Hypoxia, Fertilizer, and the Gulf of Mexico

I READ "KEEPING THE STYGIAN WATERS AT bay" by Dan Ferber (News Focus, 9 Feb., p. 968). As a AAAS member, a member of the U.S. Environmental Protection Agency (EPA) Gulf of Mexico Program's Nutrient Enrichment Focus Team, a participant at four of the seven Mississippi River/Gulf of Mexico Watershed Nutrient Task Force meetings, and a scientist who has played a leadership role in national nutrient management organizations, I am compelled to comment on several inaccuracies, a lack of objectivity, and apparent sensationalism in the article.

Hypoxia in the Gulf of Mexico has been recognized since at least 1935 and has most likely been present for centuries, long before the advent of fertilizer nitrogen use. Since first measured in 1985, the area of the bottom water hypoxic region has varied dramatically from year to year, as illustrated in Ferber's article (p. 970 and at right). In 2000, the area was smaller than in any year since 1985, with the exception of 1988. This decline occurred without any appreciable change in fertilizer nitrogen use. There is no clear cause-and-effect relationship between fertilizer nitrogen use and the size of the hypoxic region in the Gulf from 1980 to the present.

There are also no conclusive data that identify the sources of the nitrate and nitrogen that enter the Mississippi River and ultimately reach the Gulf. In the White House Committee on the Environment and Natural Resources (CENR) Topic 3 report, Don Goolsby and others used a statistical model to conclude that agriculture was the major source of nitrogen to the Mississippi River basin. Their conclusion was not surprising, since inputs to the model were based on the assumption that many nonagricultural sources (for example, urban runoff and geological nitrate) were insignificant. Their estimates of discharge are simply proportionate to the tonnage of each input source in subbasins of the Mississippi River basin. River monitoring clearly indicates that major nitrogen loads come from the geographic area of the Corn Belt, but the sources remain unclear. This geographic area contains naturally rich soils of the prairies, as well as agriculture. The proportion of the nitrogen that comes from agriculture and the proportion of the agricultural nitrogen that arises from fertilizer use remain uncertain.

Language such as "fertilizer-saturated soils" in Ferber's article is scientifically inaccurate and irresponsible. There is no reference in the public issue of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force's hypoxia Action Plan to "measures to wean farmers off heavy use of chemical fertilizers." The goal of the Action Plan is to reduce discharges and runoff to the northern Gulf from all nutrient sources.

Efficiency in the use of all nitrogen sources has become increasingly important to farmers, crop advisers, agricultural scientists, and the agricultural industry. Indeed, the amount of corn produced per unit of fertilizer nitrogen has increased by over 30% in the past two decades. Appropriate site-specific improvement in management practices, which may include some reductions in nutrient use, will lead to continued increases in crop production efficiency, reduced off-site transport of nutrients, and enhanced water quality protection.

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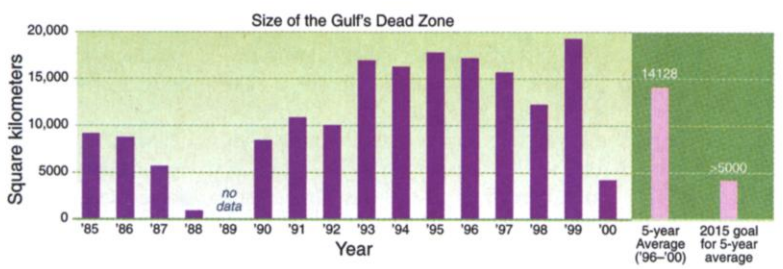
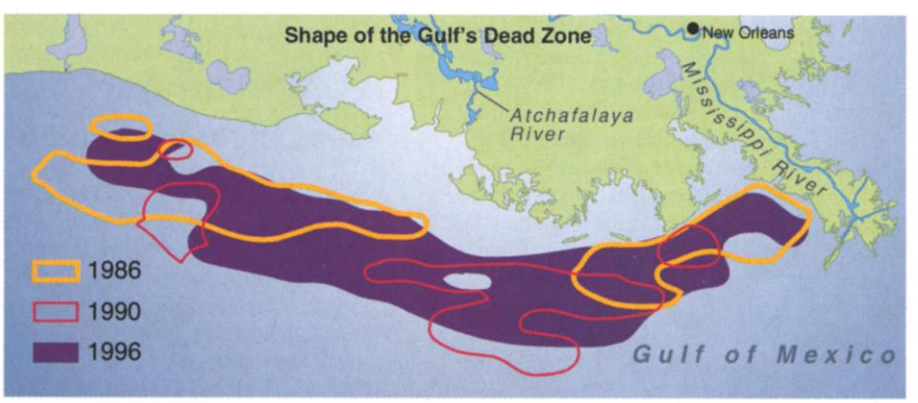
CONGRATULATIONS ON THE FINE ARTICLE BY Dan Ferber. This piece clearly describes the complex issues behind the "dead zone" in the Gulf of Mexico, and correctly states that there are only a handful of scientists who disagree that agricultural practices in the upper Midwest are the prime culprits.

Unfortunately, Ferber's companion piece ("The dead zone's fiercest crusaders," p. 970) may give undue coverage to this small minority, particularly to the assertions made by Derek Winstanley in his non-peer-reviewed reports and testimony before Congress. In fact, there is an overwhelming consensus among scientists familiar with the problem that farm practices cause the dead zone. This is reflected in the report from the National Academy of Science's Committee on Causes and Management of Coastal Eutrophication, a committee I chaired. Our report, issued last summer (*Clean Coastal Waters*, National Academy Press), fully and unanimously endorsed the findings of the CENR assessment on hypoxia. Excessive use of fertilizer and





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other farming practices have caused the hypoxic condition, and changes in farm policy can correct the problem with relatively little cost to farmers and with little or no loss of agricultural productivity. The idea proposed by Winstanley and E. Krug that modern agriculture has a "cleansing" influence on water quality is absurd, as discussed in the critique by M. David and G. McIsaac, to which the Ferber article refers. The vast majority of the science points to the need to change farming practices in the United States if we are to solve the problem of the dead zone and the deteriorated water quality elsewhere in our country.

