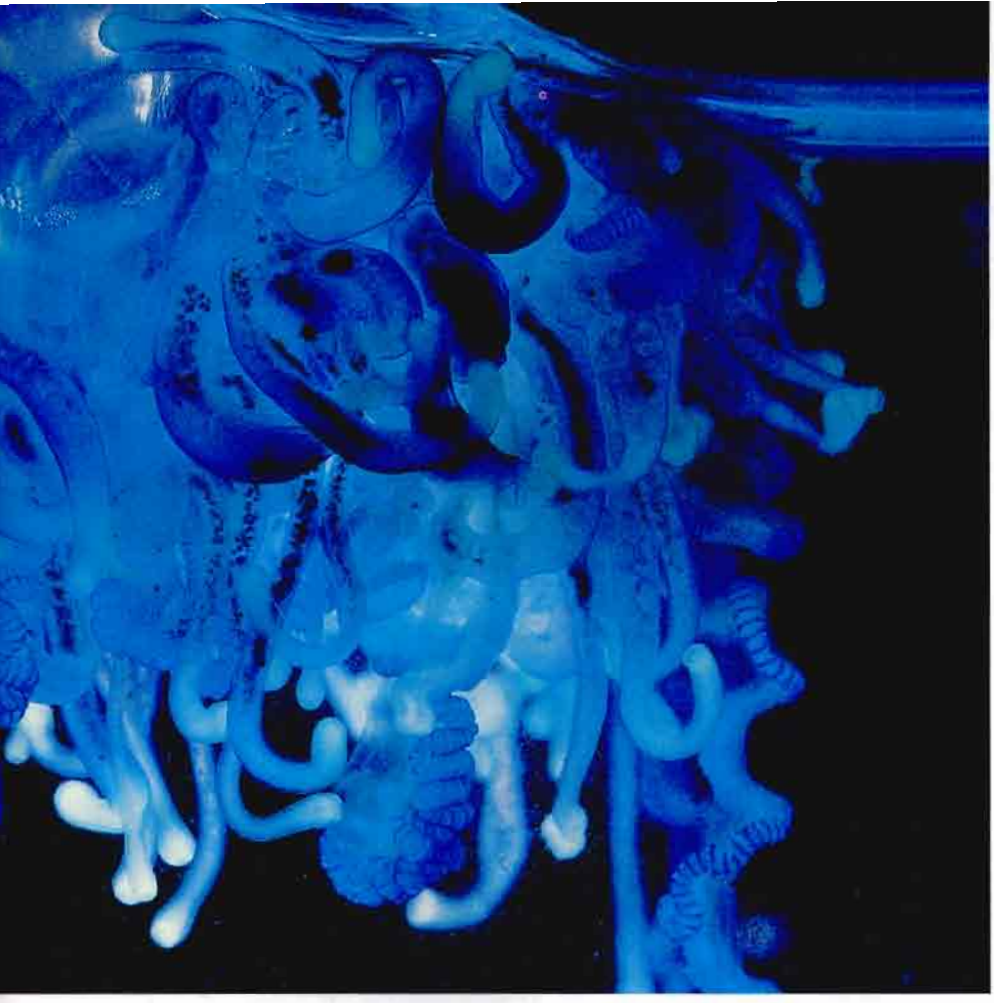
Besides the cubozoans, the northern and eastern coasts of Australia harbor the bluebottle or Portuguese man-o'-war (*Physalia physalis*), with zooids up to 100 feet long and containing an estimated one million stinging structures known as nematocysts. Resembling jellyfish but more closely related to stinging hydroids and fire corals, bluebottles inflict about ten thousand envenomations (including some that are fatal) in Australian waters each summer. The stings of this species as well as the cubozoans are so hazardous that Australian divers wear a "sting suit": a thin, full-length Lycra diving suit that affords no insulation from fluctuating water temperatures but inhibits stings and coral abrasions.

MOST VENOMOUS MARINE ANIMALS belong to one of five phyla or major groups of animals: coelenterates, annelids, mollusks, echinoderms, and vertebrates. These include such noteworthy and infamous creatures as stinging hydroids and anemones, bubble corals, fire corals, jellyfish, fire worms, cone snails, blue-ringed octopuses, flower urchins, fire urchins, crown-of-thorns starfish, stingrays, catfish, scorpaenid fishes (such as lionfish, and stonefish), and sea snakes.

