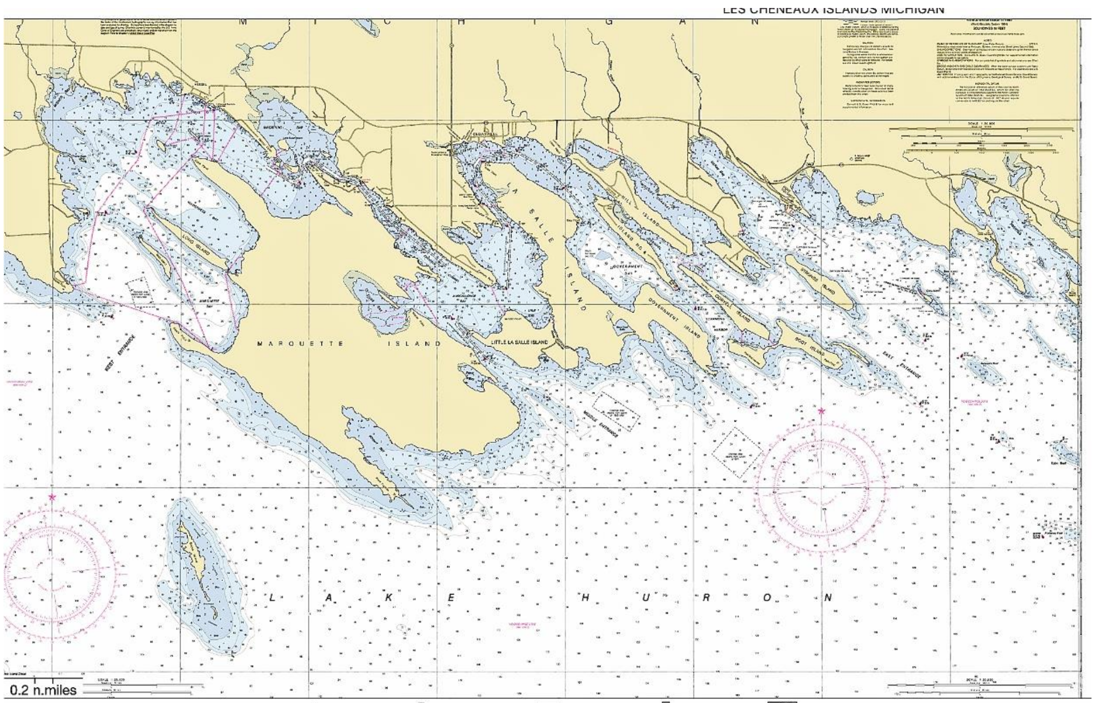

Impact of decreased Lake Huron level on Les Cheneaux Island water quality variables from 2020 through 2022.

2 February 2023

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Impact of Lake Huron level decrease on Les Cheneaux Island water quality variables from 2020 through 2022.

Summary:

A study published in 2021 tracked the changes in nutrients, plankton and temperatures in Les Cheneaux Islands (LCI) waters during a seven-year period from 2013 through 2020 in which L Huron (LH) increased to a record high level and at a record rate (Ref. 1). The LH level has decreased during both 2021 and 2022 since the record high was documented in 2020. This report quantifies changes in the same three variables during the period of decline that were monitored during the time of rapid rise.

Seasonal water temperatures within LCI channels increased from 2020 through 2022 by 1.5°-2.5° C (3.2°-5.3° F) during which time LH level declined by 66 cm (26 inches). With lower depths in the LCI channels one could expect water column nutrient concentrations to increase. As a result of warmer water and increased nutrients one could also expect plankton densities to increase. This was not the case. Rather, plankton density decreased by about 20% from 2020; the year of record high LH level.

It is not obvious why the plankton density dropped during a time of seasonal water temperature and nutrient increases. Conversely, a plankton concentration increase could be expected under these circumstances. One possible explanation is that micronutrients provided in the LH water were reduced in concentration due to the lower LH level. Another possibility is that the three year observation is not sufficient to accurately track trends of the complex water chemistry dynamics between LH and the LCI channels. Monitoring of these variables continues.

