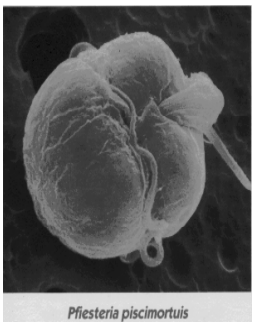
North Carolina Sea Grant Publication

KILLER DINOFLAGELLATE - Fact Sheet

Recently, N.C. Sea Grant researchers discovered a fish killer—a microscopic animal that paralyzes fish with toxins and sucks away their flesh.

JoAnn Burkholder, an aquatic botanist at N.C. State University, says people shake their heads in disbelief as she describes the dinoflagellate that appropriately is named *Pfiesteria piscimortuis*. Its species name means fish killer.



Pfiesteria piscimortuis

Sea Grant fish pathologists Ed Noga and Steve Smith of the NCSU College of Veterinary Medicine first discovered the dinoflagellate when about 300 fish in a brackish-water aquarium in his lab went belly-up with no apparent cause. The water had been taken from the Pamlico River, but Noga could find no obvious pathogens. He did, however, find the water swarming with microscopic dinoflagellates—single-celled organisms.

Dinoflagellates aren't unusual. Along with diatoms and other forms of microalgae, they compose the bottom of the aquatic food chain and are among the most primitive forms of life on Earth. But some dinoflagellate species, such as red tides, can be toxic.

Noga realized this dinoflagellate was different. It attacked fish. Its toxicity wasn't a defense mechanism designed to keep fish from consuming it. On the contrary, this dinoflagellate was a predator in search of prey.

"We were able to stimulate it to bloom in the presence of live fish," Noga says. "No one had ever documented anything like that before."

To determine its identity, Noga sent samples of the dinoflagellate-infested water to aquatic botanists along the East Coast. Among them was the laboratory of NCSU colleague JoAnn Burkholder. At first, she was unbelieving

of Noga's description. But as she and her students began to study the dinoflagellate, she made some startling discoveries.

Light brown in color, this microscopic dinoflagellate is so small that millions would fit on the head of a pin. It's an animal, Burkholder says. But sometimes it masquerades as a plant after eating algae, another of its food sources.

The dinoflagellate digests all the alga except the chloroplast, which is the part that draws energy from the sun via a process called photosynthesis. The chloroplast continues to photosynthesize inside the dinoflagellate cell, falsely giving the impression that the dinoflagellate itself is performing this plant-related process.

Unlike its close relatives, the red tide dinoflagellates, *P. piscimortuis* gives no evidence of its presence. There is no discoloration of the water or other obvious clue that it is lurking nearby.

It's even hard for scientists such as Burkholder to detect because it transforms into at least 15 life stages. It can change from a dormant cyst in the sediment to a toxin-emitting single cell with whip-Iike tails called flagella.

The dinoflagellate is easiest to detect when it's on the attack, triggered into action by an unknown substance secreted by fish. Then it transforms from one of its resting stages into a swimming cell that emits neurotoxins into the water and air.

The neurotoxins affect the fish's nervous system, causing it to become disoriented and lethargic and to gape for air at the surface. Unless a fish can escape, it will suffocate because its breathing mechanism is paralyzed. Fish can die within minutes of attack.

As the toxin affects the nervous system, the dinoflagellate attaches to the fish's flesh and sucks the skin away. This releases organic matter into the water that attracts more dinoflagellates and sends the one-celled gametes produced by the parent cells into sexual reproduction.

Now the water is swarming with more hungry dinoflagellates emitting more neurotoxin and feeding on more fish. It's a horrific feeding frenzy even Stephen King couldn't image. The final result is a mass of floating dead fish.

To escape these microscopic monsters, fish and crabs often try to leave the water. Fishermen call these occurrences "fish walks" or "crab walks."

Those fish that do escape often don't live long. They carry too many battle scars—open, bleeding sores or holes eaten through their bodies that make them susceptible to other pathogens and bacteria, Noga says.

After the fish die, the killer dinoflagellate can make one of several transformations. It can encyst and settle to the bottom in a deceitful resting stage, Burkholder says. Or it can shed its flagella and become a nontoxic amoeba. Amoebas, shape-shifting multiarmed single cells, continue to leisurely

feed on the fish carcass and other proteins in the water column or on the bottom.

