

Swinker, M.

1998 Clinical Study of *Pfiesteria* in North Carolina. March report to Dean William Roper, University of North Carolina School of Public Health, Chapel Hill, N.C.

Swazey, Judith, Melissa Anderson, and Karen Seashore Lewis

1993 Ethical Problems in Academic Research. *American Scientist* 81:542-553.

Tjossem, Sara

1990 Effects of Fish Chemical Cues on Vertical Migration Behavior of *Chaoborus*. *Limnology and Oceanography* 35:1456-1468.

Tomas, Carmelo, ed.

1997 Identifying Marine Diatoms and Dinoflagellates. New York: Academic Press.

Wilkinson, Todd

1998 Science Under Siege: The Politicians' War on Nature and Truth. Boulder, Colo.: Johnson Books.

Wright, Jeffrey, ed.

1998 The Raleigh Report 1998: *Pfiesteria* Research Needs and Management Actions. Special Report Series No. 19. Raleigh: University of North Carolina Water Resources Research Institute.

Human Organization, Vol. 58, No. 4, 1999

Copyright © 1999 by the Society for Applied Anthropology
0018-7259/99/040455-4\$1.00/1

Human Health and Environmental Impacts from Pfiesteria: A Science-Based Rebuttal to Griffith (1999)

Alan J. Lewitus, Parke A. Rublee, Michael A. Mallin, and Sandra E. Shumway

Alan J. Lewitus is a research assistant professor, Belle W. Baruch Institute for Coastal Research, Baruch Marine Laboratory, University of South Carolina, P.O. Box 1630, Georgetown, SC 29442 (e-mail: Lewitus@belle.baruch.sc.edu). Parke A. Rublee is professor of biology, University of North Carolina at Greensboro, Greensboro, NC 27412 (e-mail: rublee@uncg.edu). Michael A. Mallin is a research associate professor, Center for Marine Science Research, University of North Carolina at Wilmington, Wilmington, NC 28403 (e-mail: mallinm@uncwil.edu). Sandra E. Shumway is a professor of biology and marine sciences, Southampton College, Long Island University, NY 11968 (e-mail: shumway@southampton.liunet.edu).

Key words: dinoflagellate, environmental health, fish kill, human health, *Pfiesteria*, risk analysis

David Griffith began his article, "Exaggerating Environmental Health Risk: The Case of the Toxic Dinoflagellate *Pfiesteria*" (*Human Organization* 58:119-127), with a quotation by Angell (1995) which notes that assuming a connection between an effect and a cause, and then searching for it, is an inefficient approach that can lead to bias. Griffith clearly implied this was the approach Burkholder and her colleagues took to link *Pfiesteria* to human health problems. Griffith was in error. The approach Drs. Burkholder, Noga, and others took began with an observation of fish dying in aquaria, followed by identification of the cause as an unknown dinoflagellate (Burkholder et al. 1992; Noga et al. 1993). It was then hypothesized that this organism could potentially cause fish kills in the environment. This was followed by its identification in field samples at fish kills (Burkholder et al. 1992; Noga et al. 1996) and searches of historical records that suggested it also was a potential cause of some (but not all) fish kills during the years when phytoplankton count records were maintained. The association with human illness came after laboratory workers became mildly to seriously ill, and their symptoms were

similar to those reported by watermen (Glasgow et al. 1995). Because of the *potential* for human health problems in nature, they called for studies. Initial questionnaires used to begin to address the potential for health problems from *Pfiesteria* in North Carolina yielded little definitive information (see Oldach, Grattan, and Morris 1999). Later, clinical studies by physicians from the University of Maryland and Johns Hopkins on individuals with confirmed exposure to toxic *Pfiesteria* outbreaks demonstrated cognitive impairment lasting up to six months (Grattan et al. 1998). It is also important to note that the long-term impact of exposure to these toxins is still unknown.

On page 120 and throughout, Griffith downplayed the health problems associated with *Pfiesteria* (e.g., "mild cognitive impairment," "recovery within hours or days") and suggested that concerns about human health hazards were declining. The actual results show quite the opposite. In contrast to Griffith's statements, cognitive impairment suffered by individuals was pronounced, with 10 of 13 individuals with high exposure to affected waterways scoring below the 2nd percentile on the Rey auditory, verbal, learning, and

memory test compared to matched national norms (Grattan et al. 1998). This level of impairment "reflects a profound and potentially disabling deficit" (Oldach, Grattan, and Morris 1999:147). Recovery time was weeks to months in most cases (Glasgow et al. 1995; Grattan 1998), but Oldach, Grattan, and Morris (1999:147) reported that some individuals complain that they still have not recovered completely. In fact, in referring to affected laboratory workers, Morris (1999:1191) stated that "Although most of the symptoms appear to have resolved, concerns remain... about persistent effects (including persistent neurocognitive deficits) 6-7 years after the acute incident."

