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Proximate versus ultimate limiting nutrients in the Mississippi River Plume and Implications for Hypoxia Reductions through Nutrient Management

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A large hypoxic area (15,000 km2 on average) forms every summer over the Texas-Louisiana shelf in the northern Gulf of Mexico due to decay of organic matter that is primarily derived from nutrient inputs from the Mississippi/Atchafalaya River System. Efforts are underway to reduce the extent of hypoxic conditions through nutrient management in the watershed; for example, an interagency Hypoxia Task Force is developing Action Plans with input from various stakeholders that set out targets for hypoxia reduction. An open question is how far nutrient loads would have to be decreased in order to produce the desired reductions in hypoxia and when these would be measurable given significant natural variability. We have simulated a large number of multi-year nutrient load reduction scenarios with a regional biogeochemical model for the region. The model is based on the Regional Ocean Modeling System (ROMS), explicitly includes nitrogen (N) and phosphorus (P) species as inorganic nutrients, and has been shown to realistically reproduce the key processes responsible for hypoxia generation. We have quantified the effects of differential reductions in river N and P loads on hypoxic extent. An assessment of the effects of N versus P reductions is important because, thus far, nutrient management efforts have focused on N, yet P is known to limit primary production in spring and early summer. A debate is ongoing as to whether targets for P reductions should be set and whether nutrient reduction efforts should focus solely on P, which results primarily from urban and industrial point sources and is uncoupled from agricultural fertilizer application. Our results strongly indicate that N is the ‘ultimate’ limiting nutrient to primary production determining the areal extent and duration of hypoxic conditions in a cumulative sense, while P is temporarily limiting in spring. Although reductions in river P load would decrease hypoxic extent in early summer, they would have a much smaller effect than N reductions on the cumulative extent and duration of hypoxic conditions. Combined reductions of N and P have the greatest effect.