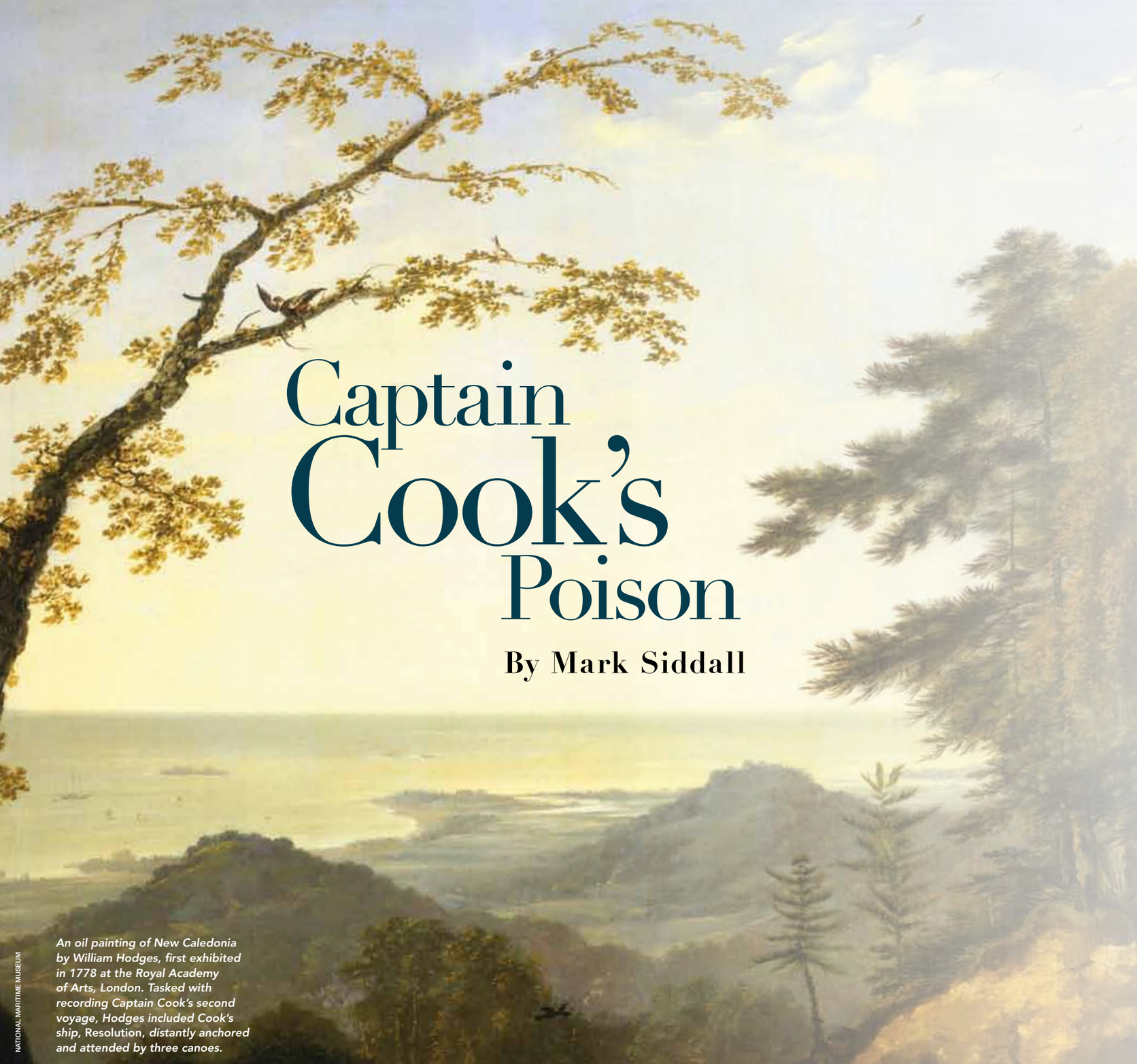
Captain Cook's Poison

How ciguatoxins and other poisons find their way into our food chain.