The vast majority of venomous marine creatures inhabit the shallow water tropics, particularly coral reef habitats, known for their high degrees of biodiversity, abundance, and competition. Coral reefs of the western Pacific—within a triangle defined by the Philippines in the north, New Guinea in the east, and central Indonesia in the west—have the highest marine biodiversity in the world. The reasons are complex and not fully understood, but include the extensive shallow, consistently warm water, the fragmented habitat, and, surprisingly, periodic disturbances caused by cyclones, volcanoes, earthquakes, El Niños, and other changes in prevailing currents.



The zooids of the colonial Portuguese man-of-war, or bluebottle (*Physalia physalis*) can be up to 100 feet long.



The study of venomous organisms has lead to a rich terminology, so some definitions are in order. Toxins are poisons produced by living organisms. Venoms are toxins transmitted via some delivery mechanism. Envenomations are poisonings caused by a bite, sting, or puncture. Sea creatures use venoms for killing or stunning prey or as a counterattack against potential predators—or both. Although many sea animals are toxic, only a small proportion of these species can actively deliver their toxins, and are thus considered venomous.

These diverse sea creatures deliver their venoms in a variety of ways, but most delivery systems can be classified as either passive (by contact) or active (by injection). The spines of echinoderms, the bristles of fire worms, and the stinging cells of the jellyfish tentacles all lie in wait passively for their victims to swim or drift by. Injectors are more aggressive. Octopods and sea snakes bite. The spines and rays of various fishes puncture the skin of their antagonist, and the slow-moving cone snails thrust their fatal darts at overly curious creatures.

COELENTERATES, THE GROUP OF marine animals that people most often encounter, best exemplify passive means for delivering venom. Of the 9,000 species worldwide, about 100 coelenterates are toxic to humans, though only a few can be fatal. Coelenterates include corals, hydroids, anemones, jellyfish, and other organisms that lack the complex organs or organ systems of most other animals; their digestive tract, for instance, is a sac with a single opening. Their bodies take the form of either a free-swimming medusa or a sessile polyp, but each form has a ring of tentacles surrounding a central mouth.

Despite their structural simplicity, coelenterates have perhaps the most intriguing form of venom transfer. Specialized cells called cnidocytes hold the unique, capsule-like stinging structures, or nematocysts. These complex, microscopic stinging structures are often concentrated in large visible groups, or batteries, along the surface of the tentacles. Each nematocyst capsule can contain powerful toxins, a mixture of polypeptides and proteins. The nematocyst discharges a hollow thread, often armed with spines or barbs, that penetrates the victim's skin. This micro-injection of venom often goes unnoticed, as toxin flows through the thread into the victim.

Passive venom transfer can also happen if a detached jellyfish or box jelly tentacle suspended in the water adheres to the skin. Pouring two liters of vinegar on the wound for 30 seconds often stops the venom's discharge and may actually prevent an otherwise fatal dose.

While conducting my field research in the tropical Pacific, in such places as New Guinea, Palau, and the Solomon Islands, on virtually every dive trip, I seem to get stung on the inside of my right wrist. I hold my underwater camera in that hand and often steady it on a promontory of exposed dead coral rock. If my wet suit sleeve rides up a couple of inches, my exposed skin contacts often-inconspicuous hydroid colonies that cover rock surfaces. In my case, the usual culprits include the stinging hydroids *Aglaophenia cupressina* and *Gymnangium gracilicaule* and fire corals (*Millepora* spp.). These sessile coelenterates inflict very intense stings like a series of bee stings. The pain lingers for days, and the sting causes minor but permanent scarring.

Considered the world's most venomous marine animal, a common box jelly can kill a person in a few excruciating minutes.

Anywhere in the tropics, a serious sting can appear seemingly from nothing as detached but still functioning jellyfish or siphonophore tentacles drift invisibly in the water. Once, off Mazatlan, in Mexico, to my horror I found what looked like a strand of angel hair spaghetti stuck to my face and plucked a stinging string from my upper lip and cheek! The offending entity was just such a drifting, but still very painful, bluebottle tentacle.

Many coelenterates are polytrophic feeders, able to derive nutrition in more than one way. For example, most coral polyps on a reef act like miniature greenhouses during the day and become efficient micropredators by night. A symbiotic relationship with unicellular algae (zooxanthellae), which live in the coral tissues, allows them to function like plants, soaking up sunlight that penetrates to the shallow sea bottom. The algae make food products by photosynthesis and pass on nutrients to the coral. At night, when photosynthesis ceases, coral tentacles armed with nematocysts capture food from the passing plankton.

