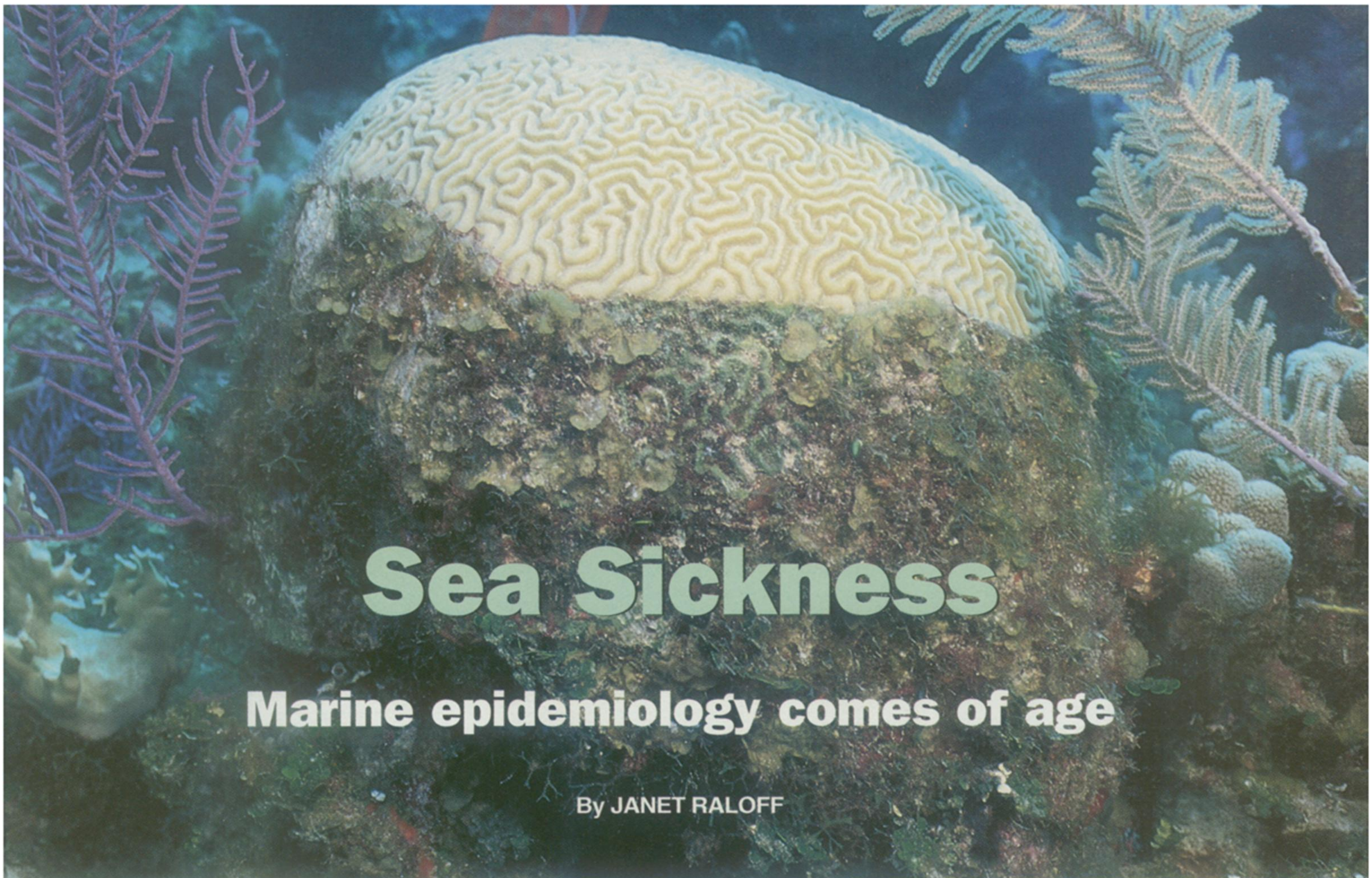


Sea Sickness

Marine epidemiology comes of age

By JANET RALOFF

James Cervino © 1998

This coral suffered bleaching and subsequent infection with black-band disease. Now, the stressed colony of tiny animals is in the throes of a third plague: It's being overgrown by algae and other opportunistic organisms.

