Review for USEPA SAB

Draft Technical Approach for Lake Erie Phosphorus Load-Response Modeling

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1. Justification and Need for this Work

Clearly there is a need to undertake a reevaluation of P objectives for Lake Erie Therefore, this effect is needed and could be considered urgent in need. The factors that support this idea are as follows:

1. There has been changes in regional climate in the Great Lakes, which have been well documented (see McCormick and Fahnenstiel 1999).
2. Recent food web changes have occurred:
    - Proliferation of invasive Dreissenid mussels
    - Proliferation of invasive zooplankton- *Bythotrephes*
    - Declines in native species
3. P loadings to the lake have changed over the past 20 years
    - Ratio of dissolved P to TP has gone up
4. Hypoxia (occurrence, extent) in the central basin has not shown a significant decline/reduction as expected (see Scavia et al. 2014).
5. Several large harmful algal bloom events in the western basin have occurred over the past 10 years (2008, 2011, 2014, see Millie et al. 2014).

2. Evaluation of Approach to this Work

2a. Modeling Effort

Strength

•Based upon the number and magnitude of the changes to the Lake Erie ecosystems, it was logical and sensible to revisit the models used to evaluate the response to P loading in the lake.

•The application of this series of models is a good idea. The notion of using multiple lines of evidence is a sound and robust approach. Moreover, many of these models have already been used in the Great Lakes, calibrated against the conditions in these lakes, and thus have either been built for this purpose or adapted to this end.

Chapra- Mass balance model,
WLEEM model- water quality: Chl, Cyanobacteria
ELCOM- water quality Chl, Cyanobacteria, hypolimnetic oxygen concentration
EcoLE- hypoxia, chlorophyll, Cyano chl
UM-GLERL- Spatial-temporal model for Cyanobacteria coverage
NOAA forecasting- Spatial-temporal model for Cyanobacteria coverage
9-Box Eutrophication model- TP, DO, Chl
1-D Central Basin- hypoxia
Great Lakes Cladophora model- Cladophora coverage

Limitations

•The assumptions of each model should be spelled out more clearly and directly so that the suitability of each application can be better considered.
These models each work under differing time and spatial scales, and with this comes assumptions about how realistic it is to use them under certain circumstances, and then compare to output to one another. The central basin hypoxia model is geared to seasonal-scaled phenomenon, while the ELCOM and EcoLE models are water quality models that can general daily output. The UM-GLERL model predicts spatial coverage of cyanobacterial blooms, which is a very different quantity.
•Most of these models do not truly weight the relative importance of variables in regulating the metrics of interest.
•Algal blooms data are difficult to predict because they do not adhere to conventional statistical and mathematic treatments (zero-inflated data).

2b. Choice of Metrics

Most of this metrics have been used before in relation to evaluation lake productivity and cultural eutrophication (see Wetzel 2001). That said, there is very little innovation here or room to consider anything new that may have been developed over the past 20 years. The key metrics being used are as follows:

Chlorophyll is an average June-August concentration
Cyanobacteria blooms (Cyanobacteria numbers, biomass)
Hypoxia- hypolimnetic oxygen concentrations in the central basin
Cladophora in the nearshore Eastern Basin

Strengths

•Many of the metrics being used here are relatively straightforward to measure and have been measured over a long time period in the Great Lakes. This is very importance, because information generated here can be compared against previous historic conditions in the lake.

•Given the routine nature of these metrics, numerous models have been developed to make these predictions; this allows several, difference models to be used and their output compared against one another. Thus, the preponderance of evidence approach can be used to achieve or achieve consensus.

Limitations

•The error related to each metric produced by the array of models being used here may be different and should be considered when interpreting results.

•These metrics may be sensitive enough in order to detect meaningful change. The use of hypolimnetic oxygen does not seem to be responsive to P loading, perhaps because it is regulated by so many other physical-chemical factors (e.g., temperature, water movement).

3. Questions and Need for Clarification

•How were these target concentrations chosen (why spring TP)?

•Are the Lake Erie target numbers too high for TP- these values seem indicative of relatively eutrophic conditions (see Wetzel 2001).

•Did the Depinto et al 2006 study consider changes in the plankton that have occurred in contemporary Lake Erie?

Given that some base conditions in Lake Erie have changed, such as temperature (McCormick and Fahnenstiel 1999) and base chemistry (see Barberio and Tuchman 2004), can we assume these metrics will behave similarly as modeled previously?

•Are key parameters using in these models still relevant to current day conditions in the lake? For example, did the uptake kinetics for Lake Erie phytoplankton (current) change from the 1980's or are the same as those measured algal cultures that were used to establish some of these input parameters?

•How will internal loading be addressed and can phytoplankton (chlorophyll) be internally loaded (see Carrick et al. 2005)?

•Why are nutrients other than P being considered? There is evidence that both Si and N can limit phytoplankton growth (see Moon and Carrick 2007).

•What about winter dynamics in Lake Erie? Some work showed that winter diatom blooms can contribute significantly to summer hypoxia (see Lashaway and Carrick 2010).

4. Literature Cited

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