In his seminal work on tropical American octocorals, the Smithsonian Institution's Frederick Bayer, commenting on one group of Caribbean corals, states, "There is some evidence that certain species of Gorgonacea with abundant zooxanthellae have lost most, if not all, of their nematocysts, and with them the power to feed. Conversely, the species with few zooxanthellae may have especially abundant nematocysts and well-developed digestive structures, indicating dependence on external sources of food." Species that derive little or no nutrition from algal symbionts rely on a battery of nematocysts, which provide their sole source of food, whereas corals that obtain plenty of nutrients from their symbiotic algae have less need for abundant and efficient nematocysts.

Nevertheless, on many Indo-Pacific coral reefs we find exceptions to this correlation between algal symbiosis and venom delivery. Diurnal, soft-bodied anemones that expand their tentacles for photosynthesis during the day, such as stinging anemones in the genus *Actinodendron*, expose themselves to potential predators. So their tentacles are often heavily armed with conspicuous batteries of stinging cells for protection.

Marine biologist and Academy Research Associate Dave Behrens was rather rudely introduced to one such anemone during the 1997 Academy research trip to the Philippines. As he recalls the incident, "I was examining the substrata for nudibranchs and started to probe some cryptic bubbly material that looked like algae....It immediately felt like putting your hand over the flame of a blowtorch or getting a blast of boiling water...the pain was incredible!" All of the half dozen or so species of branching anemones can deliver such a potent sting.

Coral reef biologist Gary Williams heads out for a dive off Palau.

Above Right: Divers frequently brush up against the innocuous-looking fire coral, which can cause intense stings and even permanent scars.