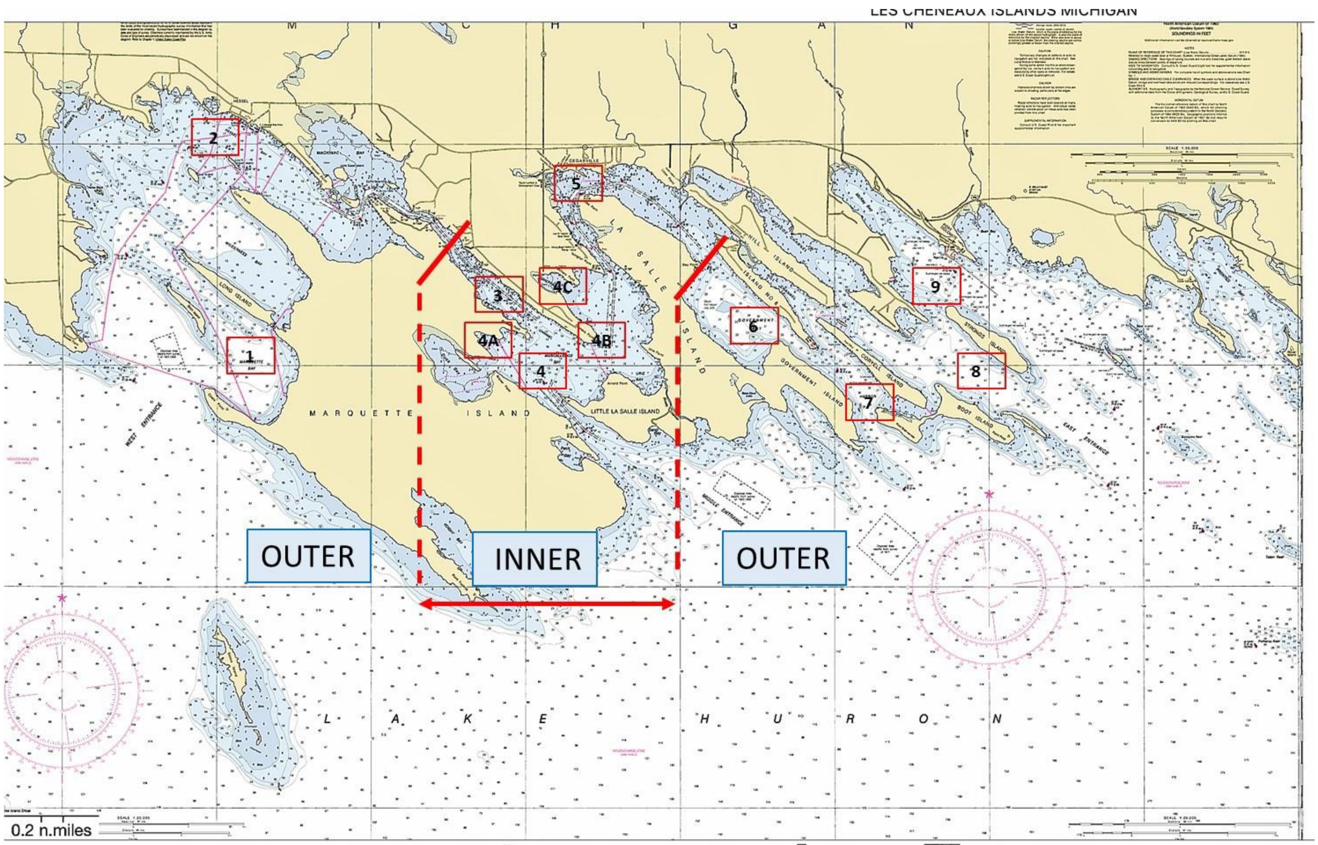
Introduction:

The Les Cheneaux Watershed Council (LCWC) has monitored water quality variables within the Les Cheneaux Islands since 2001 under sponsorship of the Les Cheneaux Islands Association (Ref 1). Lake Huron (LH) levels fluctuated during the 2001 through 2005 period then began to slowly decline through 2012 until an historic low was recorded in Dec 2012-Jan (Ref 2,3,4).

Water levels increased annually from 2013 through 2020 at rates of 4 inches to 16 inches per year until a record LH high was recorded in August of 2020 (Ref 2,3,4). This report takes advantage of a rare opportunity in LH hydrology to monitor environmental effects of the rapid LH rise that has been immediately followed by a similarly sharp decline in our primary water quality variables: plankton food source (phosphorus), temperature and plankton density itself.

Observed nutrient (trophic) patterns, aquatic conditions for a water body to support a specific level of plant and animal growth, have been delineated into an Outer Island Zone (OIZ), in which lower nutrient concentrations and conditions such as temperature and sunlight penetration to support growth are reduced, and an Inner Island Zone (IIZ) in which higher nutrient levels and conditions are available to support more dense growth (Fig. 1, App C). Study sites between the OIZ and the IIZ are considered Transition Zones (TZ) which exhibit intermediate levels of growth-supporting nutrients and growth conditions.

