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FEATURE

Tiered collaborative strategies for reducing hypoxia and restoring the Gulf of Mexico

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The Gulf of Mexico is more than just a water body south of the United States. It is an international marine ecosystem, the ninth largest water body in the world (USEPA 2007), and it receives drainage from the Mississippi River Basin (MRB), the third largest drainage basin in the world. The combined gross domestic product of the five states bordering the Gulf of Mexico (Florida, Alabama, Mississippi, Louisiana, and Texas) makes this region the seventh largest global economy (IMF 2007). Major regional industries include commercial and recreational fishing, shrimp and oyster harvesting, tourism and recreation, and oil and gas production. Many of these industries are affected by the water quality of the Gulf of Mexico, as illustrated by the economic and environmental impacts of the 2010 Deepwater Horizon oil spill. Clearly, the health of the Gulf of Mexico contributes not only to the local and regional economy, but also to the national and global economy.

Another phenomena annually affecting Gulf of Mexico water quality is the development of a "dead zone," or area of hypoxia where dissolved oxygen concentrations decrease to levels that will not support aquatic life (Rabalais et al. 2002). This hypoxic zone is caused by nutrients transported within the Mississippi River Basin and discharged into the Gulf of Mexico where they stimulate increased algae growth. As these algae die and sink, they decompose, creating an oxygen demand that depletes the Gulf bottom waters of oxygen. The size of the hypoxic zone depends on the volume of freshwater discharge into the Gulf, with larger zones occurring during wet years (Alexander et al. 2000; Alexander et al. 2008; Diaz and Rosenberg 2008; Petrolia and Gowda 2010; Rabalais 2011). The cumulative environmental and economic effects from excess nutrients are likely greater than from the 2010 Deepwater Horizon oil spill. Because of these effects, reducing excess nutrients is a priority within the MRB.

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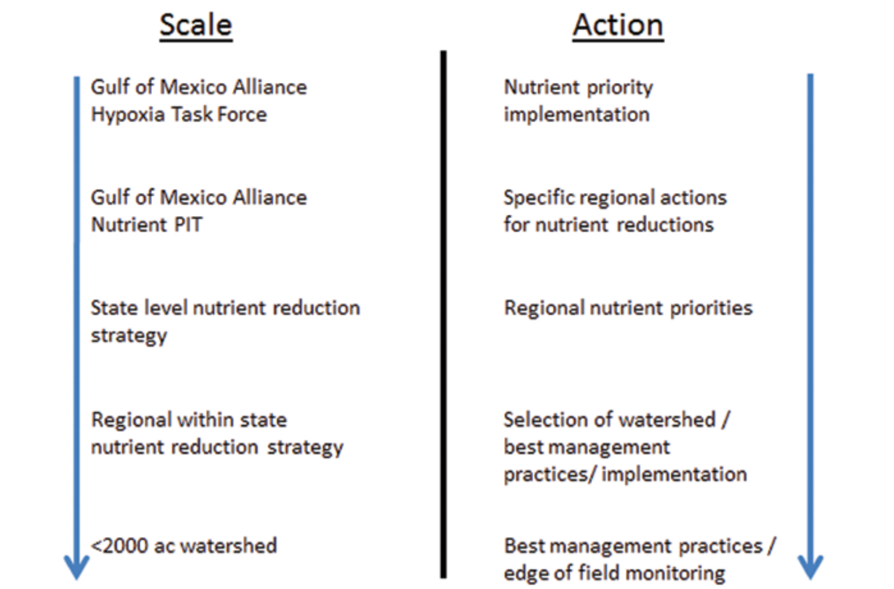
Agriculture is a substantial industry in the MRB, producing about 40% of the world's corn and over 40% of the world's soybeans (Foley et al. 2004). Agriculture is also estimated to contribute from 50% to 80% of the nitrogen (N) and phosphorus (P) load entering the Gulf of Mexico from the MRB (Turner and Rabalais 2003; Alexander et al. 2008). The US Environmental Protection Agency (USEPA) Science Advisory Board has called for the 45% reduction of both N and P loads from the MRB to achieve the goal of a 5,000 km^2 (1,930 mi^2) hypoxic zone in the Gulf of Mexico (USEPA 2007). Both the *Gulf Hypoxia Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin* (USEPA 2008) and the Gulf of Mexico Alliance (GOMA) *Governors' Action Plan II for Healthy and Resilient Coasts* (GOMA 2009) call for the development and implementation of nutrient reduction strategies to reduce excess nutrient loads to the Gulf of Mexico. The Gulf Coast Ecosystem Restoration Task Force (GCERTF), established in the wake of the Deepwater Horizon oil spill, released *The Gulf of Mexico Regional Ecosystem Restoration Strategy* which places emphasis on holistic watershed restoration (GCERTF 2011). The strategy advocates and has put in place an initiative (Gulf of Mexico Initiative) that will provide US$50 million for assistance towards agricultural producers in coastal watersheds to improve water quality, optimize water conservation, and enhance wildlife habitat. Though the GCERTF recognizes the need for innovative ways to create watershed restoration and ecosystem improvement, as well as the need for science to validate the restoration with success, it strongly emphasizes the need for long-term collaboration—collaboration from key coastal constituents to agricultural producers in the upper MRB and between state and Federal agencies.

