

PROGRESS ON THE GULF OF MEXICO HYPOXIA ISSUE

K.A. Kelling¹

In 1996, the phrase “Gulf of Mexico hypoxia” became common for agricultural scientists, regulatory agencies, the fertilizer industry, and even some farmers because the accusation was made that inefficient use of nitrogen fertilizer in the Mississippi River Basin—and especially the Upper Midwest—was creating a “dead zone” in the Gulf. There is no question that this oxygen-depleted (< 2 ppm) area exists, and that since 1993, it has remained larger than the long-term historical size (Fig. 1).

Wisconsin-Madison.

- ! Sources of Mississippi River nitrogen;
- ! Nitrogen export from agricultural landscapes;
- ! Aquatic processing of nutrient flux;
- ! Costs and benefits of decreasing agricultural nutrient flux;
- ! Future of hypoxia in the Gulf of Mexico; and
- ! Recommendations.

In general, the recommendations were an endorsement of currently recommended nutrient management practices and suggested strengthening of their implementation, and monitoring of the impact of these changes on the Gulf water quality. In several cases, the report pointed toward the need for additional information. Specifically, the listed recommendations were:

- ! Control, retain, and monitor nutrients leaving agricultural and key Mississippi River Basin lands;
- ! Create, enhance, and distribute information on cost-effective agricultural nutrient management methods;
- ! Set and achieve goals of nutrient flux reduction tied to downstream water quality improvement;
- ! Seek cost-effective solutions to enhance the security of agricultural and coastal communities;
- ! Gauge effectiveness of solutions by societal and private costs and benefits;
- ! Implement policies favoring long-term, broad strategies that enhance life and environment in the Mississippi River Basin and the Gulf Coast;
- ! Monitor changes in hypoxia, its potential causes, and the impacts of marine eutrophication on society and environment.

CENR Hypoxia Report

The second major publication issued in a draft form in 1999 was a series of six reports with the overall title of “Integrated Assessment of Hypoxia in the Northern Gulf of Mexico.” This report, commissioned by the federal Interagency Committee on the Environmental and Natural Resources (CENR) Task Force on Harmful Algal Blooms and Hypoxia, is now available for public review and comment. The six individual parts were (1) Characterization of hypoxia, chaired by N. Rabalais, Louisiana Universities Marine Consortium; (2) Ecological and economics consequences of hypoxia, chaired by R. Diaz, Virginia Institute of Marine Science and A. Solow, Woods Hole Oceanographic Institution; (3) Flux and sources of nutrients in the Mississippi-Atchafalaya River Basin, chaired by D. Goolsby, USGS; (4) Effects of reducing nutrient loads to surface waters within the Mississippi River Basin and Gulf of Mexico, chaired by P.L. Brezonik, University of Minnesota, and V.J. Bierman, Jr., Limno-Tech, Inc.; (5) Reducing nutrient loads, especially nitrate-nitrogen to surface water, groundwater, and the Gulf of Mexico, chaired by W.J. Mitsch., Ohio State University; and (6) Evaluation of economic costs and benefits of methods for reducing nutrient loads to the Gulf of Mexico, chaired by O.C. Doering, Purdue University.

The following is a summary of this report. Substantial sections have been taken directly from the report executive summary and should not be construed as the original work of this

author. Very low levels of dissolved oxygen occur naturally in the Gulf of Mexico, but evidence indicates that human activities are intensifying the natural phenomenon. Sediment cores collected in the hypoxic zone of the Gulf show that algal production and deposition, as well as oxygen stress, were much lower earlier in the century and that significant increases occurred in the latter half of the century. Over this period, there have been three major changes in the drainage basin affecting the river flux to the Gulf: (1) channelization of the river for flood control and navigation, mostly completed prior to the 1950s (except the Atchafalaya modifications in the early 1980s); (2) alterations in the landscape (e.g., deforestation and artificial agricultural drainage) that removed much of the “buffer” for runoff into the Mississippi tributaries and main stem, with the greatest rates of change in the 50-year period straddling the turn of the last century and another burst in drainage development during 1945 to 1960; and (3) a dramatic increase in fertilizer nitrogen input into the Mississippi River drainage basin between the 1950s and 1980s.