By Mark Siddall



NATIONAL MARITIME MUSEUM

An oil painting of New Caledonia by William Hodges, first exhibited in 1778 at the Royal Academy of Arts, London. Tasked with recording Captain Cook's second voyage, Hodges included Cook's ship, Resolution, *distantly anchored and attended by three canoes.*

The three voyages that explorer, navigator, and cartographer Captain James Cook made around the world between 1768 and 1779 are legendary, not to mention exemplary in cartographic excellence. Arguably, his second Pacific voyage was his least pleasant. Cook eventually met his demise at the hands of a bunch of insulted Hawaiians on his third voyage. But it was during the second voyage (1772–75) that he had to put up with the incessant whining of naturalist Johann Forster. And it was on this star-crossed second voyage that he fell ill, twice—once with "bilious colick," and then with a blocked colon; ran headlong into Antarctic ice—twice; and nearly died from eating fish—twice!

After leaving the New Hebrides (today Vanuatu), which Cook claimed for England, the HMS *Resolution* sailed to the south in order to arrive in New Caledonia in time for some surreptitious eclipse watching on September 7, 1774. Cook's careful observations of the Moon's transit during an annular solar eclipse in 1766 had determined the position of Newfoundland. Longitude was terrifically important to navigation. As another eclipse would not be visible from the British Isles until 1925, more such remote eclipse encounters were needed. For a variety of cultures, a solar eclipse was not to be taken lightly. Watching the sun being completely swallowed up by the moon seems to have been terrifying to many. The fact that half of the people watching would have gone blind could only validate any belief in eclipses as portents of evil. Cook—who ate albatrosses—was not a superstitious man. There is no indication of foreboding evident in his journals before the South Pacific eclipse of September 6, 1774.

Returning from shore to the ship the following day quite famished, Cook, along with naturalists Johann Forster and his son Georg, born in 1754, probably relished the thought of digging into an unusual-looking local fish that the crew had acquired from the locals in exchange for cloth. The ship's illustrator was busy drawing the fish, and refused to allow it to be fired up for dinner. But the fish had been cleaned, and so the liver and roe sacs were fair game. After a single bite, the trio surely must have thought better of it. The burning sensation in their mouths and throats would have been immediate. By the wee hours of the morning they were suffering the full effects of pufferfish poisoning: their skin felt as though it were in a blast furnace while simultaneously frosted over with ice, Cook later wrote. He was oddly incapable of distinguishing heavy objects from light ones, but that probably concerned Cook less than his constant and involuntary voiding at both ends as progressive paralysis set in. All these terrifying effects resulted from a very slight, mild exposure to what is now known as tetrodotoxin, a nerve poison that concen-

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A color woodcut titled Pufferfish courtesan and her jellyfish companion, *circa 1818–1830, by the Japanese artist Shigenobu Yanagawa. The piece plays upon the allure, and the possible danger, of indulging in fugu.*

trates in the livers and reproductive organs of pufferfish.

Although the crew tried, no one could catch the **ship's** dogs after the poor hounds wolfed down the scraps. Luckily the dogs voided the offending liver on their own and survived, but a hungry pig that got into the trash didn't make it through the next day. On that following day, local Micronesians, seeing a pufferfish hanging on deck, frantically pointed and made dramatic gestures to the ship's crew, which were, no doubt, the Micronesian equivalent of drawing a finger across one's neck.

If Cook had visited Japan during one of his Pacific voyages, he would have known better than to eat the livers of these deadly fish. The Japanese have prized pufferfish for a very long time—as far back as the late Jomon period, in the first millennium BC, their bones are found scattered among those of humans (though it's unclear if there was a causal relationship). Two thousand years later, during the Sengoku, or Warring Kingdoms, period (1467–1568), the fish bit back. Typhoons had twice spared Japan from Mongol invasions in the thirteenth century. These "divine winds"—the origin of the word *kamikaze*—overturned most of the hastily built Mongol ships and sent the surviving crews limping back to their captured Korean seaports. The wind shifted in 1592, however, when *daimyo* (warrior-general) Hideyoshi Toyotomi (1537–1598) summoned the samurai from all over Japan to Hizen Nagoya Castle, on the coast of Kyushu island, to rally for a full-scale invasion of Korea. Having failed, like Captain Cook, to consult the locals, a whole regiment of samurai were felled by their one last big fish feast the night before embarkation. The Japanese invasions of Korea in 1592 and 1598 ultimately failed, and were disastrous for both countries in terms of casualties and treasure. But meanwhile, Toyotomi banned the consumption of fugu (the Japanese word for pufferfish, meaning "river pig"). Any samurai caught slurping up the perilous delicacy would lose the entirety of his inheritance. The ban is said to have been overturned 300 years later, reportedly in 1888, by Japan's first Prime Minister, Hirobumi Ito, who apparently took a personal liking to fugu—and the deaths quickly resumed.

