

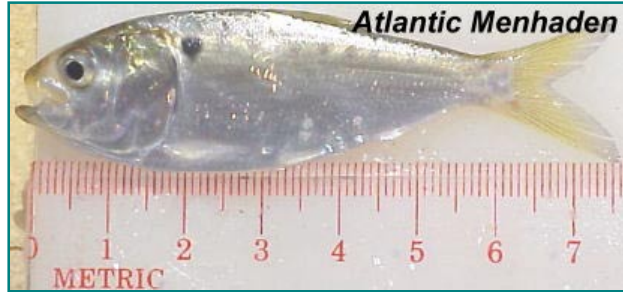


## Fact Sheet

### Estuarine Fish Kills in North Carolina

#### Context and History

Summer weather conditions in North Carolina and most other southern states create water quality conditions that can be severely stressful to estuarine fish species, particularly the Atlantic menhaden that inhabits the coastal areas in dense schools. When freshwater inflow to the estuaries decreases as the result of lower rainfall, estuarine waters are less well mixed and form stratified layers. Lighter freshwater lies on top of layers of denser, heavier saltwater.



As temperatures increase, water's ability to hold oxygen decreases and hot, windless conditions reduce the physical aeration of waters. The bottom, salt layer of water is cut off from a supply of oxygen and frequently experiences a dramatic loss of oxygen content<sup>1</sup>. The National Oceanic and Atmospheric Administration (NOAA) recognized these conditions as the leading causes of major fish kill events among 22 coastal states from 1980-1989 with the Atlantic Menhaden (*Brevoortia tyrannus*), among other small, schooling fish being the most affected in estuarine areas<sup>2</sup>.

In 1992, Dr JoAnn Burkholder and other researchers at N.C. State University attributed some of these fish kills to the dinoflagellate now known as *Pfiesteria piscicida*<sup>3</sup>. Though researchers had identified this organism as a different species before then, its presence in the estuaries had been well known before that time. In order to assess the possible effects of this and any similar species, many east coast states and several federal agencies initiated programs to assess the presence of these organisms, their role in fish kills and fish lesions, and potential human health effects of the toxins described by Burkholder, *et al.*

#### North Carolina's Response

The N.C. Division of Water Quality placed 4-member "Rapid Response Teams" near the mouths of the Neuse and Pamlico River Estuaries in 1997 and 1998, respectively in order to make more timely and intensive investigations of fish kill events. These two areas historically had been documented with the greatest incidence of fish kills among NC estuaries.



Upon receiving a fish kill report the teams immediately contact Department of Environment and Natural Resources and Department of Health and Human Services public information offices to coordinate any appropriate environmental or human health follow-up. The teams immediately characterize the location and size of the kill, species affected, and make field measurements of

<sup>1</sup> Paerl, Hans W., James L. Pinckney, John M. Fear, Benjamin L. Peirels. 1998. Ecosystem Responses to internal watershed organic matter loading: consequences for hypoxia in the eutrophying Neuse River Estuary, North Carolina, USA. *Mar. Ecol. Prog. Ser.* 166:17-25.

<sup>2</sup> Lowe, Anne Jamison, Daniel R.G. Farrow, Anthony S. Pait, Sheila J. Arenstam, and Eileen F. Lavan. 1991. Fisk Kills in Coastal Waters: 190-1989. National Oceanic and Atmospheric Administration. Rockville, Md.

<sup>3</sup> Burkholder, J.M., H.B. Glasgow, E.J. Noga, and C.W. Hobbs. 1992. New "phantom dinoflagellate is the causative agent of major estuarine fish kills. *Nature* 358:407-410.

dissolved oxygen, temperature, pH and salinity. For estuarine kills, in the Neuse and Pamlico it is also common practice to collect water samples for nutrients (nitrate+nitrite, ammonia, organic nitrogen, and phosphorus), chlorophyll (as an indicator of algal growth) and phytoplankton.

These samples are shipped to Raleigh for subsequent analysis. DWQ biologists make two separate analyses of the phytoplankton samples. The first is an identification of species of algae present in the sample using light microscopy. This "presumptive" identification will determine whether "*Pfiesteria*-like" dinoflagellates are present in a sample. Second, the sample will be viewed using epifluorescence microscopy, which utilizes a narrow wavelength light to fluoresce chlorophyll within the individual algal cells. "*Pfiesteria*-like" dinoflagellates that display a broadly fluorescent morphology are assumed to be autotrophic (feeding themselves through photosynthesis) and not likely producing toxins.

