Using Dissolved Oxygen Dynamics to Derive Nutrient Criteria: Tried, True, and Troublesome

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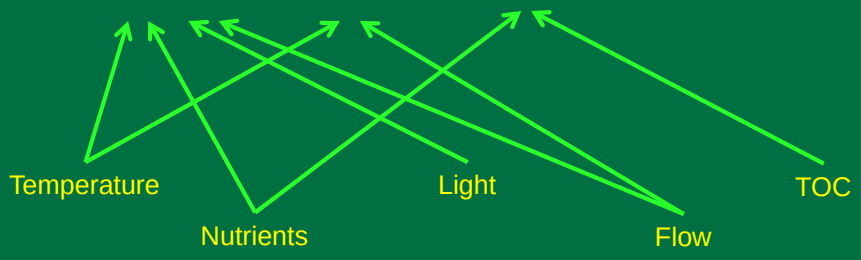
Nutrient Criteria

- Numeric values derived to protect designated uses – including aquatic life
- Oxygen is a clear aquatic life use requirement and DO criteria exist (e.g., 4-5 mg/L)
- Oxygen is affected by nutrient enrichment via photosynthesis
- Many states want to use diel range as an indicator for deriving criteria

Question: Is diel DO range an appropriate endpoint for deriving nutrient criteria?

- What are the issues?
  - Metabolism is not the only thing that affects oxygen dynamics.

DO = Photosynthesis + Reaeration - Respiration - Groundwater Dilution

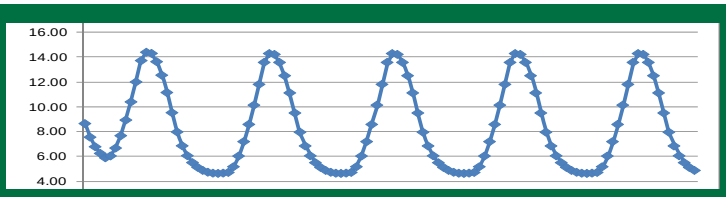


Approach

- Mass Balance DO Model
  - Created simple spreadsheet DO mass balance model (based on equation below)
    - DO = PS – R – Dilution + Reaeration
  - Limited interaction among factors (e.g., depth and reaeration not linked per se)
  - Iterative (brute force) manipulations
- Empirical Data
  - State of MS, USGS monitoring data
  - Compared diel DO data to predictors and biological response

Simple Excel DO Mass Balance Model Output

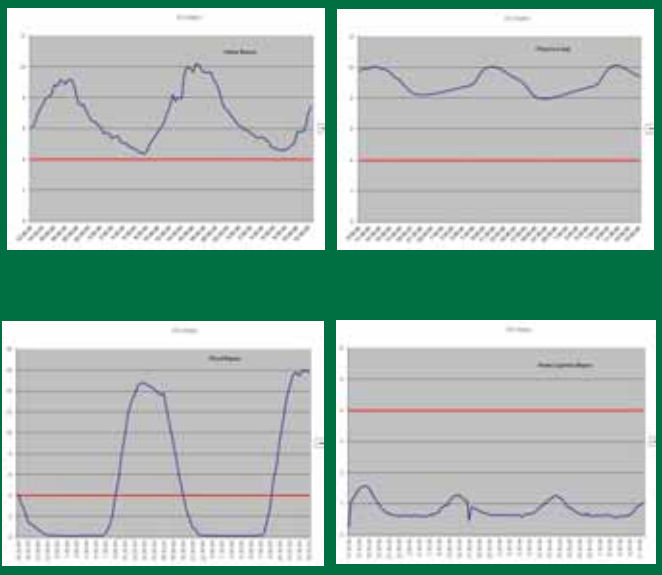
Depth (m)	Temp (C)	P (gO2/m2/hr)	R	Dilution %	k (h^{-1})	Mean DO (mg/L)	Min DO (mg/L)	Diel DO Range (mg/L)
0.1	23	0.05	2.5	1	1	7.4	6.7	1.6
0.1	23	0.25	2.5	1	1	7.5	6.7	1.6
0.1	23	1.25	2.5	1	1	7.9	6.8	2.5
0.1	23	2.5	2.5	1	1	8.5	6.8	4.3
0.1	23	2.5	2.5	4	1	8.2	6.6	4.2
0.1	23	2.5	2.5	1	0.25	8.2	4.6	9.6
0.1	23	2.5	2.5	0	0.25	8.6	4.9	9.8
0.5	23	2.5	2.5	1	0.25	8.2	7.3	2.2