Post–World War II Japan under American occupation was not a pleasant place to be. An entire way of life was in shambles, the emperor had lost his divinity, infrastructure and industry were obliterated, and people were starving everywhere, especially in the cities. Since citizens had no choice but to eat just about anything they could get their hands on, it didn't take long for entrepreneurial hibachi-ists to grill whatever scraps they managed to dig out of the trash bins from local restaurants. The death toll from street-grilled fugu entrails continued to mount until General Douglas MacArthur created a strict fugu-licensing program that required safe preparation of pufferfish and thorough incineration of their toxic offal.

For some time now, the only deaths from fugu have been self-inflicted. The muscle meat of tetraodontid fish—named for the two pairs of fused buck teeth forming their beaklike jaws, and including more than 120 species of pufferfish, globefish, porcupine fish, boxfish, and blowfish—is perfectly safe to eat. Presently, close to ten thousand tons of fugu are eaten in Japan every year, about half of which is the farm-raised species *torafugu*, or tiger blowfish (*Takifugu rubripes*). Its consumption is more common in the southern regions—there are some 80,000 fugu chefs in Osaka alone. All fugu chefs are licensed by a government agency, but only after demonstrating mastery of the proper cleaning, preparation, and disposal of pufferfish. The supposed numbing sensation that is a commonly rumored frisson of fugu sashimi is entirely imagined by the patron—perhaps after too much sake. Any actual numbing sensation one experiences should be quickly followed by hospitalization. What's more, fugu's taste is subtle to the point of being bland. Nonetheless, there is apparently a large culinary niche that offers $400 plates of tasteless fish artfully arranged in the shape of a chrysanthemum—which is, incidentally, a flower associated with funerals from Krakow, Poland, to Kyushu, Japan.