Or the dinoflagellates can transform into asexual, nontoxic zoospores that swim in the water column and are attracted to areas rich in algae and-nutrients, particularly phosphorus.

Because of these unusual transformations, some scientists and resource managers have doubted Burkholder's and Noga's findings. But Karen Steidinger, a phytoplanktonologist with the Florida Department of Environmental Research and the Florida Marine Research Institute, says this dinoflagellate is real.

"It is a very cryptic species, one that is difficult to identify because of the small size of the flagellated stages and its life cycle," Steidinger says. "Its transformations are life stages that most marine phytoplanktonologists would not associate with that kind of a dinoflagellate."

But no matter what it becomes—cyst, arnoeba or zoospore—it can transform into a killer, sometimes within minutes, in the presence of a school of fish.

Once they were able to identify the killer dinoflagellate, Burkholder and Noga documented its presence at fish kills in the Pamlico River, and at other sites in North Carolina and along the East Coast, including Chesapeake Bay.

Was the toxic dinoflagellate a new organism? Or had it been in our estuaries all along and never been identified? Burkholder believes it's the latter. Being such a primitive life-form, the dinoflagellate has probably existed for eons undetected. But Burkholder believes its abundance and visible effects—fish kills— may have increased in the last 50 to 75 years as the water quality in our estuaries has degraded because of increased agricultural and commercial development.

In her NCSU laboratory, Burkholder tested 28 species of fish for susceptibility to the toxic dinoflagellate. None were immune to the toxin, although some species were more sensitive than others. Blue crabs, clams, scallops and young oysters are also affected by the toxin. She has yet to test shrimp or adult oysters. And Noga is determining how the toxin affects fish, particularly how it increases a fish's susceptibility to secondary infections.

Are there any human effects from this waterborne killer?

There are no certain instances of the dinoflagellate affecting fishermen, swimmers or boaters on the water.

But problems have occurred in Burkholder's laboratory where lab assistants and technicians have had prolonged and direct exposures to the dinoflagellate in its active, toxin-emitting phase. One of Burkholder's research associates was hospitalized after experiencing memory loss, disorientation and speech impediments. Burkholder, too, has suffered memory loss and disorientation.

But until the toxin is fully characterized by chemists and doctors, neither Burkholder nor her research associate's problems can be fully understood. The N.C. Department of Health is investigating the human effects of this dinoflagellate, but results may be more than a year away.

For now, Burkholder has these cautions for people who work and play on the water.

- Leave an area where fish are floating at the water's surface. A fish kill may be in progress, and the neurotoxins may be in the water and air.

- If you dip your hands or feet in an area where the dinoflagellate is active, immediately wash them with a solution of 1/3 bleach to 2/3 water. Rinse well afterward in clean water. Bleach kills the dinoflagellate, Burkholder says.

- If you're a recreational fisherman, don't keep or eat fish that have visible sores or holes in the flesh.

- Don't eat dead fish that have washed ashore or beached themselves.

Consumers of seafood bought at retail outlets such as grocery stores, seafood markets and restaurants should not worry. Commercial fishermen would not harvest fish affected by the dinoflagellate because the unsightly sores make the fish unfit to sell.

To help researchers such as Burkholder and Noga learn more about this mysterious dinoflagellate, commercial fishermen and recreational water users are asked to report any fish kill they spot. Note the area where the fish are floating as exactly as possible, then leave. Do not take fish or water samples. Go to the nearest telephone and call:

In North Carolina—N.C. Division of Marine Fisheries at 1-800/682-2632, Burkholder's NCSU laboratory at 919/515-2726 or 919/515-3421 or Noga's NCSU College of Veterinary Medicine laboratory at 919/8294393 or 919/829-4236.

In Maryland—Maryland Department of Environment at 410/974-3238 or 1-800/285-8195.

In Delaware—Delaware Department of Natural Resources and Environmental Control at 302/739-344l or 302/739-4590
Or telephone the University of Delaware Sea Grant MarineAdvisory Service at 302/6454250.

In South Carolina—S.C. Department of Health and Environmental Control at 803/740-1590.

In Georgia—Georgia Department of Natural Resources emergency line (operates 24 hours a day) at 1-800/2414113.

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Produced by the North Carolina Sea Grant College Program in cooperation with the South Carolina Sea Grant Consortium, the University of Georgia Sea Grant College Program, the University of Maryland Sea Grant College Program and the University of Delaware Sea Grant College Program.

UNC SG-FS-94-01