STATE OF MISSOURI

Mel Carnahan, Governor • Stephen M. Mahfood, Director

DEPARTMENT OF NATURAL RESOURCES

OFFICE OF THE DIRECTOR

P.O. Box 176 Jefferson City, MO 65102-0176

December 17, 1999

Gulf of Mexico Hypoxia Work Group
National Centers for Coastal Ocean Science
WS 13446 SSMC4
1305 East-West Highway
Silver Spring, MD 20910

Dear Members of the Gulf of Mexico Hypoxia Work Group:

On behalf of the State of Missouri, I submit comments on the Integrated Assessment of Hypoxia in the northern Gulf of Mexico. I request that these comments be made available to the public. I reiterate the request made in my comments on the Topic Reports that the schedule for preparation of an Action Plan be pushed back. The current state of understanding does not allow a comprehensive analysis of hypoxia and precludes a quantitative assessment of any remedies

We have reviewed the Integrated Assessment (IA) and the supporting documentation, including the six Topic Reports summarized in the IA. Members of my staff have participated in many of the scientific and policy discussions throughout the last year. The Integrated Assessment has significant omissions and errors that strongly suggest that additional work must be completed prior to any attempt to develop an Action Plan. In addition, none of the suggested actions has a demonstrable effect on the hypoxia zone according to the Topic Reports. Together with the lack of any phenomenological model of hypoxia and its causes, these problems in the IA strongly suggest that any action is premature with the exception of further study. We summarize our major concerns and then present more detailed descriptions of each.

Our major concerns include:

1. Significantly better baseline data are needed to document the natural variability of the processes contributing to hypoxia. Annual measurements do not allow an examination of these complex, interacting physical and biological processes. While the scientists can be commended for their work to date, the Topic Reports clearly

underway in the early 1980's and changed the flow regime of this river. In contrast to statements in the IA and Topic Reports, the Atchafalaya River delivers over 40% of the nutrients to the hypoxia zone thus these changes are of critical importance.

3. The role of Confined Animal Feeding Operations (CAFO's) may not be accurately represented. CAFO's introduce huge amounts of nitrogen into the system. In many of these operations, volatilization of ammonia is the primary means of "treating" the nitrogen produced. This nitrogen is reintroduced to the system by dry and wet deposition within the Mississippi-Atchafalaya River Basin (MARB). In addition, large nutrient loads are being stored in anaerobic lagoons and represent a significant source of nitrogen, phosphorus, and as well as some metals.
4. Hurricanes and other phenomena that influence the hypoxia zone are not discussed. The IA and Topic Reports focus almost entirely on the upper Midwest and agricultural practices. Major increases in the area of hypoxia follow years in which the hypoxia zone and the area directly landward of the zone experience hurricane or tropical storm flooding and erosion. Marine phenomena are generally ignored in spite of their impact on the coastal zone. Data collected annually are insufficient to allow examination of these phenomena.
5. The IA underestimates municipal treatment plant and urban runoff contributions to nitrogen loads. By using NPDES estimates of waste treatment plant discharges, the IA ignores the times of bypassing. Flooding in 1993 and 1995 caused significant bypassing events in the affected areas and caused the introduction of huge volumes of untreated or minimally treated waste directly into the streams and rivers. Bypassing events occurred at the same times as the flooding noted as a major source of agricultural nitrogen introduction into the streams and the nutrients released during bypassing compound any additional input from agricultural sources.
6. Most models used in the Topic Reports and the IA are statistical in nature and are derived from sparse data. These models have inherent uncertainties not reflected in the IA. The IA notes the need for holistic modeling, yet no such modeling has been included in the IA or Topic Reports and none is proposed prior to the development of an Action Plan.
7. There is a general loss of qualifiers from the Topic Reports to the Integrated Assessment that changes the meanings of statements made in the Topic Reports. By removing qualifiers and conditional phrases, the IA fails to convey the uncertainties inherent in the studies conducted to date. This is particularly important given the issues raised in our comments #1-6.
8. The IA is based on dubious agricultural projections. The IA and Topic Reports fail to note the loss of farmland to urbanization, the changes in agricultural practices and the development of new strains of crops that require less fertilizer or more efficiently take up nitrogen from the soil. All these suggest that nitrogen application via fertilizer will decrease not increase in the future.
9. The proposed solution set is limited and is based on incorrect assumptions. By focusing nearly entirely on agriculture, the IA fails to consider other actions that might lower the extent of hypoxia. The use of broad scale averaging in the IA makes the projections it contains oversimplified. The lack of holistic models of the processes involved in hypoxia and the factors that influence it makes projections of the impacts of any proposed action tenuous at best.

10. Proposed solutions are not scaled properly to capture the full implications of the actions under consideration. Edge-of-field studies show an enormous variability in nitrogen loss and suggest that very detailed understanding of field scale processes is needed. The statistical model that was used to assess the impacts of the proposed fertilizer reductions fails to account for this variability and does not include significant social impacts likely to occur in agricultural communities as required according to the Topic 6 Report.
11. There are no demonstrable reductions in hypoxia shown for any of the proposed actions. The IA stresses in-stream improvements in the absence of an understanding of what changes in hypoxia could be expected from fertilizer or point source reductions or wetland expansions. The lack of consideration and knowledge of oceanographic and climatic variables limits the IA's ability to accurately assess the effectiveness of any of the considered actions.

While nutrients from agricultural lands in the Mississippi-Atchafalaya River Basin (MARB) may contribute substantially to the establishment of the zone of hypoxia, significant uncertainties remain. The contributions from tropical storms, oceanographic upwelling and other sources are not included in the IA and thus no complete nutrient budget is presented.

Decision-makers require a much broader knowledge base and assessment prior to moving forward with an action plan. Many statements in the IA do not reflect the conclusions and uncertainties of the Topic Reports, do not include a full analysis of the variables at meaningful scales, and thus provide a misleading view of the state and limitations of our understanding. Scientists need to document smaller scale variability and identify locally applied solutions. Finally, the scientists and economists need a greater understanding of the impacts of the options under consideration on both the agricultural community and the hypoxia zone. Further work is clearly necessary.