Griffith noted that "popular writers embellish with hyperbole and speculation"(p.119) but the tone of Griffith's article is an example of the same embellishment and hyperbole (e.g., raising the specter of AIDS and Ebola; his characterization of problems as "mild" vs. physicians' characterization as "severe" and "profound"). He continually charges that the scientists working with *Pfiesteria* characterized it as a "serious threat" to public health (pp. 120, 121, 122). The use of these descriptors (unsubstantiated with quotes or references) helped elevate the level of concern for *Pfiesteria* as a human health potential problem to a "serious threat." This distinction was important in helping Griffith create the atmosphere of exaggeration, but it has no basis in fact. In contrast to Griffith's anecdotal account, Burkholder and colleagues have been conservative in assessing *Pfiesteria*'s link to human health effects, recognizing that laboratory-related exposure is unnatural, but *leaving open* the possibility that humans might be affected in natural settings. In peer-reviewed published accounts, it is the effect from laboratory exposure that has been considered "serious" (e.g., Burkholder and Glasgow 1997), but when extrapolating to estuarine exposure, Burkholder and coauthors have consistently characterized the problem as *potential*. For example, Burkholder, Glasgow, and Hobbs (1995:58) stated that "Apart from anecdotal information provided by local fishermen, carefully designed epidemiological studies are lacking to determine whether humans who frequent estuaries with toxic outbreaks might be adversely affected." Also, Burkholder and Glasgow (1997:1073) stated that "Anecdotal information... points to the potential for this dinoflagellate to adversely affect human health in natural habitat." Such statements hardly qualify for exaggeration or the characterization that Griffith portrayed.

Why, as Griffith stated (p.122), was his epidemiological survey "dismissed or taken lightly" by outside panels of scientists (e.g., Wright 1998)? We recognize the inherent difficulty in drawing definitive conclusions from survey research and acknowledge that Griffith presented related weaknesses from such studies. However, criticism of his study was mainly derived from serious problems related to flaws in his study design. Griffith's survey was supposed to be designed to assess watermen's health in *Pfiesteria* kill areas and control areas. The only source of accurate *Pfiesteria* fish-kill maps was Burkholder's laboratory because North Carolina's environmental agency did not allow most *Pfiesteria* data to be included in

the state's official fish-kill database until after the Chesapeake outbreaks (North Carolina Department of Environment, Health, and Natural Resources fish-kill database records, Raleigh, 1991-1998). Griffith wrote his proposal (Griffith and Borré 1995) and conducted his survey without asking Burkholder for such maps until after his study was nearly completed (see the accompanying comment by Burkholder and Glasgow) and after he began to widely inform the press that his study had shown that *Pfiesteria* was a nonissue (e.g., North Carolina Sea Grant 1995; Leavenworth 1997).

In addition to not having accurate *Pfiesteria* fish-kill location maps, the other major reason why Griffith's survey cannot be related to *Pfiesteria* is that contact with fish kills was not assessed in the study. Griffith (p. 123) stated that the research goal was to assess "the effects of contact with the waters of Eastern North Carolina under normal ecological conditions (specifically in the absence of fish kills)." However, toxic *Pfiesteria* is only active during certain fish-kill/disease events (Burkholder and Glasgow 1997; Burkholder et al. 1999); thus, if information on effects of *Pfiesteria* on watermen is a research goal, it is imperative to assess the health of watermen contacting in-progress fish kills (that is, while fish are dying) or periods when active *Pfiesteria*-like lesions were present on fish. The Grattan et al. (1998) study was properly designed to do this and resulted in their findings of mild to severe cognitive impairment up to a six-month period after exposure. Griffith et al.'s (1998) results, used as evidence against the link of *Pfiesteria* with public health problems, suffered from these critical design flaws. Evaluation of that survey as too poor in quality to provide solid information about health impacts from environmental exposure to toxic *Pfiesteria* was based on these critical design flaws—it was *not* the result of a conspiracy by scientists "benefiting from *Pfiesteria* research dollars" (p. 121) or "with vested interests" (pp. 122, 123).