Sylvia A. Earle, the National Geographic Society's explorer-in-residence, encountered a disturbing change of scene late last year when she returned to scuba dive at one of her favorite haunts. Heads of centuries-old coral in a reef off the Dutch isle of Bonaire, just north of Venezuela, had always provided a dazzling backdrop for darting Caribbean fish. Now, she saw patches of coral—once yellow, electric green, purple, and brown—bleached to the point where "they looked just like snowballs."

Although still alive, the reef "looked sick," recalls Earle, a former chief scientist at the National Oceanic and Atmospheric Administration.

Indeed, Bonaire's coral is sick, says James M. Cervino, a marine biologist with the Global Coral Reef Alliance in New York City. The sad thing, he adds, is that Bonaire's reefs remain among Earth's healthiest. Having visited some 50 different reefs throughout the world over the past 2 years, he notes that most are considerably worse off.

Among tropical corals, which are actually colonies of tiny animals, bleaching has become ubiquitous, he finds. Whereas just the heads of Bonaire's corals are white, at some sites fully 80 percent of the coral has been bleached. The ghostly pallor, he explains, results from these colonies becoming too warm and feverishly expelling the colorful symbiotic algae responsible for their vibrant hues (SN: 6/15/96, p. 379). Because the algae symbionts provide an energy source, their prolonged absence eventually starves the corals, Cervino says.

Earle emphasizes that Bonaire "is still a paradise in many ways—one of the most beautiful places on the planet." But if trouble is threatening this reef, in apparently clean and protected waters, she says, what is safe?

Nor is bleaching the only threat to corals. Increasingly, Cervino points out, these colonies are also exhibiting infections, tumors, and "obscure" lesions. "We've been going to photos of corals from as far back as the 1930s," he says, and find no sign of many of these diseases.

At a briefing on Capitol Hill last December, he reported that at least 15 new syndromes causing mass coral-reef mortality have emerged over the past 20 years—many of them showing up for the first time only in the past 3 to 5 years (SN: 4/11/98, p. 229).

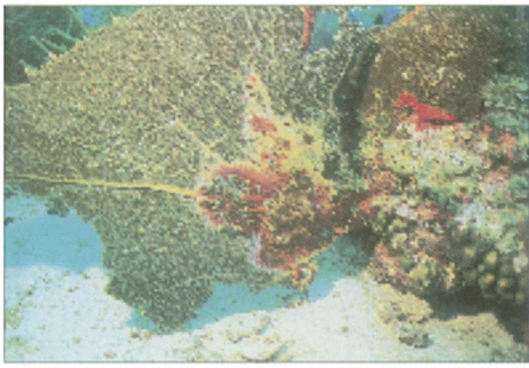
Says Earle, "I think of these coral reefs as red blinking lights, signs of trouble in our oceans."

A new program developed at Harvard University has assembled data on corals and nine other types of marine wildlife spanning from the Labrador Peninsula in Canada to Venezuela. As part of the project, Benjamin H. Sherman developed a computerized system to map outbreaks of disease affecting these plants, animals, and algae over time.

"We're mapping epidemics," explains Paul R. Epstein, a physician and associate director of the Center for Health and the Global Environment at Harvard Medical School in Boston. He explains that his team has "layered" other information onto the disease maps, including climate, pollution, economic measurements, harmful algae blooms, and regional data on water quality.

"The resulting system allows researchers to hunt for patterns—and hot spots—across time or broad regions in ways that had never been possible," says Sherman, now at the University of New Hampshire in Durham. The goal of this Health, Ecological and Economic Dimensions of Global Change Program (HEED) is to study diseases in the marine world as indicators of environmental threats to wildlife and even human health.

The picture that's emerging, Epstein and others say, is that a large share of diseases in ocean wildlife traces to a complex interplay of human activities and perturbations of Earth's climate.



James Cervino © 1997

This sea fan has been hit by a potentially lethal infection of Aspergillus, *a normally land-based fungus. The reddish growth is a secondary infection with cyanobacteria.*

Over the past 15 years, for instance, "there has been a very striking increase in the frequency and extent of harmful algal blooms," notes JoAnn M. Burkholder, an aquatic botanist at North Carolina State University in Raleigh. HEED's data now link many of these blooms of poison-producing algae to pollution (SN: 9/27/97, p. 202) and a widespread warming of coastal and shallow waters. Moreover, Burkholder observes, HEED's data suggest that the ecological impacts of these blooms are more pervasive than most biologists had realized.