The success of any proposed Action Plan would require the support of the agricultural community. However, such support is unlikely given the current lack of a documented environmental or economic impact in the Gulf and the projection (from Table 3.3 in Topic 4 Report) that roughly half of the farmers will lose profits from current narrow profit margins with some of the options mentioned.

Detailed Comments

1. There is a need for significantly better baseline data.

A critical limitation of the analysis completed to date is a lack of baseline data. To examine the influence of a change in condition, one must have baseline data for comparison. For this study, two types of baseline data are needed. Temporal data would provide a look at changes over time and provide a view of natural variation. Spatial data would provide a comparison between the affected area and areas that are not influenced by the suspected causal factors.

Table 3.3 Potential effects of imposing fertilizer use reductions based on plant nutrient stress in the Midwest on crop yields of corn, soybeans, and sorghum, losses of N and P from fields, erosion rates, and various economic conditions.*

Nitrogen Nutrient Stress Target (Average percent of growing season that selected crops are to be in nitrogen stress.)	Time in Stress 5%	10%
	Related Changes	
Change in nitrogen applied in fertilizer		
On continuous corn	-17.0%	-27.0%
On corn-soybean rotation	-30.0%	-40.0%
On continuous sorghum	-19.0%	-32.0%
Combined area weighted effect	-23.9%	-34.0%
Change in crop yield		
On continuous corn	-3.3%	-8.8%
On corn in corn-soybean rotation	-2.1%	-4.3%
On soybeans in corn-soybean rotation	-0.4%	-0.4%
On continuous sorghum	-3.5%	-8.6%
Change in total nitrogen discharges from fields		
Of continuous corn	-9.2%	-13.3%
Of corn and soybeans in rotation	-3.5%	-4.7%
Of sorghum	-15.3%	-24.5%
Combined area weighted effect	-5.4%	-7.7%
Change in organic phosphorous discharges from fields		
Of continuous corn	-1.9%	-0.5%
Of corn and soybeans in rotation	0.0%	0.0%
Of sorghum	1.6%	2.7%
Combined area weighted effect	-0.5%	-0.1%
Change in sheet and rill erosion rates due to changes in crop patterns caused by imposing nitrogen stress-based restrictions	-0.2%	-2.9%
Overall change in crop producers' welfare in the U.S. (Due to fertilizer savings and crop price increases.)	1.69%	3.63%
Change in crop producer's welfare in treated area in the corn belt	1.71%	3.42%
Percent of farmers in study area who would benefit from imposing nitrogen stress-based fertilizer use restrictions	44%	59%
Percent of farmers in study area who would lose profits due to imposing nitrogen stress-based restrictions	56%	41%
Change in the portion of U.S. consumers' welfare associated with consumption of agriculture sector products	-0.04%	-0.12%

*Source: J. Atwood, V. Benson, C. Walker, et. al., unpublished study, Blackland Research Center, Temple, TX, 1998.

Note: Estimates of changes in N and P discharges are for direct losses from crop fields, not transport to rivers, streams, and lakes. Percent changes are based on estimates of current fertilizer use and management on 1992 crop acreages.

Once a year traverses of the hypoxia zone have been carried out since 1985. These traverses do not include data from east or west of the zone of hypoxia. While some sediment core data are used to show longer trends, these do not support decision-making, as they are not extensive enough to isolate causes. A greater understanding of the variables contributing to hypoxia along the Louisiana coast is necessary to understand the approaches most likely to reduce hypoxia. Such an understanding will require more frequently collected data to show the development, growth and breakdown of hypoxia in order to provide a sound basis for modeling.

No attempt has apparently been made to systematically examine other areas along the Gulf Coast. This limits our understanding of the contributing factors. While this area appears to be responding in a manner similar to other locations around the globe, local factors related to oceanographic and climatic variables require investigation. Significant coastal waters away from the Louisiana coast are experiencing hypoxia while other are not; understanding the limitations on the zone of hypoxia are critical to understanding its causes, its destruction and the effectiveness of any proposed action to reduce it. Sources of nutrients not originating in the MARB or not originating on agricultural lands are poorly known. These should be considered as significant because they may be large enough to alter the general nitrogen budget and the projected impacts of the actions under consideration.

NOAA's Estuarine Eutrophication Survey (1997) [1] showed that 30 of 37 Gulf Coast estuaries had periodic hypoxia and 6 had periodic anoxia. This report cites water column stratification as the primary cause of anoxia in these areas. The Mississippi River and Atchafalaya/Vermilion Bay estuaries had areas of hypoxia corresponding to 0 and 5% of their total areas, respectively. In contrast, 14 other Gulf estuaries were characterized by greater than 20% hypoxia by area. The IA notes other international examples of hypoxia, yet fails to mention that this condition is common along the U. S. Gulf Coast.

The short time span of the annual measurements of the extent of hypoxia prevents an analysis of intermediate and longer term trends in both physical and biological processes in the Gulf and rivers and agricultural practices. We note that Figure 2.4 of the IA shows that streamflow was an incredibly good predictor of nitrogen flux from 1978 until 1993. After that year nutrient flux is lower than would be predicted by streamflow. This may be the result of soil nitrogen flux during the impressive 1993 floods or it may reflect the influence of changes in agricultural practices as precision farming becomes more common and more farmers use better management practices as a result of state and federal education efforts or some other, undocumented factor.

The potential pitfalls of the annual averaging and once-a-year sampling can be illustrated. At first glance, the extensive, severe flood of 1993 in the Upper Mississippi and Missouri River Basins corresponds to a very large hypoxia zone. The largest discharge measured

---

[1] National Oceanic and Atmospheric Administration, 1997. *NOAA's Estuarine Eutrophication Survey, Volume 4: Gulf of Mexico Region.* Silver Spring, MD: Office of Ocean Resources Conservation and Assessment (ORCA). 77 p.

in the lower Mississippi River occurs near the beginning of May. However, the most severe flooding in the upper Midwest occurred in very late July and into August as and after the hypoxia data were collected. This does not show up as the annual maximum because most of the Ohio valley was in drought during the period of heavy rains in the western Midwest and northeastern Great Plains. Thus much of the "cause", the nutrients flushed from farmlands of the Upper Mississippi river Basin, does not contribute to the "effect", the large areal extent of hypoxia in 1993. As mentioned in our comment # 4, Hurricane Andrew may have a significant role to play in addition to the earlier Ohio River floodwaters.