Griffith attempted to base his article on human health risks, while at the same time disparaging Burkholder and her research associates for having expressed concerns about *Pfiesteria*'s impacts on estuarine ecosystems (p. 120, Griffith's misstatement that these scientists "began making and embellishing claims that [*Pfiesteria*] posed a serious threat to public and *environmental health*," emphasis added). However, the *Pfiesteria* issue cannot be divorced from the impacts on fish. All finfish and shellfish species exposed to toxic *Pfiesteria* cultures to date (predominantly commercially important species) have been shown to be susceptible, and kills linked with *Pfiesteria* are dominated by commercially important species (Burkholder and Glasgow 1997). There is also strong scientific evidence that toxic *Pfiesteria* causes serious chronic/sublethal impacts on fish health (Noga et al. 1996; Burkholder 1998).

These observations raised two critical concerns very early in the emerging picture of *Pfiesteria*: Can toxins accumulate in seafood and be transferred to humans? And, what are the impacts on coastal communities, especially impacts of *Pfiesteria* on the seafood and recreation industries? The first

question is directly related to human health. Biomagnification of toxins through the food chain is a common mode of dinoflagellate toxin transfer (see Anderson and Garrison 1997), so the question is relevant to address in the case of *Pfiesteria* (Wright 1998). Fortunately, there is, as yet, no evidence that *Pfiesteria* toxins accumulate in affected finfish and shellfish, but note that this is a rare exception to general scientific understanding of dinoflagellate toxins.

The second question is relevant on several counts. First, fish kills can reduce the number of fish available for commercial harvest, although in estuarine kills the number of fish affected is believed to be small relative to the total number in the population. More importantly, chronic/sublethal impacts that impair fish reproduction, recruitment, and disease resistance—especially in estuarine fish nursery grounds as important as those where toxic *Pfiesteria* has been most active—would be expected to promote declines in fish populations over the long term (see Burkholder 1998). Either of these outcomes can lead to significant economic problems for the seafood industry, as can the perception of a problem. (We note also that this threat to the seafood industry—realized in a significant decline in sales in the Chesapeake Bay area during the summer of 1997 [Epstein 1998]—is a potentially strong incentive for participants in Griffith's study to have misreported health impacts). Furthermore, the estuarine tourism industry depends economically on both recreational fishing and water sports. If the quality of those activities are either actually or even perceived to be risky, the economic ramifications may be significant. Thus, aside from the direct effect on human health problems, the indirect effect on fisheries remains an important motivation for understanding *Pfiesteria*.

The many misinterpretations and lack of background research demonstrated by Griffith's writing lead us to seriously doubt that reviewers of the paper had any knowledge of *Pfiesteria* research. Nonetheless, these falsely based attacks on the scientific caliber of studies by Burkholder and her associates were published. For example, it is commonly recognized throughout the scientific community in this field that *Pfiesteria* and *Pfiesteria*-like dinoflagellates do not include *Gymnodinium breve* (if that is what Griffith meant—see note 1, p. 125). Note that Griffith's "*Gynovidinium breve*" does not exist; see Burkholder et al. 1992; Burkholder and Glasgow 1995; Steidinger et al. 1996; versus Tomas 1997. Also, which "better-known red tide" did Griffith mean on p. 120? There are many different red tides well known throughout the world, including along the eastern U.S. coastline (Anderson and Garrison 1997). Griffith described *Pfiesteria*, ciguatera, and "red-tide" dinoflagellates as "irritants" with similar health effects. Exposure to toxic *Pfiesteria* has been linked to serious human illness (Glasgow et al. 1995; Grattan et al. 1998). Toxins from some "red tide" dinoflagellates have both caused serious illness and even killed people in many parts of the world (Anderson and Garrison 1997). Toxic dinoflagellate blooms are generally unpredictable, and because they can be so potent, resource managers and health specialists generally agree it is wise to err on the side of caution. For that

reason, proactive monitoring programs have been developed for some of the better understood toxic dinoflagellates in the U.S. and elsewhere (Shumway 1990; Burkholder 1998).