At each significant kill, the teams will also contact the NCSU Aquatic Botany laboratory about its interest in receiving samples for similar analyses, for scanning electron microscopy, or for toxicity tests that can imply that *Pfiesteria* may be responsible for a fish kill. The electron microscope allows the researcher to positively identify *Pfiesteria* to the species level. Recently another tool that has become available is a test for *Pfiesteria* DNA in a sample. This analysis, conducted by Dr. Parke Rublee with the University of North Carolina at Greensboro, can definitively identify the presence of *Pfiesteria piscicida* or *P. shumwayae*, a second species reported to be toxic. Dr. Rublee's laboratory has also been offered the service of sample collection during significant estuarine fish-kill events.

#### Significance of lesions or sores on fish

Many different factors can cause sores or lesions on fish. A variety of naturally occurring parasites including bacteria, protozoans, viruses, worms and crustaceans are encountered in fish populations. While it's not uncommon to observe these conditions in individual fish, increasing lesion prevalence in schools or populations may indicate problem conditions. The lesions most frequently observed and reported in North Carolina estuaries are, again, among schools of the Atlantic Menhaden.



These lesions have been reported for some time and have been linked to possible causes including fungal growth<sup>4,5</sup> and *Pfiesteria* toxins<sup>6</sup>. Current research on the causes of lesions under way at the NCSU College of Veterinary Medicine by Drs. Mac Law and Jay Levine indicate that other factors may play significant and/or dominant roles in lesion formation in menhaden. This work has hypothesized that lack of oxygen in tissues (hypoxia) caused by surrounding water conditions may play a direct role in the development of sores or even an indirect role that involves other stresses such as formation of reactive oxygen species. Additionally, these researchers have found that more than 80 percent of menhaden observed have encysted stages of a protozoan parasite tentatively identified as *Kudoa* species, present in muscle tissues. The effects of this parasite in menhaden muscle tissues are not currently understood. However, enzymes produced by this parasite could possibly produce effects that are compounded by hypoxia. Interim findings of this research do not support a fungi or a systemic toxin as primary factors in focal lesion development.<sup>7</sup>

<sup>4</sup> Dykstra, M.J., E.J. Noga, J.F. Levine, D.W. Moye, and J.H. Hawkins. 1986. Characterization of the *Aphanomyces* species involved with ulcerative mycosis(UM) in menhaden. *Mycologia*. 78:664-672.

<sup>5</sup> Blazer, Vicki, Scott Phillips, and Edward Pendleton. 1999. Fish Health, Fungal Infections, and *Pfiesteria*: The Role of the U.S. Geological Survey. USGS Fact Sheet 114-98. U.S. Dept. of the Interior. U.S. Geological Survey. Baltimore, Md.

<sup>6</sup> Noga, E.J. L. Khoo, J.B. Stevens, Z. Fan, J.M. Burkholder.1996. Novel toxic dinoflagellate causes epidemic disease in estuarine fish. *Marine Poll. Bull.* 16:2.219-224.

<sup>7</sup> Law, J. Mac and Jay F. Levine. 2000. Pathogenesis of Ulcerative Dermatitis and Myositis in Coastal North Carolina Fish. Interim Progress Report to : North Carolina Department of Environment and Natural Resources, Division of Water Quality. North Carolina State University College of Veterinary Medicine, Dept. of Microbiology, Pathology, and Parasitology. July, 2000.

Two years of sampling menhaden populations for disease incidence by the DWQ and the Division of Marine Fisheries has indicated that while overall disease prevalence is low, occurrence in some schools (which may be tens of thousands) may be very high. A thorough understanding of these disease events has not yet been achieved but research continues.

#### Significance of fish kills to fisheries and human health

Though reports of menhaden kills numbering ten or even hundreds of thousands are of concern, these numbers actually represent very small proportions of menhaden stocks in our estuaries at a given time. With average annual commercial landings from 1990 to 1999 of approximately 68.9 million pounds<sup>8</sup>, commercial fishing alone removes a sustained rate of greater than 91 million individuals per year in North Carolina alone (assuming 0.75 pound/individual). Menhaden swim in dense schools and thus, when lethally stressed can die in large numbers due to very limited expanses of stressful conditions. While North Carolina spawning stocks of menhaden are among the largest on record there is a concern that recruitment of young individuals into the population is low. Recruitment of juveniles to the population reportedly improved in 1999.