An interesting statement in the IA appears on page 21. "The record large extent (of hypoxia) observed in 1999 may be the related to abnormally wet conditions producing high nitrate concentrations in rivers draining the upper Basin." There are no data presented to support this contention and 1999 was a relatively dry year for much of the upper Midwest with only localized wet areas in the spring. The consistent focus on the upper Midwest may be justified, but, in the absence of more widely collected and more detailed data, significant phenomena may be missing from the analysis.

On page 17 of the Topic 2 Report, the authors note that, "Our ecological assessment was based on data from 1987 and 1988, representing a time when hypoxia was less extensive, and 1993 and 1994, representing a time when hypoxia was more extensive." Hypoxia is influenced by a wide variety of oceanographic, climatic, physical and biological factors. However, none of these can be properly assessed with the minimal amount of data used in the analysis. Four measurements representing a week of time apiece have been used as the basis for examining a condition that reflects a complex system of interacting phenomena. Pages 50-52 of that report leave the clear impression that our understanding of hypoxia is low and the analysis of potential causes has been extremely limited.

Perhaps the best statement of our concern appears on page 49 of the Topic 2 Report. "In addition to the complexity of interactions among physical, chemical and biological processes that shape the northern Gulf of Mexico ecosystem, two key elements hindered this assessment of the effects of hypoxia: 1) Lack of detail on the actual occurrence and distribution of hypoxia 2) Accessibility of data on various ecosystem components." This statement clearly calls for more empirical data to be collected before U. S. farm policy is altered.

2. The role of changes along the Lower Mississippi and Atchafalaya Rivers is understated.

The loss of the filtering capabilities of the Lower Mississippi River contributes significantly to nitrogen delivery to the Gulf, particularly at times of high discharge. While we do not advocate the destruction of the levees and other structures that protect the people of Louisiana from flooding, we do expect that consideration of present and future river engineering projects will include an assessment of the likely impacts of those actions on hypoxia.

The early 1980's were a period of significant modifications in the Atchafalaya River, including channelization and levee building, as noted on page seven of the IA. As nearly half of the Mississippi River delta water is not delivered to the area of hypoxia, the Atchafalaya River actually introduces approximately 45% of the nutrients to this zone. The Atchafalaya River has been significantly altered to convey large volumes of water more efficiently from an engineering viewpoint. These changes may compound the increased flow of nutrient by limiting interactions between the river and the floodplain and wetlands bordering it. This effect would be most pronounced during times of high discharge when nutrient loading is greatest. Thus past, ongoing and contemplated changes to that river could significantly alter the conditions off shore. In contrast to the minor mention of this engineering in the Topic Reports and the IA, these changes may play an important role in the development of hypoxia in the mid-80's.

Wetland loss in the delta alone is estimated at 100 square km per year since 1930 with the highest rates in the 1960's and 1970's (Topic 5 Report; p 69). "Coastal emergent wetland loss for Louisiana represents 67% of the nation's total loss from 1978 until 1990. Much of this loss is related to altered hydrology stemming from navigation, flood control, and mineral extraction and transportation projects (USEPA, 1999)[2]." The role of land loss in hypoxia is complex, but such significant wetland losses certainly affect coastal processes and nutrient budgets. Much of this loss is directly related to changes in river management and is not irreversible. Engineered and natural changes in the river system have changed the delivery of sediment and nutrients to the Gulf of Mexico. The significance of such changes is clearly shown by the silica measurements and attendant changes in diatom populations as documented in the Topic Reports and Figure 2.2 of the IA. Such changes need to be considered as seriously as proposed agricultural solutions when the hypoxia-related problems are discussed.

Sentences on pages 20 and 21 of the IA clearly suggest that such changes are significant. "The sediment record clearly shows significant increase in algal production beginning near the 1950's." "First, the most significant flood-control and navigation channelization occurred prior to the 1950's. Second, significant alterations in the landscape that removed much of the 'buffer' for runoff into the Mississippi tributaries and main stem occurred 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." This precedes the period of most rapid growth in fertilizer use and thus provides an independent indication of the potentially significant role of river engineering.

Page 4-1 of the Topic 4 Report suggests that additional monitoring is necessary and, in effect, summarizes the current state of knowledge. "A monitoring program needs to be established to clarify the extent of nutrient retention in the Lower Mississippi. Is it a delivery pipe, or is there significant input/output/cycling of nutrients occurring?" This

[2] USEPA, 1999, *Ecological Condition of Estuaries in the Gulf of Mexico. EPA 620-R-98-04.* U. S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze Florida. 71 p.

does not mention a study of the historical role of the Lower Mississippi and its tributaries and wetlands prior to USACE activities along the Lower Mississippi and the Atchafalaya Rivers.

3. The impacts of CAFO"s may be seriously underestimated.
Confined Animal Feeding Operations (CAFO's) have expanded greatly in number over the last decade. The large animal breeding, growing, and processing facilities now dominate poultry and hog production and are becoming a larger portion of the cattle business as well. These facilities often operate under "No Discharge" conditions, but this belies their actual impact.

Anaerobic lagoon systems volatilize up to 90% of the total nitrogen load leaving about 10% to be applied to fields at Plant Available Nitrogen rates. The swine population of such facilities in one Missouri county exceeds 700,000 hogs. These produce an equivalent nitrogen load as a city of 1.7 million humans. Of this total nitrogen load, the equivalent of approximately 1.5 million humans is sent into the atmosphere. The EPA has noted that this ammonia is a precursor to PM 2.5, as it adheres to particulates in the atmosphere. Numerous studies show that this ammonia travels relatively modest distances relative to the size of the MARB with most being precipitated within approximately 200 miles. The random nature of the deposition of this nitrogen makes estimates of its contribution to rivers extremely difficult. It will be highly dependent on variable local weather conditions such as relative humidity and wind direction.