Fig. 1. Nutrient and productivity zones of the Les Cheneaux Islands. An Inner Island Zone (IIZ: higher nutrient and higher plant/ animal productivity) is shown between the vertical/angled red lines and Outer Island Zones (OIZ: lower nutrients and less productive) are shown East and West of the Inner Island Zone. Numbers signify sample sites.



Materials and Methods.

Relationship of Chl-a, TP and SRP: Three variables monitored during annual LCWC sampling of Les Cheneaux waters included Chlorophyll-a (Chl-a), Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP). The relationship of these three variables is an indicator of other water quality factors within the waters being examined. In a balanced, healthy water body the Total Phosphorus (TP) is present in a greater concentration than the Soluble Reactive Phosphorus (SRP). SRP is derived from TP and can be directly metabolized by plankton (free-floating algae, or phytoplankton) whereas the TP must first undergo a conversion, either microbiogically or chemically, in order to serve as a nutritional source for plankton (App. A,B). (include PO4 schematic)

Chl-a is a measure of a specific classification of chlorophyll that is present in phytoplankton (plankton) at the time of each sampling. The Chl-a value is an indirect estimate of the plankton density. Higher, or more dense, plankton populations require and consume greater amounts of phosphorus as an energy source. Thus, a decrease in TP or SRP would indicate a greater demand for that component as a plankton food source or it would limit the plankton density.

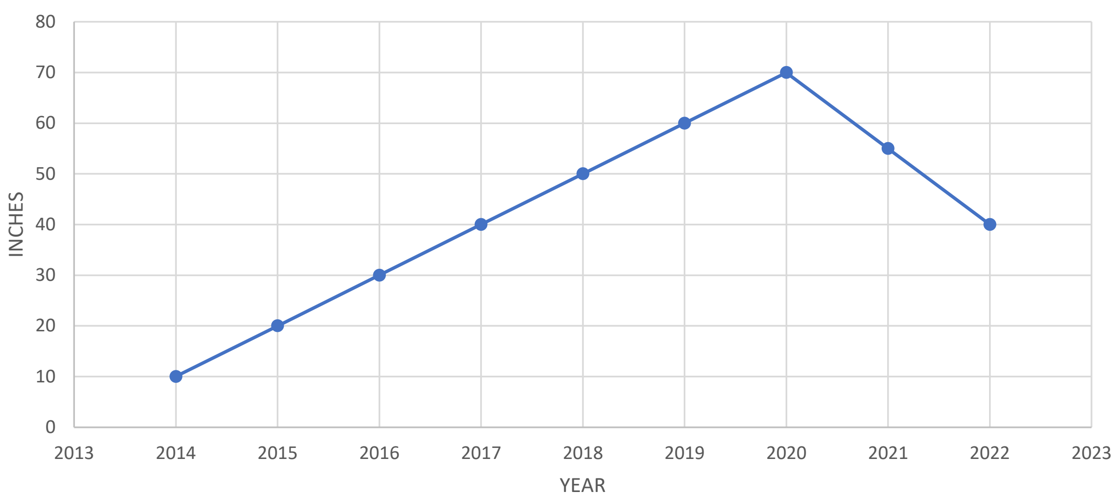
Plankton Chl-a values are normally lower than SRP concentrations. It follows that, since SRP is a component of TP, that Chl-a values will also be lower than observed TP levels. Thus, ratios of Chl-a/SRP and Chl-s/TP can be used as a measure of that relationship for a given sample event or period.

Sample analysis: Water samples and filters through which known volumes of water had been passed through 0.45µ cellulose acetate filters were analyzed by chemists at the University of Michigan Biological Station at Douglas Lake. Methods used were as reported in Smith, 2005. (Ref 2).

Results and Discussion:

LH water level increased rapidly from 2013 through 2020 after which the level has decreased through 2022 at a rate about 30% faster than the record rise (Fig. 2). LH is expected to continue a decrease in 2023 by about 6-8 inches based on

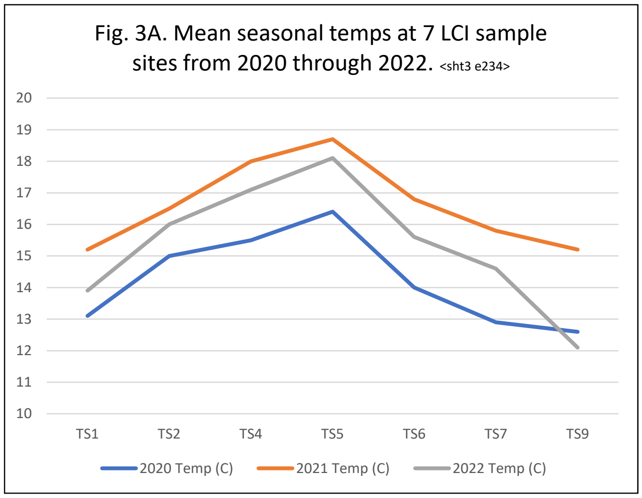
Fig.2. RATE OF LAKE HURON LEVEL CHANGE: 2013-2022. <tsirawdat 2022 sht2 AA15/ SH3 K155>

