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Interactive comment on "N and P as ultimate and proximate limiting nutrients in the northern Gulf of Mexico: Implications for hypoxia reduction strategies" *by* Katja Fennel and Arnaud Laurent

Anonymous Referee #1

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General Comments: This is an excellent and timely manuscript by Fennel and Laurent on an important problem. It is well written and presentation quality is high. The authors are active researchers in the Gulf hypoxia community and are well aware of the related work and current efforts to improve scientific understanding of hypoxia in the northern Gulf and reduce nutrient inputs to the system. However, I do not find the concept of ultimate and proximate limiting nutrients to be a particularly compelling framework for this paper (and it is only briefly mentioned in the conclusion). Instead, the significance of the work is the application of spatially-explicit physical-biogeochemical models to elucidate the influence of dual nutrient management strategies on the northern Gulf ecosystem. It is encouraging to see that the magnitude of nutrient reductions predicted

by the model align with prior regression/statistical approaches that have formed the basis of nutrient management efforts in this system.

Specific Comments: 1. Pg 1, line 23. The statement that coastal eutrophication from nutrient inputs is a growing problem. . .. ignores decades of observations of the problem of eutrophication and nutrient pollution. Perhaps it is now appropriate to state that coastal eutrophication from nutrient inputs is a long standing problem. . .

2. Pg 2, line 13-14. N is not the main target of nutrient load reductions for Gulf hypoxia. In advance of the 2008 Hypoxia Action, EPA and the Hypoxia Task Force convened a special Hypoxia Advisory Panel thru the EPA SAB to review the science and provide recommendations for reducing Gulf hypoxia (see reference below). The SAB recommended a dual nutrient strategy of reducing N&P loads by 45%. The Gulf Hypoxia Task Force endorsed the dual nutrient reduction strategy and since the 2008 Action Plan a dual N&P load reduction has been and remains the target. The focus on N&P will have local in-stream water quality benefits as well as downstream water quality benefits in the Gulf consistent with our conceptual understanding and model predictions.

U.S.EPA 2007. Hypoxia in the Northern Gulf of Mexico. An update by the EPA Science Advisory Board. EPA-SAB-08-003. Washington D.C.

3. Pg 4, line 26-27. The monthly flux estimates described by Aulenbach et al., 2007 include two different regression model approaches; adjusted maximum likelihood estimates (AMLE) and the composite method. Please indicate which method was used.

4. Pg 5, line10. Please provide the rationale for choosing TN and DIP for load reduction scenarios rather than DIN and DIP, TN and TP or NOx and PO4, or something else. The literature is inconsistent in what is used for load reduction scenarios to predict Gulf hypoxic zone size. In the lower MS River, nitrate/nitrite comprises about 65% of the TN pool, and it is the nitrate/nitrite pool that has increased several-fold due to anthropogenic activities in the MS basin.

5. Pg 10, line 3-6. The 30% N reduction goal described in the 2001 Hypoxia Action Plan comes from the work of V. Bierman and colleagues as part of the Topic 4 report for the first integrated assessment of hypoxia in the northern Gulf (see references below). Bierman et al used a version of the WASP model tailored to the Gulf hypoxia zone (which he called the NECOP model) to evaluate N and P reduction scenarios from 10% - 70%.

CENR (Committee on Environment and Natural Resources) 2000. Integrated assessment of hypoxia in the northern Gulf of Mexico. National Science and Technology Council Committee on Environment and Natural Resources, Washington, D.C., USA.

Brezonik, P.L., Bierman, V.J., Alexander, R., Anderson, J., Barko, J., Dortch, M., Hatch, L., Hitchcock, G.L., Keeney, D., Mulla, D., Smith, V., Walker, C., Whitledge, T., and Wiseman, W.J., 1999, Effects of reducing nutrient loads to surface waters within the Mississippi River Basin and Gulf of Mexico, Topic 4 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico: Silver Spring, Maryland, National Oceanic and Atmospheric Administration, NOAA Coastal Ocean Program Decision Analysis Series No. 18.

6. Pg 10, line 12. Suggest including reference to the statistical model of Turner et al. 2006 (see reference below), which helped to stimulate a series of additional statistical modeling approaches that you identify in the paper.

Turner, R. E., N. N. Rabalais, and D. Justic. 2006. Predicting summer hypoxia in the northern Gulf of Mexico: riverine N, P, and Si loading. Marine Pollution Bulletin 52:139–148.

7. Pg 10, lines 18-19. The statement that Greene et al 2009 (and Forrest et al 2011) predict >100% nutrient load to achieve the 5000 km2 goal is incorrect. Greene et al 2009 used 50% N and 45% N&P load reduction scenarios and found that model 11 (which used AMLE load estimates) could achieve the hypoxia target, whereas, model 12 (which used composite method load estimates) would not achieve the hypoxia tar-

get. These differences were attributed to differences in the AMLE and COMP load estimation methods, which influenced the model parameter coefficients. Thus, it would be correct to state on line 19 (and in Table 2) that >50% N reduction would be needed to achieve the hypoxia target using model 12.

8. Pg 17 Table 2. There is an inconsistency in abbreviations – figure caption state ‘BO’ refers to bioavailable N where the NCSU model in Scavia et al 2017 shows ‘BN’. Finally, Greene et al 2009 used ‘TP’ not ‘P’ in their dual nutrient regression models.

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