CAFO's are increasing in number in the Basin and the average size of facility is also increasing. Much of this growth has occurred since the floods of 1993 and 1995 and we have not experienced a severe flooding event since the establishment of most of these facilities. Recent flooding in North Carolina has illustrated the environmental and health threat that these facilities pose in times of flood. The moratorium on anaerobic lagoon systems in North Carolina may cause significant growth in such facilities in the MARB as new facilities are established to regain production after the North Carolina floods. This is the one part of the agricultural picture that may be significantly underrepresented in the projections of future nitrogen loading in the stream and rivers of the Mississippi-Atchafalaya system.

The sludge in these lagoons is accumulating and not being applied to fields. This sludge represents a very large nutrient storage volume with high nutrient concentrations that continues to grow. As these large facilities are a relatively new development and their numbers grew rapidly after the 1993 and 1995 floods, these lagoons represent significant nutrient sources should major flooding recur.

4. Hurricanes and other climatic and oceanographic variables that influence the hypoxia zone are not discussed
The largest increases in the extent of the zone of hypoxia occurred in 1993 and 1999 and another very large increase occurred between 1988 and 1990 (data from Rabalais et al, 1999; IA Figure 1.2 attached). Early 1993 was not an unusual year for precipitation in the upper Mississippi River; this flooding originated on the Ohio. As

noted in Rabalais et al., 1996[3], spring is the critical time for productivity and nutrient flux leading to hypoxia. The Upper Mississippi and Missouri River floods were just approaching their peak as the 1993 hypoxia data were being collected and thus are not significant contributors to the 1993 hypoxia.

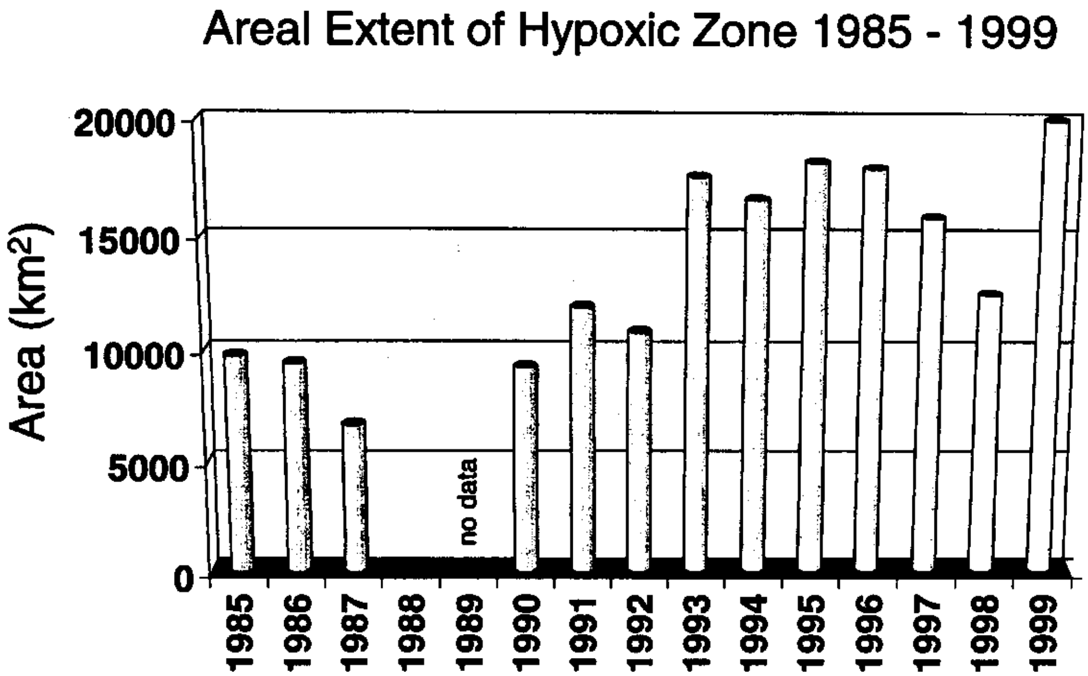

FIGURE 1.2 – Histogram of estimated areal extent of bottom water hypoxia for mid-summer cruises 1985-99 --- based on data from N. Rabalais, Louisiana Universities Marine Consortium

An examination of the hurricane tracks for the years 1985-1998 shows that hurricanes came ashore and influenced the hypoxia zone in 1989 (Chantal and Jerry), 1992 (Andrew), and 1998 (Georges). Chantal and Jerry made landfall to the west of the hypoxia zone placing this area and the Louisiana coast in the NE quadrant, the worst location for hurricane damage. Andrew cut directly through the hypoxia zone on its way to the coast as a category 3 hurricane on the Saffir-Simpson scale. Hurricane Georges was a category 2 event that struck near the east end of the zone of hypoxia. Each of these events caused severe localized flooding, shoreline erosion, disturbed shallow habitats and introduced large quantities of nutrients into the waters of the hypoxia zone in the year preceding the increases in the extent of hypoxia.

---

[3] Rabalais, N. N., R. E. Turner, D Justic, Q. Dortsch, W. J. Wiseman, Jr., and B. K. Sen Gupta, Nutrient Changes in the Mississippi River and System Responses on the Adjacent Continental Shelf, *Estuaries, 19*, 386-407, 1996.

Hurricane Andrew caused a myriad of changes in the coastal areas near the mouth of the Atchafalaya River and in the Atchafalaya Basin (Guntenspergen and Vairin, 1996)[4]. Over 30% of Raccoon Island was eroded and over 10 cm of sediment was deposited on top of some of the coastal marshes. A storm surge in excess of 1.5 m reached 20-40 km inland in some places. The seven inch rainfall event that accompanied Andrew flooded much of the lower half of the Basin before turning east into the Mississippi River Basin SW of Baton Rouge. Freshwater hypoxia resulting from organic materials introduced into the water column as a result of the storm winds and surge caused a fish kill totaling approximately one million.

The loss of wetlands, particularly the emergent wetlands of the coastal areas, and the consequent stresses on existing biota make this shoreline more susceptible to increased erosion during major storms. Over 40% of Louisiana's barrier islands have been lost in the last century and many others have been severely eroded (LADNR, 1998)[5]. The relatively shallow shelf makes this area more prone to hypoxia as well as to disruption of the benthic biota and bottom sediments during major storms. These storms can introduce nutrients into the hypoxia zone from the flooded areas inland, from the bottom sediments of shallow bays and inlets, and from the shallow offshore areas that are above the deepest penetration of wave and tidal action and storm surges.