The possibility that toxins produced by *Pfiesteria* or *Pfiesteria*-like dinoflagellates might affect human health either directly by exposure in the environment or indirectly by consumption through fish or shellfish has been a public concern. The U.S. Environmental Protection Agency has stated that "There is no evidence that shows that people can get sick from eating fish or shellfish that have been caught in coastal waters that contain toxic *Pfiesteria piscicida*"<sup>9</sup> but it goes on to warn that to be safe, people should avoid eating fish with lesions.

North Carolina epidemiologists concluded in 1998 that there had been no adverse human health effects plausibly linked to *Pfiesteria* reported by physicians practicing in the state<sup>10</sup>. The N.C. Department of Health and Human Services, Division of Public Health, Harmful Algal Bloom program is currently conducting epidemiological research or health surveillance in North Carolina to thoroughly investigate any potential human health risk. The program also maintains a toll-free telephone number (1-888-823-6915) to report any suspected exposures to harmful algal blooms (including *Pfiesteria*).

The Harmful Algal Bloom Program has also contracted the UNC School of Public Health at Chapel Hill to conduct a prospective study to carefully monitor the health of fishermen who have agreed to participate in this research effort. Two of the six funded states, Virginia and Maryland, are also conducting prospective studies. Approximately 475 estuarine and ocean fishermen are being closely followed for their exposure to fish kills, areas being fished, and any changes in results in the medical and neurocognitive testing that is conducted every six months and after exposure to fish kills. After two years of close health monitoring, the study results will be available. The Department maintains a world wide web page that discusses health implications of *Pfiesteria* and fish kills at <http://www.schs.state.nc.us/epi/hab/faq.html>.

The federal health agency, the Centers for Disease Control and Prevention has funded a study through state health agencies in Delaware, Maryland, Virginia, South Carolina, Florida and North Carolina to identify citizens who experience a group of health symptoms, termed "Possible Estuary Associated Syndrome" (PEAS) and report contact with the estuaries, areas where *Pfiesteria piscicida* has been discovered in its "toxic" form.

In the Morbidity and Mortality Weekly Report of May 5, 2000, the CDC summarized findings of an 18-month survey of six east coast states, including North Carolina, for effects that could be linked

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<sup>8</sup> North Carolina Division of Marine Fisheries. 2000. Atlantic Menhaden Stock Status. <http://www.ncfisheries.net/stocks/atmenhaden.htm>.

<sup>9</sup> United States Environmental Protection Agency. 1999. What you should know about fish lesions. CBP/TRS229/99. USEPA Office of Water. Washington, DC.

<sup>10</sup> Smith, C. Gregory and Stanley I Music. 1998. *Pfiesteria* in North Carolina: The Medical Inquiry Continues. North Carolina Medical Journal. August 1998.

to exposure to estuarine waters<sup>11</sup>. Based on the states' PEAS surveillance data, using the consensus definition of a case, the CDC concluded that since June 1998 no illnesses were reported that met the criteria that might be indicative of adverse health effects from exposures to the estuaries or *Pfiesteria*. While this research does not imply that a hazard of exposure to *Pfiesteria* toxin does not exist, it does indicate that such a hazard may be so rare, so subtle or so short lived, that environmental exposure may not produce effects that have been significantly recognized by the medical community.

### Reporting and Tracking Fish Kills

The Division of Water Quality actively assesses significant fish kill events and records any validated kills of greater than 25 fish. This information is maintained in a database and made available to the public, along with other water quality information, on the World Wide Web at <http://www.esb.enr.state.nc.us/>. Contact Mark Hale at (919) 733-6946 for specific questions about this database. Fish kills can be reported to DWQ regional offices in:

Asheville (828) 251-6208	Washington (252) 946-6481
Fayetteville (910) 486-1541	Wilmington (910) 395-3900
Mooreville (704) 663-1699	Winston-Salem (336) 771-4600
Raleigh (919) 571-4700	

After normal work hours or weekends fish kills can be reported to the N.C. Emergency Operations Center at (800) 858-0368.

In the area around New Bern, the Neuse River Rapid Response Team can be notified **at any time** at (888) 764-7662 or (252) 514-4903.

In the area around Washington, the Pamlico River Rapid Response Team can be notified **at any time** at (877) 337-2383 or (252) 946-6481.

Questions about water quality or information presented here can be directed to Jimmie Overton or Larry Ausley at (919) 733-9960 or by e-mail available at <http://www.esb.enr.state.nc.us/>.



<sup>11</sup> United States Centers for Disease Control. 2000. Surveillance for Possible Estuary-Associated Syndrome---Six States, 1998--1999. Morbidity and Mortality Weekly Report. May 5, 2000/49(17):372-3. <http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/mm4917a4.htm>.