Holistically, the wellness of the Gulf of Mexico is a basin-wide problem. Without collaborative efforts starting at small spatial scales, integrated with larger regional and basin-wide efforts, the overall goal of improving the Gulf of Mexico ecosystem will be unattainable and untenable. This article describes a unique example of how nutrient-reduction efforts in small subwatersheds in Mississippi, within the MRB, were integrated into region-specific strategies (i.e., Mississippi Delta). This was accomplished through stakeholder interactions among private sector companies, nonprofit organizations, academia, and multiple state and Federal agencies (within and between states), all of which were tied to holistic watershed nutrient priorities of the Gulf of Mexico (figure 1). There is a companion article that addresses specific mechanisms for improvements being implemented to reduce discharge of excess nutrients from state waters in Mississippi to the Gulf of Mexico (Kröger et al. forthcoming).

The Mississippi example illustrates how holistic, integrated, collaborative nutrient-reduction strategies were developed and are being implemented. While Mississippi is estimated to contribute only about 3% of the total P and total N loads to the Gulf (Alexander et al. 2008), it is a Gulf-bordering state and experiences the environmental and economic effects of excess nutrients. Furthermore, nutrient delivery from agriculture in the state of Mississippi to the Mississippi River and the Gulf of Mexico is assumed to be conservative, with little or no transformation occurring between runoff and coastal delivery. In addition, if Mississippi did not implement significant steps toward nutrient reduction, upper river states could

Figure 1

A tiered collaboration framework that ties on-the-ground specific nutrient reduction projects with regional interests of nutrient reduction in the Gulf of Mexico.



question whether downstream states were committed to improving water quality in the Gulf of Mexico.

The western portion of Mississippi (the Delta) has a significant agricultural landscape, with fertilizer applications and nutrient runoff common in the spring and early summer. In 2009, Mississippi drafted a nutrient reduction strategy plan for the Delta (MDEQ and Delta F.A.R.M. 2009). This document was the first consensus-driven, holistic document integrating stakeholder awareness, outreach and education efforts, targeted priority watersheds, and effective delivery of management practices with tiered monitoring for adaptive management in the MRB. Mississippi's steps in outlining and implementing a practical, in-depth nutrient reduction strategy have reverberated upstream and have other states interested in adopting similar measures.

COLLABORATIVE NETWORKS

The Mississippi River and Gulf of Mexico Hypoxia Task Force, GOMA, and GCERTF all have action plans that call for the reduction of nutrients discharged to the Gulf of Mexico. The State of Mississippi, as a member of all three programs, developed and is implementing nutrient reduction strategies tailored for specific geographic regions of the state, but consistent across the state to reduce nutrient discharge to the Gulf of Mexico. Mississippi Department of Environmental Quality (MDEQ) and Delta Farmers Advocating Resource Management (Delta F.A.R.M.) are co leading this effort in the Mississippi Delta. They established four key questions that are envisioned to be answered by the strategies:

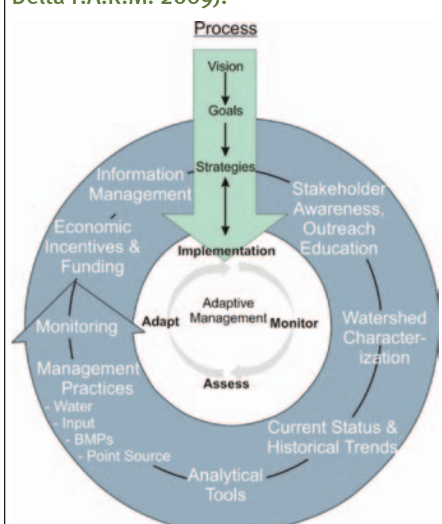
1. What nutrient load reductions are achievable and by when?
2. What will these reductions cost?
3. What is the value to each stakeholder from these reductions?
4. What nutrient reductions will protect Delta waterbodies and the Gulf of Mexico?