We do not argue that these storms alone directly cause hypoxia, but this pattern strongly suggests that these storms and other climatic and oceanographic variables should be taken into consideration and their effects analyzed while considering the causes of hypoxia and its variability. Rabalais, et al., 1996 point out the critical role of the halocline in hypoxia, yet we have no documentation of any trends in the either the primary or secondary haloclines that vary seasonally and on shorter time periods in the area of hypoxia. Longer-term variations can not yet be analyzed because the data record is too short and too sparse to support such an analysis (see #1).

Hypoxia occurs during the period of the anti-cyclonic gyre in this part of the gulf. This makes much of the Texas coast as well as areas of upwelling outside the hypoxia zone potential sources of nutrients yet there is no attempt to include these in the nitrogen budgets.

Page 64 of the Topic 3 Report includes the following statements: "The period during which (nitrogen) residuals decreased most rapidly is the period during which fertilizer use and N outputs in harvested crops increased most rapidly. Fertilizer use and N

---

[4] Guntenspargen, G. R., and B. A. Vairin, 1996, *Willful Winds: Hurricane Andrew and Louisiana's Coast,* Louisiana Sea Grant College Program, Baton Rouge, LA and U. S. Department of the Interior, Lafayette, LA. 16 p.

[5] Louisiana Department of Natural Resources, 1998, Restoration Efforts on Queen Bess Island, *Louisiana CoastLines,* 2-5.

output in harvested crops leveled off around 1980, at about the same time the residuals leveled off." If fertilizer use is the main culprit, why should the area of hypoxia continue increasing well after its use has leveled off?

The IA's exclusive focus on agricultural nitrogen ignores existing data that suggest that many other factors are necessary to the formation of hypoxia and limits its usefulness in addressing a broad range of potentially effective remedies. As an example, Sarasota Bay has 25% of its area cited as anoxic though 0% is noted as having a high total dissolved nitrogen (NOAA, 1997).

5. Municipal treatment plants and urban runoff are not properly represented. An additional concern is high nutrient loading by municipal treatment plants and storm sewers during times of high precipitation and runoff. By using National Pollution Discharge Elimination System (NPDES) values for municipal plants, the report ignores times when the systems are bypassed as a result of extraordinary flow rates. This is a considerable concern as the report data includes the 1993 and 1995 flood years and bypassing events introduce very large nutrient loads directly into streams and rivers with no "processing" or dilution. Increases in impermeable surface and expanding urbanized areas over recent years have been compounded by these large rainfall events, thus the potential for significant nutrient delivery is large, but is not fully credited in the topic reports or the IA. During the flood of 1993, bypassing of the Quad Cities, Omaha, St. Louis and many other wastewater treatment plants occurred continuously for weeks. The USEPA has begun a major initiative to address dry weather bypassing from such systems. Data exist at the state level as part of the NPDES process to allow a better estimation of these contributions.

The 1993 flood was the result of a 100-year rainfall event of extreme duration over much of the upper Midwest. Bypassing was widespread as many combined storm water systems in the area were overwhelmed by the high discharges. In addition, numerous wastewater treatment plants were flooded with the resulting delivery of significant nutrient loads from their lagoons to the rivers. Similarly, 1995 was another period of extensive local flooding and bypassing. These facilities represent a major source of nutrients that is represented in the report by their permitted discharges only.

These underestimates are most pronounced at the same times as heavy runoff from agricultural lands and their role in hypoxia has not been effectively separated from that of agricultural nutrients.

6. The statistical models generated with sparse data have inherent uncertainties. The data upon which many of the models are based do not have sufficient density to provide a sound basis for the modeling completed thus far and fall far short of what is needed to produce phenomenological models. The measurements of the hypoxia zone are taken annually and provide only a coarse view of the zone's extent and variability. Similarly, the discharge and total load measurements are averaged over annual periods. We don't criticize the scientists for producing models to bring insight into the extent of hypoxia. However, the use of the results of this modeling without abundant qualifiers and the implication that these data and models allow us to identify potential changes in hypoxia that might result from actions under consideration in the basin are irresponsible. These models are generally statistical, not based on the physical and biological processes that create, maintain and break down the hypoxia in the Gulf. Thus, they contain inherent uncertainties made more serious by the lack of data. The data collected since 1985 represent an annual snapshot of a complex process and almost certainly do not capture critical variability that needs to be understood before the statistical analyses are used to formulate policy. The contrasts in language used in the Topic 3 Report and the IA are particularly critical, but are, unfortunately, representative.

Page 43 of the IA describes the adaptive management framework. This framework is built upon holistic models of processes and the ability to differentiate among trends. This requires sophisticated coupled biological and physical models that are well beyond the scope of work completed to date. The omissions and uncertainties contained in the data and interpretations that form the basis for the IA make clear that the current state of knowledge can not support such a framework.

While the temporal correlation between the increase in fertilizer use and the growth of the hypoxia zone is repeatedly noted in the Topic Reports and the IA, such an analysis may grossly oversimplify relationships. There is little understanding of the response times of this complex system to stimuli and no reasonable hope of isolating any of the variables that control hypoxia with such a broad brush approach. Annualized data may mask critical signals that reduce this correlation or that show the importance of other variables to hypoxia. The lack of consideration given to other factors that are known to influence hypoxia elsewhere further undermines the applicability of the models and raises serious doubt about their value.

Nitrogen is a nutrient that can be recycled in this environment making direct correlation between nutrient supply and hypoxia difficult. A statistical model based on annual data is unlikely to provide much insight and a physical/biological understanding is required to provide the basis for meaningful modeling. Because the IA focuses nearly exclusively on sources in the upper Midwest, trends driven by coastal storms, losses of wetlands, oceanographic variables and other phenomena are never addressed. As the 1999 season represents the most extensive hypoxia extent yet observed, its causes warrant close examination not the very weakly worded comment in the IA (page 21 of the IA, see our comment #1, paragraph 6).

