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Biogeosciences Discussions

Interactive comment on "The nitrogen pendulum in Sandusky Bay, Lake Erie: Oscillations between strong and weak export and implications for harmful algal blooms" *by* Kateri R. Salk et al.

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Reviewer comment: Issues in associating chlorophyll concentrations with HABs Author response: This point is well taken. Originally, the authors had planned to publish an accompanying manuscript on the genomic composition of the community in Sandusky Bay, which more clearly illustrates that the connection between chlorophyll and HABs in the system is justified. However, the authors are now planning to add a brief section to the manuscript on the metagenomic analysis of the phytoplankton community, which demonstrates a dominance by Planktothrix and the presence of N-fixing cyanobacteria during periods of high rates of N fixation. This will include a paragraph each in the

methods, results, and discussion, with an accompanying figure of the species composition in Sandusky Bay.

Reviewer comment: Use of the term "Great Lakes estuary" or "freshwater estuary" may not be appropriate Author response: "Freshwater estuary" is indeed a class of estuary, as defined by the U.S. National Oceanic and Atmospheric Administration (https://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar05e_fresh.html). These systems are common in the Laurentian Great Lakes, and they are characterized by gradients and hydrology similar to marine estuaries (including conductivity gradients). Another system in Lake Erie, Old Woman Creek, is a freshwater estuary in the National Estuarine Research Reserve System. Although this term is unusual, we prefer to use it to illustrate common processes among these systems and marine estuaries (i.e., freshwater estuaries often behave more like marine estuaries than lakes).

Reviewer comment: p. 11 – denitrification relies on carbon supply as well as nitrate, potential dependence on C:nitrate ratios Author response: Given the high rates of primary productivity in this system and the high carbon content of the sediments (e.g., Ostrom et al. 2005), the consideration of C limitation on denitrification was not a major concern for this study. Additionally, a recent study showed that sediment C:N ratios were not significant predictors of denitrification rates across the Great Lakes and in Lake Erie (Small et al. 2016). Considerations of C supply will be mentioned in the revised manuscript in the methods section where Sandusky Bay is introduced as the study system. Ostrom et al. 2005. Evaluation of primary production in Lake Erie by multiple proxies. Oecologia 144: 115-124. doi: 10.1007/s00442-005-0032-5 Small et al. 2016. Large differences in potential denitrification and microbial communities across the Laurentian great lakes. Biogeochemistry 128: 353. doi: 10.1007/s10533-016-0212-x

Reviewer comment: p. 12 – obvious comments in lines 6-12 on N2O production as byproduct of denitrification, but logic linking this to last sentence in paragraph 2 is not

justified Author response: These lines will be incorporated into the first paragraph of section 4.2, which will help to improve the flow and more clearly tie the results to the final sentence emphasizing that shallow regions may make up the majority of N2O emissions from the Great Lakes.

Reviewer comment: Section 4.3 – Impact of remineralization on N budget needs to be discussed further, particularly the distinction between the gross and net rate of phytoplankton uptake (is uptake a sink?) Author response: Remineralization is discussed on p. 13 lines 20-30, and the issue of phytoplankton assimilation as only a temporary sink is discussed on p. 15 lines 9-15. The reviewer points out an opportunity to make this connection more explicit. As a result, we will revise those paragraphs to more thoroughly describe the distinction between gross and net rates of phytoplankton N assimilation, and the capacity for recycling to retain N in the system.

Reviewer comment: Section 4.3 – These results encourage a thorough investigation of the controls of nitrogen fixation, including a supply of P and Fe Author response: The reviewer points out an interesting and relevant consideration, which the authors considered as well in the preparation of this manuscript. While Fe limitation of N fixation has precedent in the literature in several systems, we dismissed this mechanism for two reasons: (1) as the Sandusky River discharges into the bay, it brings a high sediment load that is expected to have a sufficient trace metal load to support phytoplankton demands, and (2) the sediments in Sandusky Bay are anoxic, and it is likely that nighttime sediment oxygen demand is high enough that transient anoxia develops at the sediment-water interface, thus enabling P and reduced Fe to be released into the water column and be taken up by phytoplankton. These internal loading events, while outside the scope of this study, have been captured on several occasions over the course of multi-year surveys of the bay. While P limitation was certainly at play during portions of the season in both years, the substantial phytoplankton biomass and high N fixation rates indicated that P was likely not a driving factor for the activity of N fixation. We will include an additional section on cyanobacterial community meta-

transcriptomics in the revised manuscript (see author response to comment #1), which lends additional support to the biogeochemical measurements of N fixation.

Reviewer comment: Section 4.4, line 29 – not sure it is straightforward to extrapolate this argument to other coastal areas (likely that water flow is not operating as a pendulum in other coastal systems, where tides and other factors might be stronger controls) Author response: This is a great point that other factors come into play beyond changes to precipitation and N loading, which in turn make it complicated to extrapolate results from Sandusky Bay to other systems. Despite the potential differences, many estuarine systems experience strong river input and therefore may experience similar hydrology-driven swings in nutrient availability and biogeochemistry (thus the pendulum may apply in other systems as well). The authors will edit the language in this paragraph to reflect this.

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