These strategies are applicable not only to reducing excess nutrients, but also to improving overall water resources (i.e., health, integrity, quality, quantity) of Mississippi waters and the Gulf of Mexico. The process was initiated through a visioning exercise with key partners and stakeholders within the Mississippi Delta (e.g., MDEQ, USEPA, Delta F.A.R.M., USDA Natural Resources Conservation Service, US Geological Survey, major producers, landowners). This shared vision helped foster stakeholder buy-in and created a mental picture of how resources could be leveraged and where each stakeholder could make a contribution to realize this shared vision (figure 2). This vision served to guide a planning team in setting goals that would permit the vision to be realized. The planning team was transdisciplinary, being composed of multiple governmental agencies, nonprofit organizations, academia, and private sector representatives, including agricultural producers. This planning team of over 30 individuals identified 11 strategic elements needed to achieve effective nutrient reductions in the Mississippi Delta:

1. Involve and engage stakeholders
2. Characterize Delta watersheds and prioritize sites
3. Analyze current water quality status and assess historical trends
4. Evaluate and select appropriate analytical tools
5. Implement management practices for water conservation and reuse
6. Implement input management practices based on the right nutrient rate, time, place, and form
7. Implement best management practices to avoid, control, and trap nutrients
8. Reduce point source nutrient loads
9. Monitor water quality improvements in Delta watersheds at Tier I, II, and III levels
10. Identify and provide economic incentives and funding

Figure 2

Mississippi model for developing holistic, integrated nutrient reduction strategic and implementation plans (MDEQ and Delta F.A.R.M. 2009).



11. Manage information and effectively communicate results to stakeholders

Eleven work groups were established around each of the 11 strategic elements to provide the detail needed to implement these strategies. This process was initiated in March 2009 and completed in December 2009 and resulted in the *Mississippi Delta Nutrient Reduction Strategies* Implementation Draft (MDEQ and Delta F.A.R.M. 2009). Implementation of these strategies has begun in six watersheds within the Mississippi Delta, following an adaptive management approach.

While the emphasis in these strategic elements was on nutrient management practices, team members recognized that precision agriculture and input, water, and sediment management practices all effectively reduce nutrients. Every environmental management practice can contribute to nutrient reduction. It is this perspective that makes these plans equally applicable for restoring the integrity of the Gulf of Mexico and contributing to the *Gulf of Mexico Regional Ecosystem Restoration Strategy* (GCERTF 2011).

This transdisciplinary approach was subsequently used to develop nutrient reduction strategies not only for the Delta, but also for the coastal and upland regions of Mississippi. All three strategies were integrated into an overall state nutrient reduction strategy for Mississippi. In addition, a transdisciplinary workshop was conducted with representatives from the five coastal states forming GOMA—Alabama, Florida, Louisiana, Mississippi, and Texas—to develop a Coastal Nutrient Reduction Strategic Template (CNRST) that each coastal state could use to develop comparable, compatible, and consistent strategic plans among GOMA states (GOMA 2010).