Historically, she says, scientists have focused on the acute effects of these blooms—fish kills or a few human deaths from downing contaminated shellfish. "But it was always assumed that unless the fish died, they were not affected."

In retrospect, she says, that was naive. "We now know that fin fish and shellfish can and do get sick from toxins of harmful algae." They can develop cancer, their reproduction can be impaired, and their immune system can lose its ability to fend off disease. HEED's data, she says, are tying the toxins produced by microscopic algae to such problems.

Researchers at the Florida Marine Research Institute in St. Petersburg contributed some of those data. A few years ago there, Jan H. Landsberg began examining whether certain algal toxins, which stimulate cancer growth in mice, might also play a role in the growing incidence of tumors in East Coast shellfish.

By layering maps of algae blooms over regions of high tumor incidence and correlating the dates of blooms to reports of tumors, "I found a very compelling picture," Landsberg told SCIENCE NEWS. "You see that high rates [of shellfish tumors] cluster very strongly with the incidence of algal blooms." In particular, the tumors appeared linked to surface blooms of *Alexandrium* algae off New England.

The association could be just circumstantial, she admits. She and her colleagues hope to find out by testing. And that, Landsberg notes, is what HEED's all about—pointing out what associations to scrutinize and where.

Other algae, whose poisons induce the development of papilloma tumors in mice, are suspected of playing a role in triggering devastating tumors in sea turtles, she says. The suspect species is a dinoflagellate—a member of a broad class of algae that include *Pfiesteria* (SN: 9/6/97, p. 149) and algae that cause blooms known as red tides.

Though benign, the tumors can affect the turtles' ability to see or eat.

Because this dinoflagellate tends to dwell on the ocean floor, it doesn't produce colorful surface blooms. It does, however, produce a toxin—okadaic acid—that has been associated with a problem called diarrheic shellfish poisoning in people. "We're now proposing that the long-term effect of the turtles' chronic exposure to okadaic acid may be a high risk of these tumors," Landsberg says.

Last year, she began collaborating with researchers studying green sea turtles in Hawaii. They are mapping the incidence of the large tumors, called fibropapillomas, and concentrations of the particular dinoflagellate suspects. "And we have found that there are much higher levels of these particular dinoflagellates in what we'd call the high-risk areas versus those where turtles have no tumors," Landsberg says.

An as yet unidentified virus is also suspected of playing a role. The tumors afflict primarily immature turtles at rates that vary widely by region and even from year to year, observes Barbara Schroeder, sea turtle coordinator for the National Marine Fisheries Service in Silver Spring, Md. However, Landsberg says that her data suggest that the virus does not cause tumors unless the algae toxin is also present.

Fueling a suspicion that pollution also plays a role, Landsberg says, is the fact that the tumors tend to occur primarily among turtles in waters "where there is a lot of runoff of nutrients from land activities, pollutants that are likely to help fertilize the growth of these algae."

These same fertilizing pollutants, principally nitrogen and phosphorous, are also being tied to ailing sea-grass beds along the northern and middle Atlantic U.S. coasts. Here, meadows of eel grass (*Zostera marina*) have served as important nurseries for young fish. Increasingly, however, these marine prairies have been plagued by a "wasting disease," in which a slimy fungus turns leaves brown.

Unlike almost all other plants, this grass lacks the ability to shut off the uptake of nitrate through its leaves, Burkholder has found. She notes that in nutrient-poor coastal areas, this would have proved a selective advantage.

"But *Zostera* never anticipated dealing with us," she adds, wryly. In waters fed with municipal sewage, livestock wastes, and crop fertilizer runoff, these plants are now drowning in nitrogen. Once their small storage sites fill to capacity, the plant produces amino acids nonstop, quickly drawing down internal stores of carbon. These plants "literally begin starving themselves internally for carbon," she says. The result is that "overenrichment of nitrate can kill these plants" or render them so stressed that they can't ward off the deadly fungus.

A far more unusual pollutant, apparently from tilled soil or deforested lands, began showing up on Caribbean sea fans about 15 years ago. These sea fans are a type of soft coral.

Garriet W. Smith of the University of South Carolina in Aiken and his colleagues traced a deadly infection in the fans to the normally land-bound fungus *Aspergillus*. Smith's team now suspects that eroded soil particles that are washed to sea ferry the pathogen to its marine hosts.