Moreover, Griffith (p. 124) wrote (without citing any of the many available papers on the subject) that scientists working with *Pfiesteria* claimed that certain human behaviors, specifically nutrient loading, have been implicated as the primary cause of *Pfiesteria*'s transformation from a dormant, plant-like state to an active killer of fish and other organisms. Actually, it is clearly stated in several peer-reviewed international science publications that substances secreted by schools of fish, principally Atlantic menhaden, cause the transformation of *Pfiesteria* from a nontoxic to a toxic stage (e.g., Burkholder et al. 1992; Burkholder, Glasgow, and Hobbs 1995; Burkholder and Glasgow 1997). It is also clearly stated that nontoxic stages of *Pfiesteria* have been shown to respond positively to increases in nutrient loading (Glasgow et al. 1995; Burkholder and Glasgow 1997).

As another example, Griffith took issue with terms such as "ambush predator" and "phantom," claiming that such terms were more appropriate to military history than biology. However, such descriptors are standard in aquatic biology, as any cursory survey of the literature would reveal. For instance, the term "ambush predator" is used to classify a vast functional group of organisms in relation to their feeding behavior (Greene 1985). A good example is the chaetognath *Saggia*, the "arrow worm," one of the most important predators in marine zooplankton communities (Fulton 1984). Its counterpart in freshwater systems is *Chaoborus*, the "phantom midge," one of the most well-studied aquatic invertebrates in the world (Riessen, O'Brien, and Loveless 1985).

In summary, there may be differences of opinion in scientific issues, but these must be argued in an objective, factually based manner. We call for a dependency on hypothesis-driven, peer-reviewed science in international journals as the primary basis for understanding such issues; for professional conduct so that respected scientists are not falsely disparaged; and for the peer-review process to include appropriate specialists to ensure that the quality of scientific information can be fairly evaluated, rather than cursorily condemned on false grounds. Griffith's accusations—that scientists involved with *Pfiesteria* research exaggerated the link to human health, and that there is no evidence for serious health impacts from this toxic dinoflagellate—have no basis in fact. This rebuttal refutes the critical points in his allegations on the basis of peer-reviewed international publications on the biological and medical science of *Pfiesteria*.

References Cited

- Anderson, Donald, and David Garrison, eds.
1997 The Ecology and Oceanography of Harmful Algal Blooms. *Limnology and Oceanography* 42:1009-1305.
- Angell, Marcia
1995 Science on Trial: The Clash of Medical Evidence and Law in the Breast Implant Case. New York: W.W. Norton.