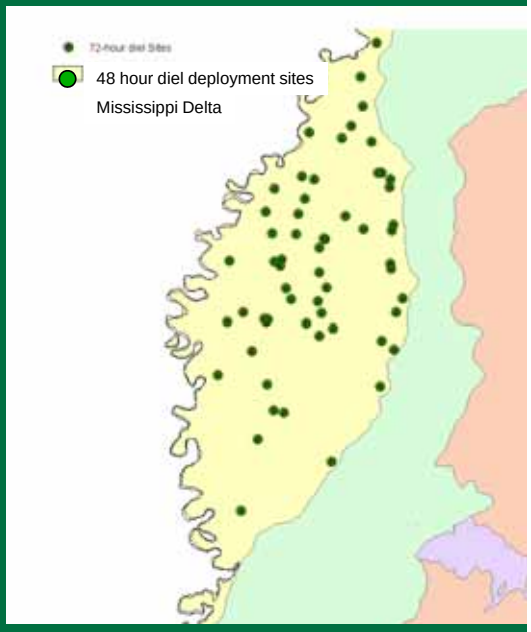


Mississippi Empirical Diel Data

- Range of wadeable streams encompassing typical assessment range
  - Mean Q = 230 L/s (<100 to 2000 L/s)
  - Mean width = 4.0 to 57 m
  - Mean depth = 0.2 to 2.8 m
- Large nutrient/productivity gradient
- 48 hr diel deployments
- Invertebrate and water chemistry collected

Mississippi Diel DO database





- Wide range of diel DO curves

Data

- Standard transformations
- Pearson correlation
- Forward stepwise regression
  - DO = f(TN, TP, Temp, TSS, TOC, Chl, Depth, Width)
- CART
  - Same predictors

DO diel Range

- Weak MLR model
  - Best predictor = +Temperature : r^2=0.05
- CART model
  - Best predictors = +Temp, +TOC, -depth, and +width
  - (PRE: 0.11 to 0.43)

Minimum DO

- More predictive MLR model
  - -TOC/-TP : r^2=0.20 (higher TOC/TP, lower min DO)
  - TOC and TP were correlated and were best predictors
- CART model
  - -TP, +Width, -TSS (high TP, shallow streams, with low TSS = lower min DO)
  - (PRE: 0.37 to 0.65)

What is related to biota?

- Correlation with common invertebrate metrics

	MIN DO	DO RANGE
TOTAL TAXA	0.270	0.066
EPT TAXA	0.452	0.003
SHANNON	0.254	0.061
% EPT	0.366	0.061
% INTOLERANT	0.343	0.057
% TOLERANT	-0.233	0.016
HBI	-0.199	-0.065

Data used are preliminary and subject to change

Summary

- Models
  - Diel range responds to more than metabolism
  - Reaeration, dimensions, dilution, etc. all matter
- Empirical data
  - Poor prediction for range
  - Better prediction for minimum DO
  - Invertebrates relate (negatively) more to minimum DO than to range

Question: Is diel DO range an appropriate endpoint for deriving nutrient criteria?

- Range is an indicator of metabolism.
- So, it can be an endpoint – if all else is equal.
- But, all else is never equal in state monitoring programs.
- Do organisms care about range in DO?
- Help requested.