VENOMOUS MARINE CREATURES: CAUSES & EFFECTS

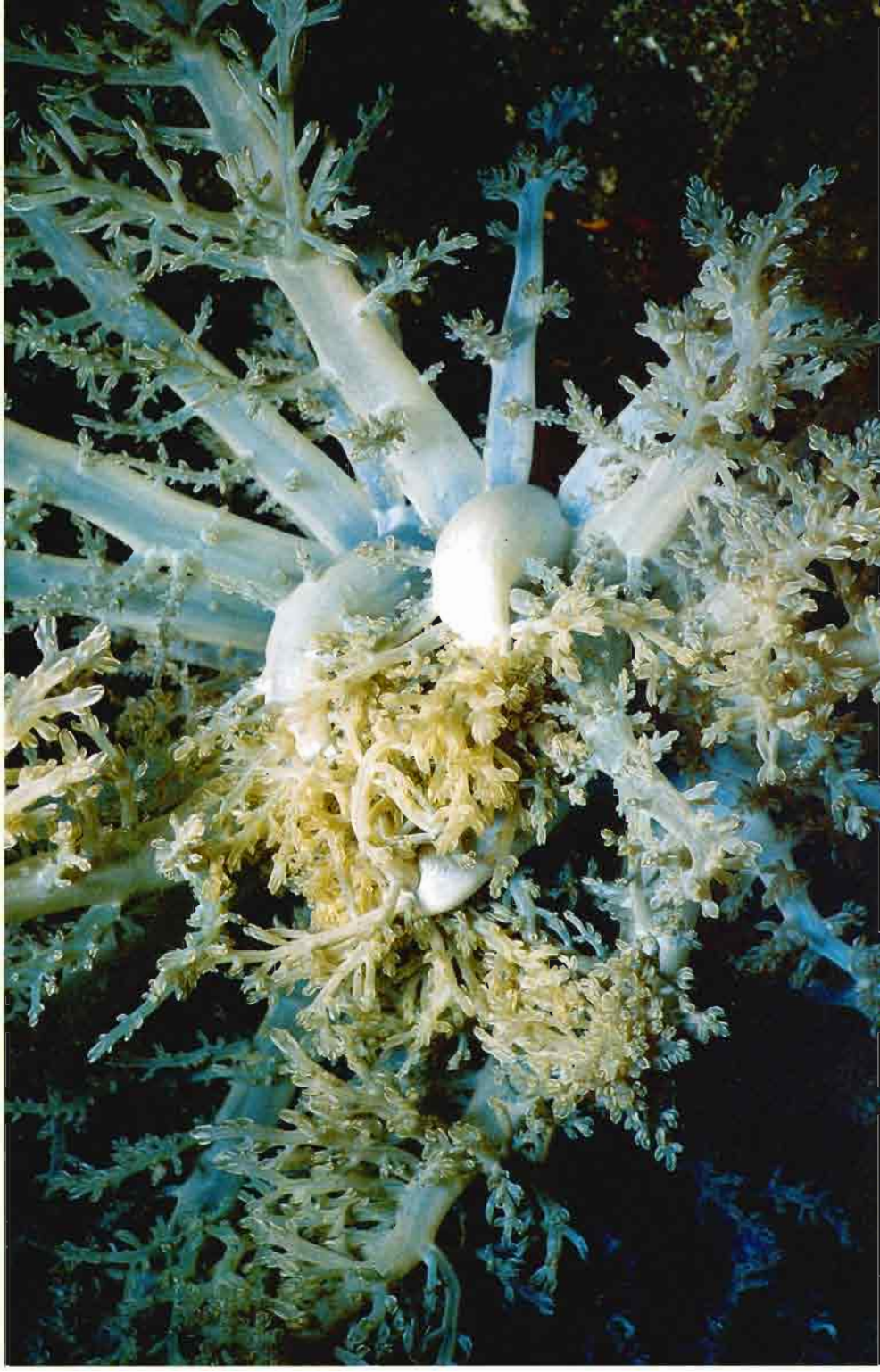
Type of animal	Toxin	Effect
Phylum Coelenterata (passive sting)		
Stinging hydroids, Fire coral	—	skin rash/lesions
Bluebottle	neurotoxin	tissue necrosis, hemolysis
Jellyfish	—	cardiovascular distress
Box jellies	myotoxin and vasoactive toxins	respiratory or myocardial arrest
Stinging anemones	—	skin rash/lesions
Bubble corals	—	skin rash/lesions
Phylum Annelida (passive sting)		
Fire worms	—	itchy skin rash
Phylum Mollusca (active)		
Cone snails (dart thrust)	neurotoxin	paralysis
Blue-ringed octopus (bite)	neurotoxin	paralysis and respiratory failure
Phylum Echinodermata (passive puncture)		
Flower and fire urchins, crown-of-thorns	—	nausea and respiratory distress
Phylum Chordata (active)		
Stingrays (puncture)	hemotoxins	tissue necrosis
Catfish (puncture)	neurotoxins or myotoxins	respiratory distress
Scorpaenids (puncture)	neurotoxins or myotoxins	respiratory distress
Sea snakes (bite)	hemotoxins	anticoagulation
	neurotoxins	paralysis and respiratory arrest

ACTIVE VENOM DELIVERY SYSTEMS include darting, biting, or puncturing prey. Cone snails (*Conus* spp.) have evolved a unique, sophisticated system to thrust darts for lethal injections. Many evolutionary biologists believe that natural selection has generated an arms race between predator and prey, escalating their morphological and behavioral complexity over time. The predators have evolved ever more potent venoms and more efficient means of delivery, while the prey have evolved such defenses as explosive speed, formidable armature, or increased resistance to toxins. Academy herpetologist Joe Slowinski (see *CALIFORNIA WILD*, Spring 2000) has made this case for venomous snakes and their prey. Marine biologists suspect that a similar phenomenon is currently taking place between tropical cone snails and the fast-moving fish that are their primary prey.

The world's only lethally toxic octopus, the blue-ringed octopus (*Hapalochlaena lunulata*) lives in shallow rock pools of tropical Australia, New Guinea, Indonesia, and the Philippines. Rather than ejecting ink in defense, this diminutive cephalopod inflicts an almost imperceptible bite with its beak and releases a powerful neuromuscular poison from its salivary glands. The toxin resembles the tetrodotoxin of pufferfish (see *CALIFORNIA WILD*, Summer 1998), but a blue-ringed octopus bite produces a flaccid paralysis far quicker than eating the flesh of a puffer. Academy malacologist Terry Gosliner recalls a scary encounter near the Christensen Research Institute in Madang, Papua New Guinea in 1988.

