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Ref.:	**tsis**	**(6 pages)**
To:	Tony Blouin PhD, Manager, Environmental Performance (Water) Sustainable Environment Management Office Environmental Management Services (EMS), HRM	
Date:	March 16, 2005	
Subject:	**Trophic status and data evaluation methodology**	

This has to be read in conjunction with the accompanying 3-page document I prepared under the purview of the SWCSMH, Ref. phosphorus_ccme2004, which was an overview of the 135-page CCME narrative on phosphorus management (Environment Canada, 2004, http://lakes.chebucto.org/DATA/PARAMETERS/TP/ccme.pdf).

As it is cautioned in the CCME narrative (Environment Canada, 2004), the pelagic trophic parameters have to be applied with caution to shallow lakes, and the policy states further that there may be exceptions in dystrophic lakes, especially in Nova Scotia!

A "shallow lake" or "pond" is usually defined as a permanent standing body of water that is sufficiently shallow to allow light penetration to the bottom sediments adequate to potentially support photosynthesis of higher aquatic plants over the entire bottom (Wetzel, 2001).

Select texts and handbooks narrate methodologies for trophic analyses for shallow lakes in various ways but only a handful incorporate regressions, some being quite complicated, and others are simpler!

At the present, I choose the methodology as published not only by the United States Environmental Protection Agency-USEPA (Porcella *et al.*, 1979) but also as recommended in the latest handbook of the North American Lake Management Society-NALMS (Holdren *et al.*, 2001).

Though this methodology is (supposedly) applicable to all lakes and not just to those that are shallow. But I understood from communicating with one of the original authors some time ago that it had not been tested widely. Hence, I found it interesting that NALMS' authors included it in their year 2001 handbook.

During one of the occasions that I was a guest lecturer at Dalhousie University, the summer school instructor had approached me for project ideas and agreed to apply the USEPA's Lake Evaluation Index (LEI) to two lakes, Russell and Bissett, during 2002. Details on that class project can be viewed in one of our web pages, http://lakes.chebucto.org/WATERSHEDS/COWBAYR/holt.html

I and the instructor were quite satisfied with the results, they were as expected. The only major drawback in the university class project was that they could not apply the DO-depletion index because of lack of equipment and due to time constraints during a short summer school time span. Incidentally, the summer school students included undergrad as well as grad students, part time as well as full time, inclusive of an ecologist from Environment Canada Atlantic.

Shallow lakes (http://lakes.chebucto.org/shallow.html):

Notwithstanding the narrative above, I recommend that it is worthwhile applying the USEPA's Lake Evaluation Index (LEI) to shallow lakes rather than deeper lakes primarily since it also includes a trophic state index, TSI, for macrophytes as well.

In addition, I and some volunteers are applying this to other shallow lakes whenever we find time! The results will hopefully be included in future updates of the Excel-based archives and/or in separate analytical reports.

The Trophic State Indices (TSIs) were developed by Carlson (1977) and they included TP (total phosphorus), Ch*a* (chlorophyll *a*), and SD (Secchi disk). The USEPA added indices for macrophyte cover and for DO-depletion over the whole lake! The TSI for TN (total nitrogen) was developed by Kratzer and Brezonik (1981) for Florida lakes.

The Lake Evaluation Index based on scalar transformations of the trophic state indices (TSIs),

LEI=0.25[0.5(XCA+XMAC)+XDO+XSD+(XTP or XTN)], **where only the higher rating value of the XTP and the XTN is to be used; the target variables for all parameters are July-August average epilimnetic zone concentrations (Porcella *et al.*, 1979; and Holdren *et al.*, 2001), and**

XCA = 30.6 + 9.81 ln (CA)

XMAC = PMAC -- (the area of the lake subject to growth of macrophytes can be defined as the area encompassed by the lake margin and either the 10m line or the depth at which light becomes limiting to vascular plant distribution and growth [2 times SD] whichever is shallower. The percent of this area that is actually covered by vascular plants is defined as the target variable. Only relatively crude surveys during the growing season [July-August] are needed to assess the percent of that area that is actually covered by the vascular plants.)

XDO = 10 (net DO) -- (the net DO, calculated as an average over the principal summer months [July-August], is the difference between the DO in a pure water lake and what is actually measured. The best situation [XDO=0] would occur if net DO was zero, and a very poor quality [XDO ≥ 100] would be if net DO is ≥10)

XSD = 60 - 14.427 ln (SD)

XTP = 4.15 + 14.427 ln (TP)

XTN = 14.427 ln (TN) - 23.8

Table: Rating scale for lake water quality parameters (Porcella *et al.*, 1979)

Rating (x)	SD (m)	TP µg/l	TN µg/l	Chlorophyll *a* µg/l	Net DO mg/l	Macrophytes (% available area)
0 (minimally impacted)	64	0.75	5.2	0.04	0.0	0
10	32	1.5	10	0.12	1.0	10
20	16	3.0	21	0.4	2.0	20
30	8.0	6.0	42	0.94	3.0	30
40	4.0	12	83	2.6	4.0	40
50	2.0	24	170	6.4	5.0	50
60	1.0	48	330	20.0	6.0	60
70	0.50	96	670	56.0	7.0	70
80	0.25	190	1300	150.0	8.0	80
90	0.125	380	2700	430.0	9.0	90
100 (maximally impacted)	≤ 0.062	≥ 770	≥ 5300	1200.0	≥ 10.0	100

Data evaluation methodology based on Trophic State Indices (TSIs):

Utilizing the TSIs for TP, Chl, and SD, one can evaluate probable shortcomings in data analyses and/or to delineate other environmental effects/scenario.

It is generally understood that the values for TSI(TP), TSI(Chl), and TSI(SD) should be within four to five (4 to 5) points of each other. If they are not, it does not necessarily imply lab data analyses errors, but may indicate other environmental aspects some of which were summarized by Carlson and Simpson, 1996 (*cf.*, table below).

Table: Using the Indices Beyond Classification (Carlson and Simpson, 1996)

Relationship Between TSI Variables	Conditions
TSI(Chl) = TSI(TP) = TSI(SD)	Algae dominate light attenuation; TN/TP ~ 33:1
TSI(Chl) > TSI(SD)	Large particulates, such as Aphanizomenon flakes, dominate
TSI(TP) = TSI(SD) > TSI(CHL)	Non-algal particulates or color dominate light attenuation
TSI(SD) = TSI(CHL) > TSI(TP)	Phosphorus limits algal biomass (TN/TP >33:1)
TSI(TP) >TSI(CHL) = TSI(SD)	Algae dominate light attenuation but some factor such as nitrogen limitation, zooplankton grazing or toxics limit algal biomass.

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