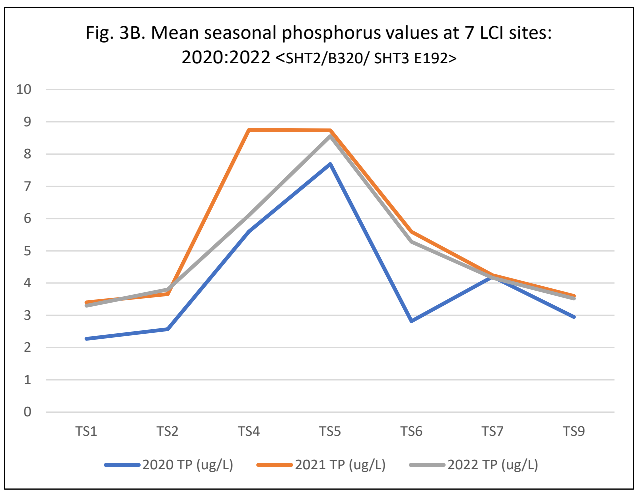


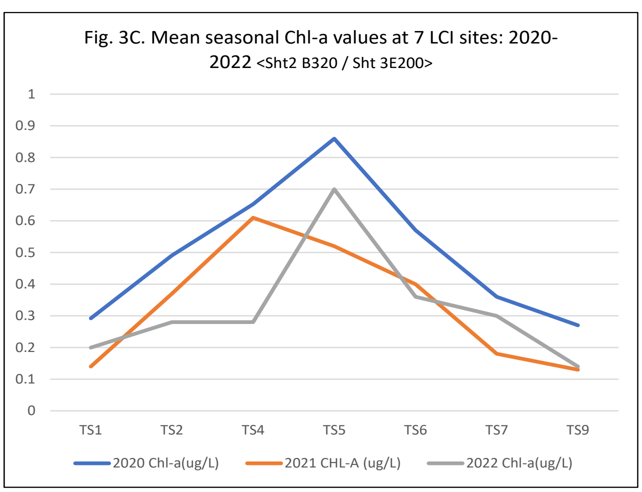
USACE (Ref. 5) predictions as of Jan 2023. On the plus side, lower water in the present range reduces stress on Les Cheneaux shorelines, docks and boathouses. However, the growth of non-native plants, both submerged (Eurasian watermilfoil, *Myriophyllum spicatum*) and emergent (non-native cattail, *Typha X glauca*) increases due to less inhibitory stress from higher lake levels.

Primary factors influencing plankton growth: temperature (temp) and nutrients (phosphorus) were plotted for each sample site from 2000 through 2022. The mean values for each sample station and for each variable are shown in Fig 3. Patterns for temperature, phosphorus and plankton density were consistent for each station in that they conformed to the OIZ, TZ and IIZ assigned trophic ranges for all three years reported. Seasonal temperatures for each site indicated that mean temps were cooler in 2000 and warmest in 2021 for all sample sites. (Figs. 3A, 3B and 3C).

Fig. 3 A,B,C. Plot of LCI sample collection site temperatures, phosphorus and Chl-a from 2020 through 2022.







Primary factors influencing plankton growth: temperature and nutrient (phosphorus) were plotted as mean values for each sample site for 2020 – 2022 (Fig. 3A,B,C). Patterns for all variables were consistent for each sample site in that they conformed to the OIZ, TZ and IIZ trophic ranges for all three years reported and were within ranges of previously recorded ranges over a longer time period (Ref 1).

Mean temperatures were coolest in 2020 and warmest in 2021 for all sample sites. One would expect plankton (Chl-a) densities to be higher in 2021 when temperature and phosphorus were elevated. That was not the case. Rather the maximum Chl-a values were recorded for 2020 when both the lake temperature the phosphorus concentrations were lower.