The Topic 2 Report states on page 32, "Considering this mix of physical and biological processes that are known to affect community structure, the lack of obvious long-term hypoxia effects on benthic community structure is not surprising." The models developed and applied to date do not include any of these processes, but serve the basis for all of the following Topic Reports and the IA. Before we consider major changes in agricultural practices, it seems fair to expect that the problem is clearly defined and its causes delineated with some semblance of certainty.

7. There is a general loss of qualifiers in the Integrated Assessment.
The Integrated Assessment (IA) contains numerous statements that omit the qualifiers present in the six Topic Reports. As a result, the conclusions as stated in the IA are much stronger than are supportable by the contents of the Topic Reports. The scientists who prepared the Topic 2 and 3 Reports used appropriate phrases to reflect the confidence that they have in the data and interpretations of the data. Those conducting the Topic 6 Report understand the limitation of the USMP model and its application to individual farms. However, the corresponding sections of the IA lose a substantial fraction of the original meaning (and credibility) because of an abundance of absolute statements where statements were precisely qualified in the Topic Reports.

The Topic Reports repeatedly point to the need for additional data to understand the complex set of interacting phenomena that contribute to hypoxia in the Gulf of Mexico. However, the IA very clearly presents options for actions to reduce hypoxia in advance of the necessary scientific understanding. Congress issued a directive for a scientifically sound Action Plan, not a proposed set of approaches based on an incomplete knowledge of the contributors to hypoxia, the effectiveness of the proposed approaches and their economic and social impacts.

"The information provides a basis for an action plan but this assessment is intended to describe options rather than make recommendations." This statement in the Executive Summary (page 6) of the IA directly conflicts with numerous statements in the six Topic Reports that point out that current data, interpretations and models are not sufficiently robust to support either the development of an Action Plan or policy-making on this complex issue. These inconsistencies and the uncertainties that remain raise serious doubts about the validity of any Action Plan developed without a much greater understanding of hypoxia along the Louisiana coast and its contributing factors.

"Monitoring, research, and decisions about taking action to reduce hypoxia should be integrated using holistic models that simulate our understanding of how the overall system functions and how actions can best be implemented." We agree with this statement on page 10 of the IA, however, no such model has been produced and none is on the horizon. The production of such a model would have to include a detailed understanding of field scale processes, oceanographic variability and processes acting over thousands of square kilometers. The ability to scale over orders of magnitude with the inherent variability in climatic and physical conditions compounded by variations in agricultural practices is likely a decade or more away.

These points are exacerbated by the comments in #1-5 above. While we recognize that the IA was prepared under strict time constraints and relied upon existing data, we do feel that an honest expression of the uncertainties in all parts of the report is critical. Unless the authors accurately reflect statements in the six Topic Reports and issues raised by those commenting on the report, the credibility of their efforts will be jeopardized.

The IA may be the only scientifically oriented document read by those who are likely to sit in judgment of the Action Plan; it must reflect the true extent of the scientific and economic uncertainties. The IA needs to show clearly the limits of our knowledge of hypoxia and the uncertainties in developing a plan to mitigate the perceived problem.

8. Agricultural projections are open to serious disagreement.
The IA assumes that nitrogen inputs from agricultural lands are likely to remain steady or increase with time. Loss of farmland to urbanization is a significant concern in much of the area that is claimed to have contributed most of the inorganic nitrogen during the period of study. In addition, improved agricultural practices, requirements for comprehensive nutrient management plans, new varieties of crops and better educational programs for farmers all strongly suggest that the volume of nutrients leaving the fields will decrease with time. Increasing use of precision agriculture is the most promising of all approaches for reducing edge-of-the-field nitrogen losses, but is barely mentioned in the Topic Reports and not at all in the IA. Programs such as the Conservation Reserve Programs, Wetlands Reserve Programs and other federal programs aimed at improving local stream quality may augment these reductions.

Measurements of soil nitrogen are critical to understanding agricultural sources and to designing a reasoned response. From 1976 until 1993, streamflow was an excellent predictor of total nitrogen flux from the MARB to the Gulf of Mexico (Figure 4.2 of the IA). These same data also suggest that streamflow significantly overestimates nitrogen flux to the Gulf during the period from 1994 to the present. This may be the result of high soil nitrogen loss during the massive floods of 1993 and 1995 or a significant change in excess nitrogen available because of improved agricultural practices or another cause yet unknown. This knowledge is critical to developing an Action Plan.

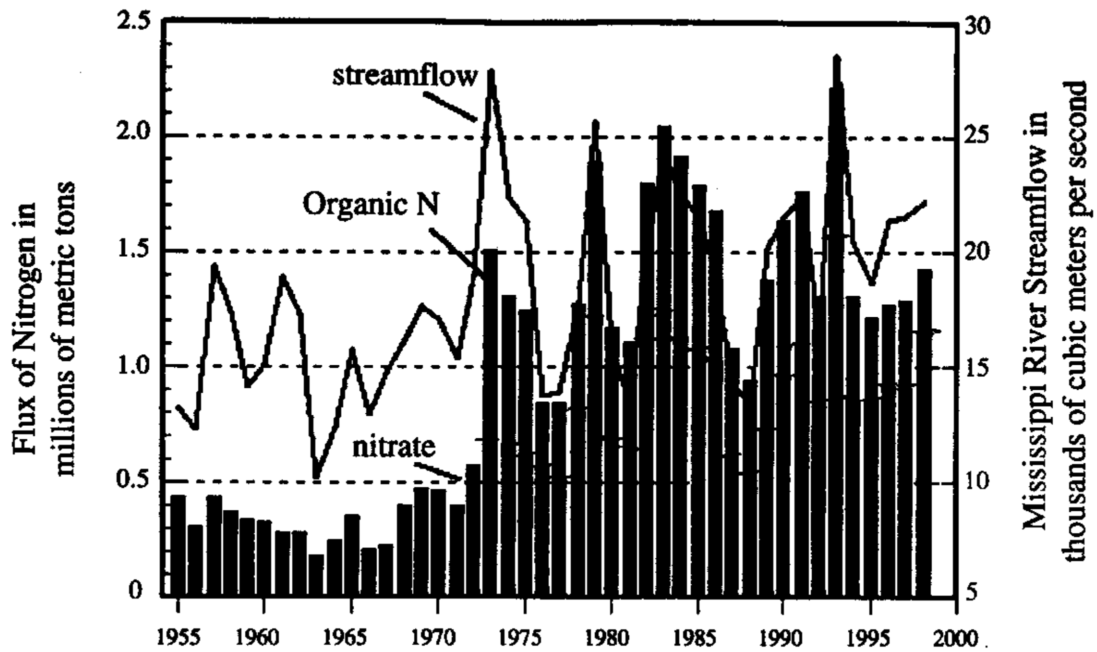

FIGURE 2.4 – Annual loads of nitrate, organic nitrogen and annual streamflow from the Mississippi River Basin to the Gulf of Mexico 1955-98