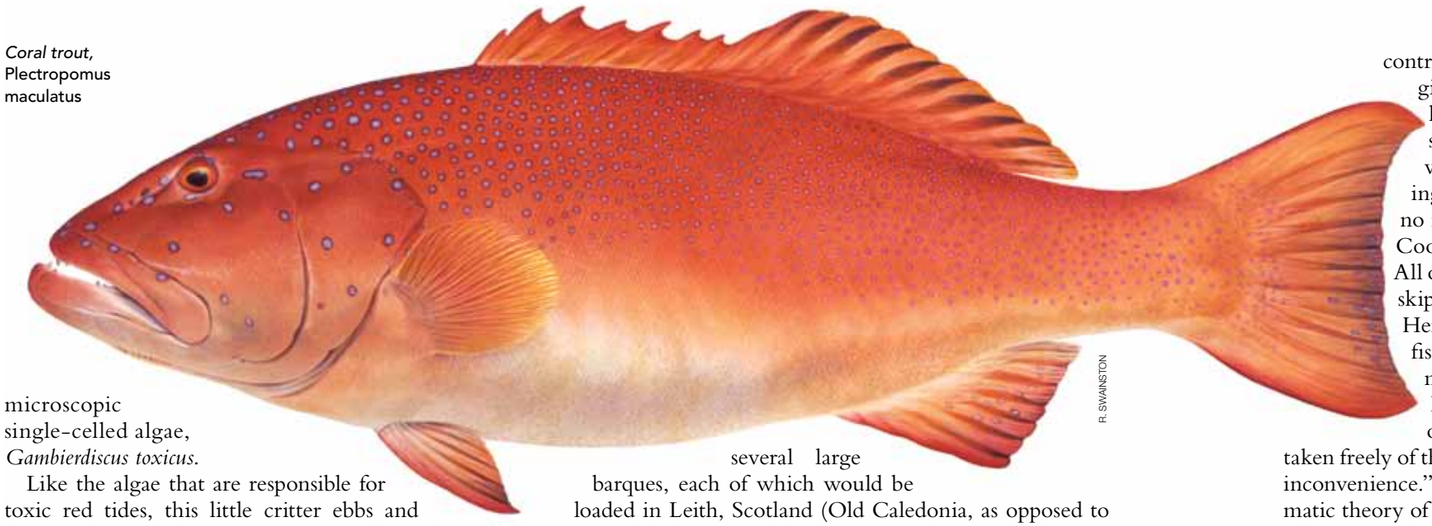
ARNIS DEZDINS

Fugu restaurant on touristy Dotonbori Street in Osaka, Japan

Several months before the New Caledonian eclipse "picnic"—the one that nearly extinguished Cook and the two Forsters with fugu liver—there had been a previous near miss with a fish, one that remains unidentified, as it was quickly consumed by a hungry crew. As *Resolution* reached the tiny and isolated island nation today known as Vanuatu, which Cook dubbed the "New Hebrides" (he was fond of antipodean Scottish place names that would annoy the French), an "away team" was briefly put ashore to meet the locals.

Cook was meticulous with his crew, keeping them on a rigid diet to hold scurvy at bay. One can imagine a salivating crew dropping anchor in azure blue, cool seas resplendent with reef fish. Absent Cook's stern gaze while he was ashore, the prospect of fresh food roasting on deck would have been a tantalizing and welcome respite from the daily doses of "antiscorbutic" sauerkraut and spruce "beer" rations. For a crew of 118 they'd need a lot of fish, though, or at least some big ones. By the time Cook returned to the ship, two huge, reddish-colored fish had been snagged and hauled on board. They were promptly cooked and divvied among the crew, with the officers and petty officers getting more than their fair share, of course. Vegetable side dishes are not noted in Cook's journal. What is noted is that "in the Evening everyone who had eat of these fish were seiz'd with Violent pains in the head and Limbs, so as to be unable to stand, together with a kind of Scorching heat all over the Skin." The symptoms of scorching heat foreshadow the same neurotoxic symptoms Cook and the Forsters would experience three months later. According to the account of the ship's surgeon, William Anderson, at least five of the men suffered for four days before getting back on their feet. This time, unfortunately, the scavenging animals on board fared worse from eating the scraps, with the final death toll amounting to one dog, a hog, and a parakeet.

Ciguatera poisoning was well known to the Carib people of the Lesser Antilles, who attributed the condition to the cigua, a local turban snail (*Cittarium pica*) still prized today for stews in the Virgin Islands. Ciguatera is characterized by paralysis of the legs, uncontrolled salivation, and a burning sensation all over. It is interesting to speculate whether the crew of the HMS *Resolution* experienced ciguatera's characteristic dyspareunia, a peculiar priapism that is perhaps best not fully described in these pages. The poison responsible for causing such pain, ciguatoxin, would later be determined to be produced not by the kind of fish that Cook's crew ate, nor by the marine snails that those fish might themselves favor, but, instead, by a species of