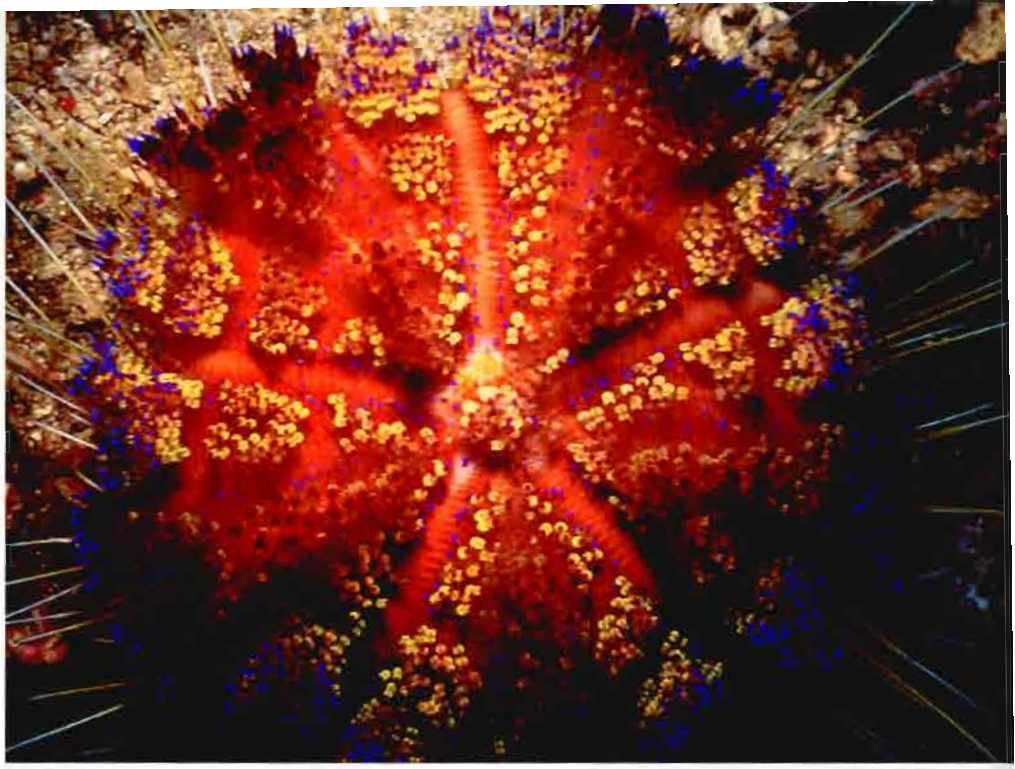
Natural selection has generated an arms race between predator and prey.

"It was one of those dives," Gosliner relates, "...first I saw a big shark on the south side of Magic Passage, then a stonefish and two scorpionfishes. I began to work up into the shallows, turning over slabs of coral rubble, looking for nudibranchs. I held one slab down with my left hand so it wouldn't move in the surge, while I probed the newly exposed broken rubble beneath. All of sudden I felt a sensation along my bare arm. A five-centimeter-long blue-ringed octopus had crawled up from the slab onto my arm. Antivenom was available at the Madang Hospital, about 45 minutes away by boat and car, but I would have had only 20 minutes to get there...there would have been no way. I shook my arm and gasped in relief as the octopus fell away. The best part was that I found a new species of nudibranch under that slab!"



Sea anemones of the genus* Actinodendron *have batteries of toxin-injecting nematocysts.

Many of the 250 or so venomous marine fishes belong to the family Scorpaenidae, collectively known as "rockfishes." It includes many notable species with names that reflect their reputation: firefish, lionfish, stingfish, and scorpionfish. Perhaps the most famous is the drab reef stonefish



Two venomous echinoderms, the sea urchin* Asthenosoma *(top), which has venom glands among the shorter spines, and the crown-of-thorns starfish (below) which has two-inch-long, extremely sharp spines that project from its body and its many arms.

(*Synanceia verrucosa*). When disturbed, its dozen venom-tipped dorsal spines suddenly project perpendicular to the back of the fish, injecting venom that can lead to severe pain or even death.

Most of the various toxins associated with venomous marine animals can be classified into three groups of chemical compounds: myotoxins, neurotoxins, and vasoactive toxins, which affect the muscles, nervous system, or blood vessels, respectively. Some of the more notable and infamous compounds include:

- T1 and T2 myotoxins from the box jelly that produce potentially lethal muscle contractions
- Conatokin neurotoxins from cone snails that chemically disrupt the central nervous system
- P3 neurotoxin from bluebottles (*Physalia* spp.) that can significantly disrupt the nerve conductance system
- CrTX vasoactive toxins from the box jelly *Carybdea rastoni* that induce blood platelet aggregation and smooth muscle contractions.