Once in the water, the fungi seem unable to produce reproductive spores. The researchers argue that the sea-fan infections would probably die out without a continuing importation of fungi from land.

Until recently, scientists typically investigated marine disease outbreaks as isolated incidents. The idea that some might be linked struck Epstein when he began ruminating about a host of events in 1987.

Landsberg

Turtle grass off the south coast of Florida, infected with a lethal slime mold.

That was a year of sea-grass die-offs around Florida and increased bleaching of Caribbean corals. Large numbers of whales and dolphins stranded themselves on Cape Cod. A toxic alga that causes neurologic poisoning in people who eat tainted shellfish and normally is confined to the Gulf of Mexico made a dramatic northward extension to Cape Hatteras, N.C. And a common, one-celled alga—a *Pseudo-nitzschia* diatom—was implicated for the first time in disease;

tainted shellfish killed three people and sickened 100 others.

"You may remember that 1987 was also a large El Niño event," Epstein says, referring to the recurring global climate phenomenon signaled by upwellings of warm waters in the eastern Pacific (SN: 1/24/87, p. 55). That fact and the coincidence of environmental problems suddenly suggested to him that climate might be liable for the problems, some directly and some by interacting with local pollutants and conditions. To test the role of global climate, he began comparing the number of epidemic events in years with and without an El Niño.

"El Niño years tend to be warmer and wetter in the Northern Hemisphere overall," Epstein says. That leads to more extreme events in regional weather. An El Niño can play out as hotter summers or colder winters; one region may experience protracted droughts, while others fall prey to a rapid succession of flood-provoking storms.

HEED's data now show that many ocean disease outbreaks peaked during El Niño events. This suggests "a significant climatic influence on the interactions among hosts, pathogens, and the environment," says Epstein.


Landsberg

An initially unexplained 1996 die-off of Florida manatees was eventually tied to poisons produced by an unseasonable bloom of red-tide algae.

Upon reflection, that's not surprising, he says. Warmer waters can alter the metabolism of microbes, sometimes increasing organisms' energy use by a factor of 10. In the ocean, this might foster algae blooms, he notes.

Unusually heavy rains have the potential to wash large amounts of pollutants to sea. The pesticides and wastes can directly suppress large organisms' immune systems, and the nutrients can fertilize the growth of toxic algae. When researchers combine the maps developed by HEED, Epstein says, algae emerge as "a key leading indicator of ocean health."

With HEED—or better yet, a global version of it—scientists can systematically scout for trends that go beyond a single species or ecosystem, Epstein maintains. Satellite imagery might turn up signs of nascent algae blooms or heavy runoff, allowing researchers to quickly sample affected waters for poison-producing organisms. Where burgeoning communities of toxic algae are identified, health warnings could go out along with notices to temporarily close affected fisheries and beaches.

Long term, governments might be able to monitor the complex interplay of stressed ecosystems to learn where protective measures might offer the biggest payoff, Epstein says. For instance, they could impose tighter restrictions on animal waste and fertilizer runoff into surface waters.

"The biosphere—the place where life occurs—is 95 percent ocean," observes Earle, herself an oceanographer. Not only does the marine world house and feed much of the planet's life, but it also governs the climate and habitability of the planet. It's not an exaggeration to consider the oceans to be Earth's primary "life-support systems," she maintains.

"So if the oceans are in trouble," Earle argues, "so are we. And the oceans are in trouble." With research and stronger pollution controls, she adds, that needn't remain the case.

She advocates "a vigorous commitment" to ocean exploration and research—activities that probe not only threats to marine productivity but also the interplay of climate with ocean circulation and chemistry.

Fortunately, Earle says, "awareness of the need to explore our own aquatic backyard is growing" in the United States. A partnership of NOAA, the National Geographic Society, and the Goldman Fund, a private philanthropy, has just launched a 5-year program to explore the nation's continental shelf using newly developed submersible technologies. The goal is to establish ocean-monitoring programs and to survey native wildlife in marine sanctuaries, the undersea counterparts of national parks.

"As the century and millennium come to a close, there is an urgent need to consider the ocean as not just the 'next frontier,'" Earle says, but as the means to sustaining humanity's teaming masses on what is essentially "an aquatic planet." □