- Burkholder, JoAnn
1998 Implications of Harmful Microalgae and Heterotrophic Dinoflagellates in Management of Sustainable Marine Fisheries. *Ecological Applications* 8:S37-S62.
- Burkholder, JoAnn, and Howard Glasgow, Jr.
1995 Interactions of a Toxic Estuarine Dinoflagellate With Microbial Predators and Prey. *Archives für Protistenkunde* 145:177-188.
1997 *Pfiesteria piscicida* and Other *Pfiesteria*-like Dinoflagellates: Behavior, Impacts, and Environmental Controls. *Limnology and Oceanography* 42:1052-1075.
- Burkholder, JoAnn, Howard Glasgow, Jr., and Cecil Hobbs
1995 Fish Kills Linked to a Toxic Ambush-Predator Dinoflagellate: Distribution and Environmental Conditions. *Marine Ecology Progress Series* 124:43-61.
- Burkholder, JoAnn, Michael Mallin, and Howard Glasgow, Jr.
1999 Fish Kills, Bottom-Water Hypoxia, and the Toxic *Pfiesteria* Complex in the Neuse River and Estuary. *Marine Ecology Progress Series* 124:43-61.
- Burkholder, JoAnn, Edward Noga, Cecil Hobbs, Howard Glasgow, Jr., and Steven Smith
1992 New 'Phantom' Dinoflagellate is the Causative Agent of Major Estuarine Fish Kills. *Nature* 358:407-410; and *Nature* 360:768.
- Epstein, Paul
1998 Marine Ecosystems: Emerging Diseases as Indicators of Change. Year of the Ocean Special Report. Center for Health and the Global Environment. Boston: Harvard Medical School.
- Fulton, Raleigh III
1984 Effects of Chaetognath Predation and Nutrient Enrichment on Enclosed Estuarine Copepod Communities. *Oecologia* 62:97-101.
- Glasgow, Howard Jr., JoAnn Burkholder, Donald Schmechel, Patricia Tester, and Parke Rublee
1995 Insidious Effects of a Toxic Estuarine Dinoflagellate on Fish Survival and Human Health. *Journal of Toxicology and Environmental Health* 46:501-522.
- Grattan, Lynn
1998 Current Status and Future Directions for the Investigation and Management of the Human Health Effects of Exposure to *Pfiesteria piscicida* or *Pfiesteria*-like Dinoflagellates. *Maryland Medical Journal* 47:148-150.
- Grattan, Lynn, David Oldach, Trish Perl, Mark Lowitt, Diane Matuszak, Curtis Dickson, Colleen Parrott, Ritchie Shoemaker, Martin Wasserman, J. Richard Hebel, Patricia Charache, and J. Glenn Morris, Jr.
1998 Problems in Learning and Memory Occur in Persons with Environmental Exposure to Waterways Containing Toxin-Producing *Pfiesteria* or *Pfiesteria*-like Dinoflagellates. *Lancet* 352:532-539.
- Greene, Charles
1985 Planktivore Functional Groups and Patterns of Prey Selection in Pelagic Communities. *Journal of Plankton Research* 7:35-40.
- Griffith, David
1999 Exaggerating Environmental Health Risk: The Case of the Toxic Dinoflagellate *Pfiesteria*. *Human Organization* 58:119-127.
- Griffith, David, and Kristen Borré
1995 An Exploratory Study of Potential Human Health Effects of Deteriorating Water Quality Among North Carolina Crabbers. Greenville: East Carolina University. Available from North Carolina Sea Grant, Raleigh.
- Griffith, David, Kristen Borré, Aaron Shechter, and Vernon Kelley
1998 Occupational Risks of Crabbing: A Report with Special Emphasis on the Public Health Threat of *Pfiesteria piscicida*. In *Research on Toxic Algae: Pfiesteria-like Organisms*. Pp. 1-43. University of North Carolina Sea Grant College Program UNC-SG-98-02.
- Leavenworth, Stuart
1995 Fish-Killer No Danger to People, Study Finds. Raleigh (N.C.) News and Observer. April 29.
- Morris, J. Glenn, Jr.
1999 *Pfiesteria*. "The Cell from Hell," and Other Toxic Algal Nightmares. *Clinical Infectious Diseases* 28:1191-1198.
- Noga, Edward, Steven Smith, JoAnn Burkholder, Cecil Hobbs, and Robert Bullis
1993 A New Ichthyotoxic Dinoflagellate: Cause of Acute Mortality in Aquarium Fishes. *Veterinary Record* 133:96-97.
- Noga, Edward, L. Khoo, J. Stevens, Z. Helen Fan, and JoAnn Burkholder
1996 Novel Toxic Dinoflagellate Causes Epidemic Disease in Estuarine Fish. *Marine Pollution Bulletin* 32:219-224.
- North Carolina Sea Grant
1995 1995 Sea Grant News. New Research Results Available on *Pfiesteria* Dinoflagellate. Raleigh: North Carolina State University. April 28.
- Oldach, David, Lynn Grattan, and J. Glenn Morris
1999 *Pfiesteria piscicida* and Human Health. In *Emerging Infections 3*. W.M. Scheld, W.A. Craig, and J.M. Hughes, eds. Pp. 135-151. Washington, D.C.: ASM Press.
- Reissen, Howard, W.J. O'Brien, and B. Loveless
1985 An Analysis of the Components of *Chaoborus* Predation on Zooplankton and the Calculation of Relative Prey Vulnerabilities. *Ecology* 65:514-522.
- Shumway, Sandra
1990 A Review of the Effects of Algal Blooms on Shellfish and Aquaculture. *Journal of the World Aquaculture Society* 21:65-104.
- Steidinger, Karen, JoAnn Burkholder, Howard Glasgow, Jr., Cecil Hobbs, Ernest Truby, Julie Garrett, Edward Noga, and Steven Smith
1996 *Pfiesteria piscicida* gen. et sp. nov. (Pfiesteriaceae, fam. nov.), A New Toxic Dinoflagellate Genus and Species with a Complex Life Cycle and Behavior. *Journal of Phycology* 32:157-164.
- Tomas, Carmelo, ed.
1997 Identifying Marine Diatoms and Dinoflagellates. New York: Academic Press.
- Wright, Jeffrey, ed.
1998 The Raleigh Report 1998: *Pfiesteria* Research Needs and Management Actions. Special Report Series No. 19. Raleigh: University of North Carolina Water Resources.