Coral trout, Plectropomus maculatus

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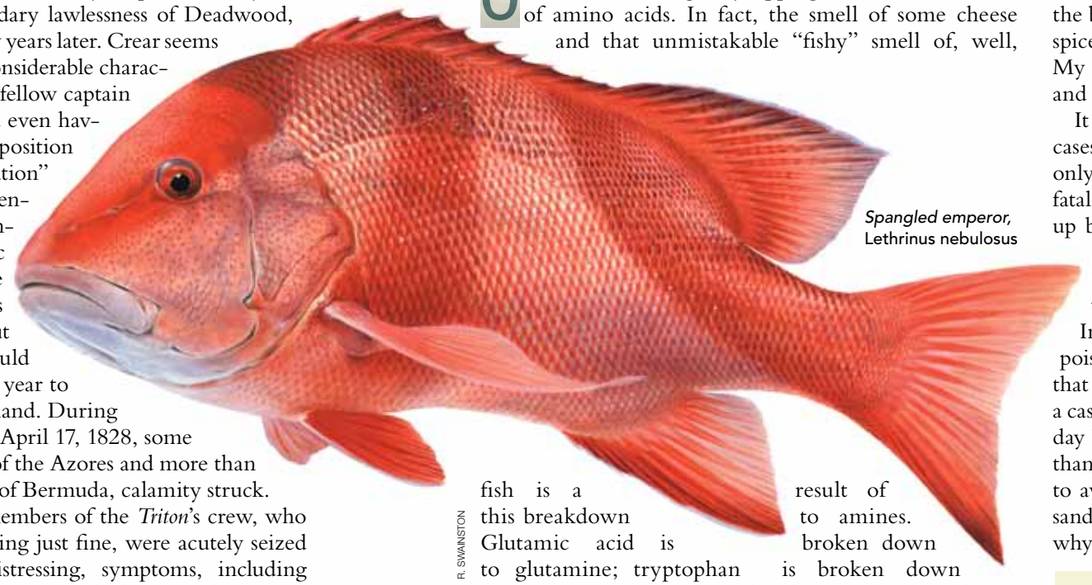
microscopic single-celled algae, *Gambierdiscus toxicus*.

Like the algae that are responsible for toxic red tides, this little critter ebbs and flows with cyclical oceanic patterns. The problem is bioaccumulation. One little fish eats algae and absorbs some ciguatoxin. When a bigger fish eats ten little fish, it retains all of their ciguatoxin. Then huge fish eat the big fish that ate the little fish, in turn accumulating all of the ciguatoxin all those little fish ate. So it stands to reason that the biggest and the most predatory fish are going to have the most ciguatoxin and will be the most dangerous to eat, like the big red fish (probably coral trout) the crew ate on the *Resolution* on July 23, 1774—or like the barracuda occasionally consumed in the Florida Keys and Saint Thomas that result in the odd death here and there. As for those who don't die, because they got only a minute dose—or because they were put on a respirator in time—symptoms of ciguatera can recur for over a decade, depending on the dose and the individual survivor.

Ciguatoxin poisoning can happen anywhere. However, it seems to be concentrated around small, isolated oceanic islands and atolls. The reasons for this remain obscure. And unlike annual warm-water red tide–related toxins, ciguatera seems to be correlated with the cool phases of El Niño and the Pacific Decadal Oscillation. Too bad for Cook's crew, then, that Vanuatu is one of the most isolated reef systems on the planet, and suffers even today a correspondingly enormous problem with ciguatera—especially from eating those very big, reddish reef fish such as coral trout and emperor fish. It is also interesting to note that it was during one of the strongest Pacific Decadal Oscillations on record that the HMS *Resolution* plied the Pacific. The Hawaiians who killed Cook were "lucky" to even meet him.

As a direct result of Captain James Cook's three voyages, each of which included stops in New Zealand, Europeans were soon frequenting the Tasman Sea and the Southern Ocean, hunting whales and establishing a foothold in Maori Land. The Australia Company, in particular, had several large barques, each of which would be loaded in Leith, Scotland (Old Caledonia, as opposed to New Caledonia), with hardware, merchandise, and munitions to supply the growing British presence in Australia. Each would return home full to the gunwales with sperm oil. One of them, the *Triton*, was captained by James Crear in the early 1800s following his exit from the Royal Navy. Crear would eventually settle in New Zealand for good, and at a time when it was an unruly outpost that may well have outdone the legendary lawlessness of Deadwood, South Dakota, some fifty years later. Crear seems to have been a man of considerable character, having once saved a fellow captain who was drowning, and even having taken a principled position against the "transportation" (read: "extraordinary rendition") of British prisoners to the South Pacific colonies. With the trade routes and shorelines masterfully mapped out by Cook, the *Triton* could make two return trips a year to Tasmania and New Zealand. During one such return trip, on April 17, 1828, some six hundred miles west of the Azores and more than one thousand miles east of Bermuda, calamity struck.