FOR MORE INFORMATION

A wealth of information on marine venoms is provided by a variety of websites, including:

California Academy of Sciences Library: Venomous creatures on the web *http://www.calacademy.org/research/library/biodiv/biblio/Venomsites.html*

The Medical Journal of Australia *http://www.mja.com.au*

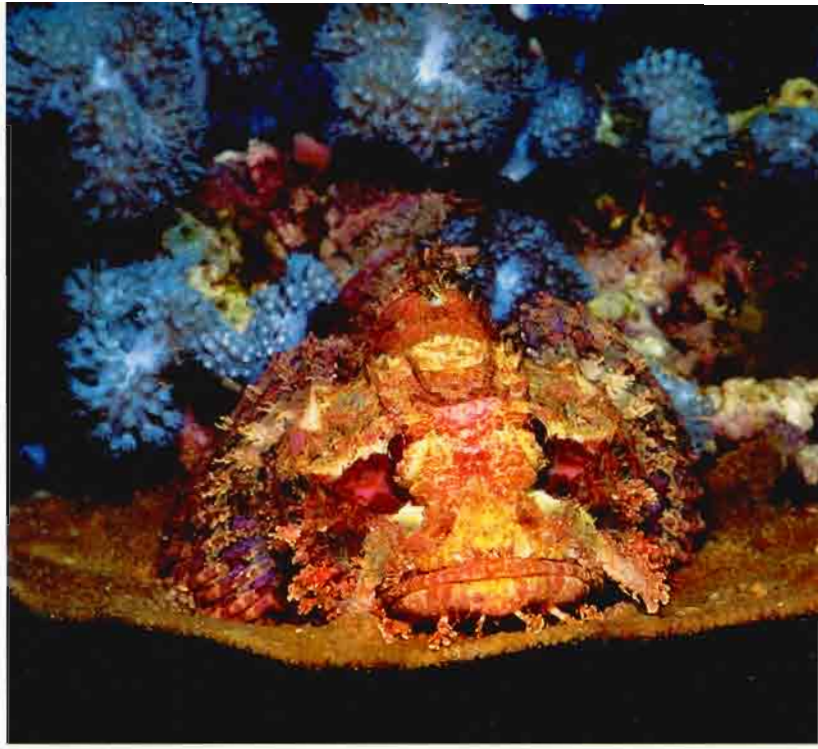
University of Maryland Department of Dermatology *http://medschool.umaryland.edu/Departments/Dermatology/som.html*

The Jellyfish Sting Newsletter of the Australian College of Tropical Medicine *http://www.jcu.edu.au*

British Marine Life Study Society *http://ourworld.compuserve.com/homepages/BMLSS*

Just last year, Dave Behrens received some unwelcome toxins in a series of hits while diving off Roatan, on the Caribbean side of Honduras. "Swimming through some sea grass beds in about three feet of water," he said, "we began getting pinprick like burns or stings on the side of the face and neck...any exposed skin was affected. We couldn't figure out what was going on until we started seeing small translucent anemones attached to the blades of the plants." They had gotten too close for comfort to turtle grass anemones (*Viatrix globulifera*).

Invisible free-floating pelagic coelenterates such as the chain-like siphonophores, related to bluebottles, may have been responsible for an earlier incident off Puerto Vallarta. Dave's wife, Diana, was snorkeling over a sun-soaked coral reef. Suddenly, he heard screams and shouts and noticed that she was kicking and splashing at the surface. "Something felt like it was biting or stinging me as I swam



towards her," he remembers. "She was grabbing her forearm in pain and had developed bright red welts, each about half-an-inch in diameter, from her shoulder to her wrist. An antihistamine helped...the welts receded in about an hour but it took about three hours for the pain to go away."

So swim carefully around those coral reefs, or the next nasty story may be yours.

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Top left: There are over 2,200 species of fresh- and saltwater catfish worldwide, many of them venomous, including these striped catfish. Spines on their dorsal and pectoral fins, which normally lie flat but extend when the fish is disturbed, penetrate a victim's flesh. Venom runs into the open wound. Raggy scorpionfish (top right) and ragged-finned firefish (bottom left) have venom glands at the base of their spinous dorsal and anal fins. A sting from the spines inflicts an intense burning and throbbing pain. Blue-spotted stingray (bottom right) has a spine with jagged edges at the base of its long tail.