The reports suggest two possible alternatives:

(1) Potential futures if current activities are unchanged—Nitrogen loading appears to have reached a plateau at the level of about 1.6 million metric tons/year, which is the mean loading over the period 1980 to 1996. If the set of activities that affect nutrient flux continues to prevent increasing trends, the current range of dimensions and severity of the hypoxic zone on the Louisiana shelf would most likely be maintained. Hypoxia would vary, depending on other factors, such as the timing and extent of spring and summer stratification, weather patterns, temperature, and precipitation in the Gulf and drainage basin. Thus, even if flux did not trend upward, natural variability could produce new extremes of hypoxia extent and impacts. Nutrient impairments to water quality in the basin are unlikely to improve without some changes in current activities.

(2) Potential futures if loading is reduced — Experience has demonstrated that large ecosystems do respond positively to nutrient reductions. Examples include Chesapeake, Tampa, and Sarasota Bays. In the Gulf of Mexico, reductions in total nitrogen flux of about 40% are necessary to return to loads comparable to those before the large increases in the 1950 to 1970 period. Model simulations indicate that nutrient load reductions of 20 to 30% would result in a 15 to 50% increase in bottom water dissolved oxygen concentrations and a 5 to 15% decrease in surface chlorophyll concentrations. Such increases in oxygen are significant in that they represent an overall average for the hypoxic zone and that any increase above the 2 mg/L threshold will have a significant effect on marine life.

The reports recommended actions included:

The two primary approaches suggested to reduce and control hypoxia in the Gulf of Mexico are (1) reducing inputs of nitrogen to streams and rivers in the basin and (2) restoring and enhancing natural denitrification processes in the basin.

In the first category, the most effective actions include improved management practices to retain nitrogen on fields, reducing application of nitrogen fertilizer (particularly above recommended rates), implementing alternative cropping systems, decreasing feedlot runoff, and reducing point sources. Other measures, such as reducing urban nonpoint sources and

atmospheric deposition, could provide important contributions, but, on a basin-wide scale, they are not as significant. Nitrogen trading among all sectors could offer opportunities to obtain least-cost reductions. Based on economic analysis, the cost of reducing edge-of-field nitrogen losses by 20% under economically optimum conditions was estimated to be about \$0.40 per pound. The committee estimated edge-of-field nitrogen losses could be reduced by about 10% through a 20% reduction in fertilizer use at estimated costs of \$0.31 per pound.

In the second category, the most effective actions would be increasing the acreage of wetlands and riparian buffers within the basin. Nitrogen transformations in wetlands and riparian soils, in surface water and in groundwater involve several microbiological processes, some of which denitrify—that is, they make nitrogen effectively unavailable as a nutrient for plant uptake by removing it from the water as nitrogen gas. At typical denitrification rates for flow-through wetlands, 5 million acres (0.7% of the basin area) of constructed or restored wetlands would reduce nitrogen load to the Gulf by 20%. Riparian areas are vegetated areas, next to water resources. They are also effective in removing nitrates, but typical denitrification rates are less than those of wetlands. An estimated 19 million acres (2.7% of the basin) of additional riparian buffers would be needed to reduce nitrogen load to the Gulf by 20%. Direct costs of creating and restoring 5 million acres of wetlands were estimated to be about \$4.05 per pound.

Industry Action Needed

These recommendations have very broad sweeping implications for much of agriculture and should not be swept aside or dismissed. This report is currently available for public comment on the National Oceanic and Atmospheric Administration (NOAA) web site at www.nos.noaa.gov. The steps that are likely to follow after this period of public comment is to draft an integrated assessment of all six of the report chapters and, following another review, prepare a final report that includes an action plan. Some industry and agricultural reaction and input are being provided by the American Farm Bureau Federation, the Fertilizer Institute, and the Potash and Phosphate Institute; however, it is also important that a broad spectrum of agriculture understand and react to issues such as hypoxia.