That morning, five members of the *Triton*'s crew, who had until then been feeling just fine, were acutely seized with remarkable, if distressing, symptoms, including violent headaches, capillaries nearly bursting from their bloodshot eyes, and bright red skin. Most alarmingly, their faces and whole bodies were so swollen with edema as to render them unrecognizable to their crewmates. The ship's doctor, Patrick Henderson, sprang to their aid, adding insult to injury. All five received powdered morning-glory root with the immediate, unhelpful effect of uncontrollable projectile vomiting, and two were given a good, long bleeding to relieve their headaches—an approach that could have succeeded insofar as it would have aggravated their deep shock to the point of passing out. The source of this sudden illness was no more a mystery to those present than was Cook's fugu poisoning fifty-four years earlier. All of the afflicted had breakfasted on the same skipjack tuna that morning. It is notable that Henderson attributed the sorry state of the fish to having been left overnight "while the moon was up," when in fact the real clue lies in his description that for "a number of days previous . . . everyone had partaken freely of the same fish without suffering the slightest inconvenience." It is fair to point out here that the miasmatic theory of disease would not give way to the notion of contagion for another half century; it would be another twenty-six years before John Snow stole the handle off the Broad Street water pump and stopped an outbreak of cholera cold in its tracks.



Spangled emperor, Lethrinus nebulosus

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Certain bacteria are able to extract energy from protein instead of sugar by ripping a carbon dioxide off of amino acids. In fact, the smell of some cheese and that unmistakable "fishy" smell of, well, fish is a result of this breakdown to amines. Glutamic acid is broken down to glutamine; tryptophan is broken down to tryptamine; and a few select bacteria, such as the lactobacilli in sauerkraut and yogurt, are able to break down histidine into histamine. Antihistamines had yet to be invented, so what the five crew members of the *Triton* were suffering from was acute anaphylactic shock, just as severe as if they had all been allergic to peanuts and had eaten Fluffernutters for breakfast. In this case, though, instead of their own immune systems dumping throat-choking levels of histamine into their systems, they had received near-lethal doses of histamine from fish that had been, by all accounts, lying about on board for some "number of days"!

Scombroid poisoning is probably the most common illness associated with eating fish. It is also the easiest to avert. Scombrid fish include various tuna, mackerel, bonito, and wahoo. That scythe of a tail fin attached to a narrow end is characteristic of fish built for speed. These fish have evolved a way to deal with lactic acid buildup in muscles that should be the envy of any Olympic sprinter: high concentrations of histidine serve as a natural buffer, keeping the pH near neutral. At these concentrations, though, the histidine is just too tempting for bacteria if the fish is mishandled or left at room temperature. The histamine by-product is toxic at a measly fifty milligrams per one hundred grams of fish.

Alas, scombroid poisoning is hardly confined to those species, a fact this author knows from a personal experience with a bluefish. Bluefish, *Pomatomus saltatrix*, is one of my summer time favorites. As an oily fish, it is perfect for grilling; just a little salt and some lemon tame this precious piscine pièce de résistance. My first intimation that I was in trouble should have been that nagging feeling in the back of my head that I may have somehow way overspiced the fish, when, in fact, I hadn't spiced them at all. My next intimation was total disorientation, wheezing, and considerable homage to a porcelain god.

It is difficult to get a handle on the precise number of cases of scombroid poisoning, and this is a good thing. The only poisonings no one tracks are the ones that are rarely fatal, and this is one of them—knock wood, I'm not giving up bluefish. The connection between histamine poisoning and improperly handled fish (mea culpa) wasn't made until the 1940s. Most cases are reported from the United Kingdom, the United States, and Japan. Investigations following a 2008 outbreak of scombroid poisoning in Alaska found histamine levels in mahi-mahi that were easily three times the known toxic levels, and in a case in the UK, tuna-fish sandwiches that sat on a shelf all day before they were sold to unwitting victims had more than fifty times the allowable levels. Still, it is easy enough to avoid scombroid poisoning: make your own tuna-fish sandwich, and, if you didn't order spicy tuna, ask yourself why it feels so hot in your mouth.

Mark E. Siddall is a curator in the Division of Invertebrate Zoology at the American Museum of Natural History. His research focuses on the biodiversity of leeches and the evolution of their hemoxic venoms. This article is adapted from his forthcoming book, *Poison: Sinister Species with Deadly Consequences* (Sterling Signature, 2014).