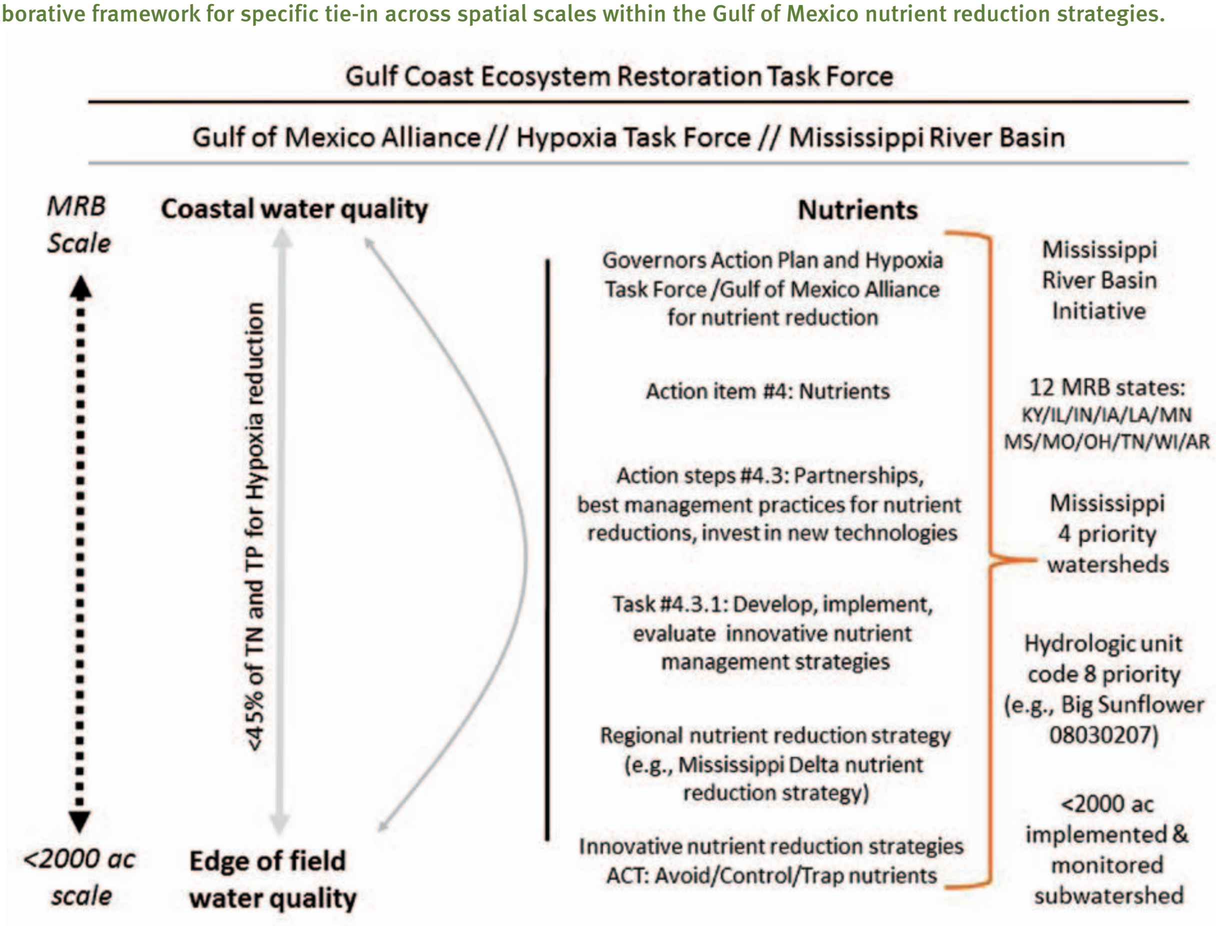
Before the 2010 USEPA Gulf of Mexico Hypoxia Task Force meeting, 11 MRB states, USEPA, USDA NRCS, and USGS representatives held a workshop to develop a similar framework for developing nutrient reduction strategies that could be used by each state in the MRB.

KEY TO SUCCESS

Collaboration is the ultimate key for effective water quality improvement. Technical considerations about specific management practices usually receive the greatest attention in watershed implementation plans, but watershed and basin management are, fundamentally, social activities (Thornton and Laurin 2005). As critical as science is in discovering and fostering innovation, collaboration is the quintessential keystone in effective nutrient management. Collaboration at, and among, all spatial scales is essential to effectively improve water quality in the Gulf of Mexico. In Mississippi, these collaborative links are extensive (figure 3), ranging from discus-

Figure 3

Collaborative framework for specific tie-in across spatial scales within the Gulf of Mexico nutrient reduction strategies.



Notes: MRB = Mississippi River Basin. TN = total nitrogen. TP = total phosphorus.

sions with farmers about the applicability and installation of structures, to engaging local, county, and regional political leaders in discussions about the benefits of water quality improvement, to sharing ideas among states on solutions to nutrient losses and having joint meetings of state and Federal agencies to create consensus-driven outputs such as the *Mississippi Delta Nutrient Reduction Strategies* Implementation Draft.

Pertinent data documenting water quality benefits should emerge from close collaboration between on-the-ground nongovernmental organizations and the USDA, working shoulder to shoulder with the farmers and researchers who are monitoring the systems. The next challenge will be to translate the results and benefits of nutrient reductions at the field scale to catchments, watersheds, and ultimately to the Gulf of Mexico. This entire spatial collaborative network is aiming toward the common goal of local, regional, and Gulf of Mexico water quality improvement. The network (figure 3) is a complicated, yet very manageable, set of information transfer pathways between spatial tiers of on-the-ground, state, and regional collaborations. By creating the requisite collaborations and implementing innovative nutrient management strategies, holistic improvement will occur within the Mississippi River Basin, and thus, in the Gulf of Mexico.

CONCLUSION

Improvements in water quality in the Gulf of Mexico are feasible and possible. However, to be effective, these improvements need to be integrated, holistic, strategic, and stakeholder-driven.

Collaboration is the key. Tiered collaboration (on-the-ground to state-led strategies to interstate and Federal cooperation) needs to be couched in a framework operating at all spatial scales within the entire Mississippi River Basin.

Frameworks are available and being used to develop compatible, comparable, and consistent strategic implementation plans within the Mississippi River Basin for reducing nutrients and restoring the Gulf of Mexico.

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