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IN DAN FERBER'S REPORT ON HYPOXIA, HE tells a good-girl/bad-boy story about N. Rabalais and me rather than describing legitimate differences of scientific opinion. In so doing, he makes inaccurate and misleading statements.

(i) Ferber states that Edward Krug and I conclude that modern agriculture has greatly cleansed the Illinois River. We in fact conclude that reduction in the concentration of nitrogen is attributable to both point- and non-point-source pollution control. The discharge of nutrients from Chicago wastewater has decreased by more than 90% since the 1920s.

(ii) Ferber reports that I argue that the dead zone in the Gulf of Mexico is a natural phenomenon. My position is that the relative contribution of offshore sources of nutrients from upwelling waters of the continental slope is unknown. The White House Committee on the Environment and Natural Resources recognizes that algal blooms in shallow coastal zones can be caused by upwelling of deep nutrients (*1*). The coastal zone of the Pacific Ocean from Canada south to Chile experiences natural hypoxia (*2*).

(iii) Ferber also reports that I have led an effort to clear the Mississippi Basin's name. This is false. As the CENR report itself acknowledges, a large body of additional data is available, but was not used. The failure of the report to incorporate a large body of scientific data reflects a bias with the report, not with me.

(iv) Ferber knows that I support the implementation of agricultural best management practices, but does not mention this in his report.

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References and Notes

1. CENR, *National Assessment of Harmful Algal Blooms in US Waters* (White House, Washington, DC, 2000).
2. R. J. Diaz, R. Rosenberg, *Oceanog. Mar. Biol.* **33**, 245 (1995).

Response

WINSTANLEY HAS CRITICIZED WHAT HE CALLS "the fertilizer hypothesis" in Congressional testimony, in public comments he ghostwrote for Illinois officials, and in several speeches, including one at the annual convention of a major farm lobbying group, the American Farm Bureau Federation. (Snyder's claim that fertilizer nitrogen has not been clearly linked to Mississippi River nitrogen dismisses several modeling studies, including Goolsby's, that point to nitrate from fertilizer as the major source.) Also, while the federal action plan does refer to all sources of nitrogen, it clearly aims to cut fertilizer use in the Mississippi Basin by calling for funding of agricultural best management practices, which help reduce wasteful fertilizer application.

DAN FERBER

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

A Global Strategy to Defeat Invasive Species

IN "BLACK CARP AND SICK COWS" (EDITORIAL, 13 Apr., p. 169), Donald Kennedy illustrates that globalization of trade, travel, and transport can have unintended negative consequences, namely, the relocation and establishment of invasive species (*1*). He is justifiably concerned that there is too little awareness of this international threat and no general strategy for dealing with the invaders.

In 1996, this same concern was voiced by representatives of 80 countries and the United Nations (*2*). This led The Scientific Committee on Problems of the Environment, The World Conservation Union, CAB International, and invasive species experts from a wide array of disciplines to establish the Global Invasive Species Program (GISP) in 1997. GISP's mission is to employ its scientific and technical expertise to increase the ability of all nations to minimize the spread and impact of invasive species.

In its first phase of operations, GISP has produced four books (*3*) and designed a database for the world's worst invaders (www.issg.org) and a toolkit of best management practices. GISP's global strategy recommends actions that governments and other bodies can take to address the invasive species problem. Its recommendations informed the development of the United States' first national invasive species management plan, released by the National Invasive Species Council in January (available at www.invasivespecies.gov).

GISP's studies indicate that prevention is more economical and feasible than controlling outbreaks of invasives. Thus, the improvement of prevention systems and their expansion to incorporate agricultural and environmental threats should be an international goal. Many invasive species have "lag periods" after introduction when small populations can be eradicated or contained; therefore, limited resources are best expended to detect and respond to newly established invasives. Ultimately, a nation's ability to address its invasive species problems is determined by its access to global information sources, the strength of its taxonomic capacity, and its willingness to cooperate with other countries.

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References and Notes

1. "Invasive species" means an alien (non-native) species whose introduction does or is likely to cause economic or environmental harm or harm to human health. U.S. Executive Order 13112, 3 Feb. 1999.
2. O. T. Sandland *et al.*, Eds., *Norway/United Nations Conference on Alien Species* (Norwegian Directorate for Nature Management and Norwegian Institute for Nature Research, Trondheim, Norway, 1996).
3. J. A. McNeely, Ed., *The Great Reshuffling: Human Dimensions of Invasive Alien Species* (World Conservation Union, Cambridge, MA, 2001); H. A. Mooney, R. J. Hobbs, Eds., *Invasive Species in a Changing World* (Island Press, Washington, DC, 2000); C. Perrings *et al.*, Eds., *The Economics of Biological Invasions* (Edwar Elgar, Northampton, MA, 2000); C. Shine *et al.*, *A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species* (IUCN, World Conservation Union, Bonn, Germany, 2000).

The Identity of Plant Glutamate Receptors

ION CHANNELS ARE IMPORTANT IN THE perception and transduction of environmental signals in essentially all organisms. Plants are no exception. Completion of the *Arabidopsis* genome-sequencing project has revealed that among the 600 *Arabidopsis* genes predicted to encode membrane transport proteins of one sort or another are 20