The simplified view of the future presented in the Topic Report and the IA contradicts major, national trends in agriculture and may grossly distort all projections of the impacts of the actions under consideration.

9. The proposed solution set is limited and contains incorrect assumptions.
The IA includes a reduction in fertilizer use as a potential solution with no explanation of how this would be achieved. This "solution" could take any number of forms that would punish farmers who are applying only the Plant Available Nitrogen (PAN) rate by causing nitrogen to become a limiting nutrient on their lands. The world market in grains and other commodities would buffer any increase in prices caused by reduced local productivity. Thus, while the economic model may hold at a local level, it is unlikely to show the complete effect of the fertilizer reductions mentioned to illustrate potential actions to be taken.

This approach ignores the fact that "Very little nitrate-nitrogen is lost from the agricultural landscape via surface runoff (Jackson et al., 1973; Logan et al., 1994)" (Topic 5 Report). As surface runoff is noted to have low nitrate-nitrogen content, the broadly applied fertilizer reductions discussed would target significant acreage that does not contribute significantly to the problem. The simple cuts in fertilizer use are shown to be roughly one-half as effective as edge-of-the-field reductions (IA, Table 5.3). Combined with the high variability shown in field scale studies, this option is clearly less attractive than other approaches.

The Topic 3 Report contains clear evidence that tiled fields behave significantly differently than non-drained fields, yet this critical information apparently is not considered important in the other Topic Reports or in the IA. Field-level studies suggest extreme variability in nitrogen losses. Edge-of-the-field measurements need to be greatly expanded before individuals will "buy into" any planned response. Such variables need to be carefully measured prior to the implementation of an Action Plan in order to produce a viable and reasonable set of responses.

Data from a large number of individual field studies show a significant variability in edge-of-the-field nitrogen losses. Scaling a solution or set of solutions from the entire basin to individual fields or watersheds ignores a critical, fundamental limitation in our knowledge of nutrient sources to the streams and methods of reducing those sources that are most likely to be successful.

If a 40% reduction in applied nitrogen in the world's most productive grain producing region is a "reasonable" approach in light of the need to feed the increasing world population, significant changes in the plumbing system of the Mississippi Delta and the Atchafalaya River should also be presented. Two of the topic reports summarize methods of reducing nitrogen flux and their economic costs and benefits, yet little mention is made of the loss of natural wetlands in the delta areas and their potential

TABLE 5.3 – Summary of Economic Costs of N-loss Reduction Actions

Scenario		N-loss Reduction (Thousand metric tons/yr)	Unit Cost ($/kg N-loss)	Net Cost ($/kg N-loss)
edge-of-field N-loss reductions				
	20%	941	0.88	0.80
	30%	1,412	1.90	1.80
	40%	1,882	3.37	3.25
	50%	2,352	5.20	5.08
	60%	2,822	7.48	7.37
fertilizer reductions:	20%	503	0.69	0.67
	45%	1,027	2.85	2.81
500% fertilizer tax		1,027	14.54	14.50
wetlands	1M acres	67	6.06	- 2.19
	5M acres	350	8.90	1.00
	10M acres	713	10.57	2.81
	18M acres	1,300	11.93	4.27
riparian buffers (19M acres)		692	26.03	
river diversions to coastal wetlands		75	~6	
tertiary treatment of waste water		20	~40	

The Topic 5 Reports shows a great variability in the effectiveness of wetland restoration in reducing nutrient delivery to streams (p. 85). We assume that most of the wetlands would be placed where they would be most effective, not randomly. By using near average values, the IA severely underestimates the value of wetlands in reducing nutrient flux to rivers and the Gulf.

While the general sources of nutrients have been identified, far more study is needed at much smaller scales. Better and more abundant water quality and discharge data are needed at the scale of local watersheds. The USGS has been reducing its support of stream gauging networks while the need for accurate estimates of discharges is increasing, particularly in light of the potential for more extreme events. Further expansion of water quality testing near potential agricultural non-point sources will be needed to come up with effective plans for reductions in nutrients and to assess the effectiveness of any policies or actions that are proposed.

Of the 20 million metric tons of nitrogen introduced into the MARB annually, only 1.6 million metric make it to the Gulf of Mexico (roughly 8%) (Topic 3 Report). With the wide variability in losses from individual agricultural fields and our poor knowledge of this variability, any broad-brush solution is unlikely to be as effective as a more focused approach based on a better understanding of field-scale processes. Edge-of-field and in-stream approaches will be far more efficient at reducing nitrogen loss as they approach nearly 100% effectiveness rather than an averaged 8% effectiveness.

10. Scaling of solutions is problematic at best.
Individual reports contain repeated disclaimers about using the data and/or interpretations as the basis for policy, yet the IA clearly points to and weighs potential actions to reduce hypoxia. The scale of the studies that have contributed to the IA is very broad; however, extreme variability in processes at much smaller scales has been documented. The economic analyses were conducted at such large scales that they ignore significant impacts of some of the discussed options for nitrogen reduction. The IA needs to be edited to reflect better the inappropriateness of the use of some of the data and analyses in the Topic Reports for policy-making.

