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P. 54 in EPA's TSD: Comments on EPA's interpretation of the Steward and Lowe (2010) regression models.

The narrative on p. 54 reveals (1) a healthy debate within EPA regarding the utility of the Steward and Lowe (2010) regression models (S&L models); but (2) some misunderstanding about what the models represent and what utility, within proper constraints, they can offer.

What are the S&L models; how were they developed?

- The models are regression relationships that define the upper mesotrophic nutrient loading limit for Florida systems as a function of water residence time (or, more appropriately, relative nutrient residence time) or as a function of hydraulic loading (mean depth/residence time).
- The nutrient loading limit (g m^{-2} yr^{-1}) in this case is associated with the upper mesotrophic level (UML) because it's based on nutrient TMDLs that were set for nutrient-impaired (and presumably eutrophic) systems. TMDLs are intended to achieve, at minimum, an "upper threshold" compliance with a specific WQ standard endpoint (= upper mesotrophy or what some may consider as the assimilative capacity at the critical threshold of eutrophy).

What purpose can the models serve?

- The model can be applied to systems **as one line of evidence** to approximate a nutrient loading limit required to achieve or maintain upper mesotrophy. (Therefore, it should not be relied upon to approximate loading limits for systems in which a lower trophy is desired).
- A lower mesotrophic level (LML) was theoretically calculated for Florida systems. This LML along with the empirically-established UML, both serving as the upper and lower bounds of mesotrophy, can be used to estimate a system's general trophic state by plotting that system's annual loading (e.g., current, past, future, or targeted loading) as a point on the graph and assess its position relative to the UML and LML. For NE Florida estuaries, we can show a fair relationship between their plotted position of points and their calculated TSI values. As one line evidence, the models can help determine where along the trophic continuum a system may be located, indicating whether the loading is desirable or should be further evaluated for adjustment.
- The S&L models can o be used in tandem with a Vollenweider TP model modified to fit Florida systems or in tandem with the Dettmann (2001) TN model to approximate TP or TN concentrations that correspond to the chosen loading limit. Again, it is preferable the models be applied as one line of evidence in a weight-of-evidence approach to develop nutrient criteria.

Comments on specific statements made on p. 54 of EPA's TSD

"…accurate prediction of loading limits depend on estimates of average residence times, which can be difficult to estimate precisely…"

I agree, but this is true with any environmental variable that is used as a basis for prediction.

"…relationships…[only] associated with mesotrophy…"

True, and is definitely a limitation of the model. A similar model should be developed for oligotrophic/upper oligotrophic systems. A theoretical upper oligotrophic (or lower mesotrophic line) was developed (see p. 441 – 442 in Steward and Lowe, 2010), but requires a reality check using data from oligotrophic systems in Florida.

discussion beginning with and following "…the strength of the relationships is a consequence of scaling."

The statement should read: "The strength of the relationships is **partly** a consequence of scaling." This is not a spurious relationship contrived mathematically. There are mechanistic and biological reasons, as well as a mathematical basis for the relationship as the authors discuss, and as others have already discovered or support (Vollenweider, Schindler, Dillon, Boynton, Kelly, etc.). The log-transformed regressions are supported by equally robust non-transformed regressions.

The log(τ_w) or τ_w in the models actually represents a relative nutrient residence time (relative τ_n) across system types. Freshwater residence times (R_{63}) for the shallow, typically non-stratified or weakly stratified estuarine bays and lagoons were scaled up to R_{99} to represent their longer nutrient residence times relative to riverine estuaries and freshwater systems where R_{63} can serve as their relative τ_n. About 39% of the points on the graph (Fig. 3-4, p. 54) are the "R_{99}" estuaries. τ_n is generally longer than τ_w; and as τ_w lengthens, τ_n becomes more of a factor in determining the allowable nutrient loading. For example, lagoons typically have long residence times and considered strong nutrient recyclers having very high nutrient utilization efficiency (Scavia and Liu 2009). I think the graph (Fig. 3-4) supports that idea and that relatively low nutrient loading limits for lagoons and other long-residence systems are appropriate to maintain a given trophic state (mesotrophy or oligotrophy).

The estuaries with the longer residence times in the graph have, on average, shallower depths, not deeper depths. When depth was factored into the model (as hydraulic loading, q_s), the power of prediction was improved.