The economic analysis appears to have been done at the basin scale in 30 days (Topic 6 Report Acknowledgements). This analysis is based upon sparse data that were used to generate statistical models with inherent limitations to produce estimates of nutrient reductions with large uncertainties. This analysis does not account for many disruptions and changes that would occur at smaller scales and certainly does not include a variety of unintended consequences. While the Topic 4 Report purports to show the economic and social impacts of reduced nitrogen loads, it contains no analysis of the number of farmers that would be forced out of production as a result of the imposition of reductions in fertilizer applications. It is estimated that nearly half of farmers would lose profits with the mentioned approaches (Topic 4 Report, Table 3.3), yet this summary of economic and social impacts makes no mention of hardships in agricultural communities throughout the basin. This is a gross oversight that must be corrected if this Assessment is to have any credibility amongst those who are going to be asked to take action and whose livelihoods would be put at risk with the implementation of some of the actions under consideration.

The section of the IA that discusses approaches for reducing nitrogen loads does not even mention the social impacts though that was a purported focus according to the Introduction in the Topic 5 Report. Before moving forward with a proposed Action Plan, serious study needs to be given to the socioeconomic effects of the actions under consideration. The drastic actions included in this analysis threaten agricultural communities throughout the upper Midwest.

11. There is no proof that any of the actions considered will have a positive effect on the perceived problem.
Table 5.1-1 clearly indicates that little is known about the causes and solutions to hypoxia in the Gulf. The state of understanding is insufficient to support the detailed analyses required before going forward with this process. The models are not sufficiently

Table 5.1-1 Summary of Estimated Benefits Associated With Hypoxia Reduction in the Gulf of Mexico as Reported by *Topic Group 2: Ecological and Economic Consequences of Hypoxia*.

Potential Benefits of Hypoxia Reduction	Conclusion From Topic Group 2
Restoration of Ecological Communities in the Gulf of Mexico	Data Not Available to Estimate Benefits
Increased Commercial Harvesting of White and Brown Shrimp	Given Available Data, No Estimable Benefits From Hypoxia Reduction
Increased Commercial Harvesting of Gulf Menhaden	Given Available Data, No Estimable Benefits From Hypoxia Reduction
Increased Commercial Harvesting of Red Snapper	Given Available Data, No Estimable Benefits From Hypoxia Reduction
Increased Recreational Harvesting	Data Not Available to Estimate Benefits

sophisticated to provide a basis for evaluating the effects of proposed policies. The authors could not document a single action that they could identify as reducing hypoxia. Yet, somehow, an Action Plan is to be developed. How can any scientist who has reviewed all the documentation justify moving forward without far better knowledge to guide them?

The Topic 2 Report "Shrimp and hypoxia summary", begins with the statement, "Unfortunately, the results of this analysis are equivocal." Comparison with areas to the east and west of the hypoxia zone failed to prove any correlation between hypoxia and this fishery. Later in the same paragraph the case is more clearly defined. "However, there is sufficient hint of such a relationship – at least for CPUE – that the possibility can not be dismissed." We find the scientific integrity of such statements encouraging. Their omission from the IA is troubling and undermines the credibility of the Assessment. Commercial fish and shellfish landings are currently significantly higher than in 1950 according to a recent EPA report (USEPA, 1999). In addition, commercial landings of oysters actually increased in Louisiana from 1990 to 1996 according to that report. Thus, we feel compelled to question the value of any economic trade-off analysis as the return is apparently "no demonstrable benefit."

Failing to show any reduction in Gulf hypoxia, the IA shifts to a focus on the in-stream improvements that could be expected from fertilizer or point source reductions or wetland expansions. This transferal of focus illustrates better than any outside comment the uncertainties in our current understanding and the lack of critical information upon which to base policy decisions.

Implications for Future Actions
Much of the agricultural community is currently operating on small profit margins. Approaches to nutrient reduction, if required, need to be data-driven and applied on local scales to be effective. It will be extremely difficult to get cooperation from individuals without data supporting the need for change. Such approaches are highly unlikely to be imposed as national policy, but need to be incentive-based and focused on individual approaches designed to fit farmers' agricultural practices and climatic and physical settings.

These are particularly critical uncertainties and omissions given the lack of a clearly documented economic impact on Gulf fisheries as indicated by the first conclusion of the Topic 6 Report "Concluding Observations". A more complete analysis is needed before the IA is used to guide public policy. In the absence of known impacts of any of the actions under consideration, the formulation of an Actions Plan is unwarranted. Clearly the policy debate has gotten in front of the scientific analysis and no drastic actions can be justified on the basis of what is presently known.

In summary, I request that the development of an Action Plan be delayed until the supporting scientific framework for studying hypoxia in the Gulf of Mexico and for examining potential remedies is far stronger than the one that currently exists. Once such a framework is developed, we shall work closely with the other states in the Mississippi-Atchafalaya River Basin to address this important environmental issue.

Thank you for the opportunity to comment on this important issue.

Sincerely,

DEPARTMENT OF NATURAL RESOURCES

Stephen Mahfood
Director

SM:jm

c: Governor Mel Carnahan
Senator John McCain, Chairman, Senate Committee on Commerce, Science and Transportation
Senator Ernest Hollings, Ranking Minority Member, Committee on Commerce, Science and Transportation
Senator Olympia J. Snowe, Chairwoman, Subcommittee on Oceans and Fisheries

Senator John F. Kerry, Ranking Minority Member, Subcommittee on Oceans and Fisheries
Senator Christopher (Kit) Bond, Chairman, Appropriations Subcommittee on VA-HUD, and Independent Agencies
Senator Barbara Mikulski, Ranking Minority Member, Appropriations Subcommittee on VA-HUD and Independent Agencies
Senator Judd Gregg, Chairman, Appropriations Subcommittee on Commerce, Justice, State, and the Judiciary
Representative Bud Shuster, Chairman, Committee on Transportation and Infrastructure
Representative James L. Oberstar, Ranking Minority Member, Committee on Transportation and Infrastructure
Representative Wayne T. Gilchrest, Chairman, Subcommittee on Coast Guard and Marine Transportation
Representative Peter A. DeFazio, Ranking Minority Member, Subcommittee on Coast Guard and Marine Transportation
Representative Harold Rogers, Chairman, House Appropriations Subcommittee On Commerce, Justice, State and the Judiciary
Representative James T. Walsh, Chairman, Appropriations Subcommittee on HUD, VA and Independent Agencies