In 2020, at the time of highest recorded LH level, the temp maximum was 16° (C), total phosphorus was around 7.8 µg/L and chlorophyl-a (Chl-a, or plankton concentration) was a maximum of 0.86 µg/L. Maxima for all three variables occurred at sample site 5 which is in the IIZ (Fig. 3A). With coolest temps occurring in 2020, one would expect the Chl-a concentrations to be lowest. Data indicate the opposite. Rather, Chl-a levels were found to be higher in 2020 than in 2021 and in 2022, when lake temperatures were higher (Fig. 3 B,C). Moreover, with phosphorus maxima at two sites in 2021 one would expect the Chl-a concentrations to be high as well. Not so. Maximum Chl-a concentrations were recorded in 2020 with higher LH level, lower temperatures and lower phosphorus.

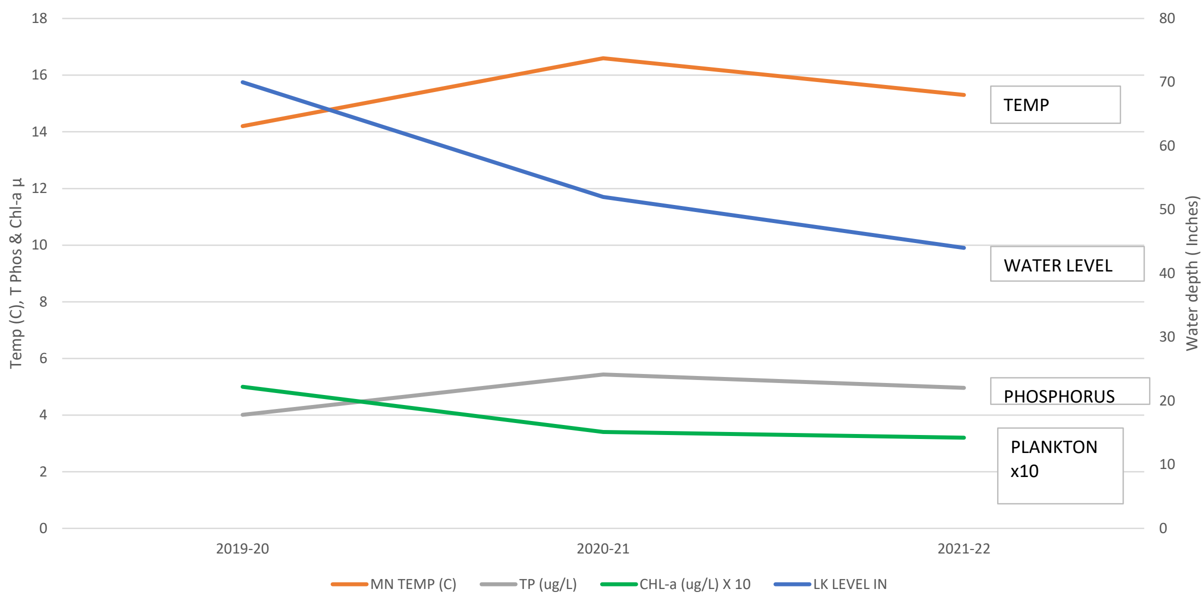
Comparison of annual change in measured variables is shown in Fig. 4, which provides a similar perspective as Fig. 3. During a 2-yr period of LH level decline the mean island-wide temperatures increased as did the total phosphorus concentrations. With both water temperature and nutrient in the form of phosphorus rising, one would expect that the plankton density (Chl-a) would increase as well. Both Fig. 3 and Fig. 4 indicate that was not the case.

Given the actual vs expected concentrations over the three-year period monitored, it appears that something in the relationships of these three variables is incomplete. What effect did the LH level loss of 18” in 2021 and another loss of 8” in 2022 have on the variables measured?

First, a loss of at least 26” of cooler LH water could be expected to result in warmer waters within the LCI channels. This did occur. Also, unless consumed by plankton as reflected by an increase in Chl-a, the phosphorus levels could be expected to be somewhat elevated as the LH level declined and phosphorus concentrations would increase (Fig. 3B).

Surprisingly, plankton (Chl-a) density was lower during two years of lower LH level and warmer LCI channel temperatures (Fig.4). Possible explanations include: (a) incoming water from LH contains micronutrients or nutritional factors not found within LCI and the presence of those micronutrients/factors in the higher water promoted more plankton growth. (b) the LCI plankton species may be better acclimated for cooler waters. If so, could the temperature shift over two years explain the observed difference? (c) Finally, the observed results could be within a normal range for temperatures, phosphorus and plankton density. Additional years of observation may clarify the excursions seen in data for the past three years.

Fig. 4. Impact of decreased L Huron level on Les Cheneaux seasonal water temperatures, Total phosphorus and Chlorophyll-a concentrations. <TSI RAWDAT 2022 / sht2 ce310 / L 300>



CITATIONS

The following citations refer to internal documents and can be found at the LCWC Website in the Library section.

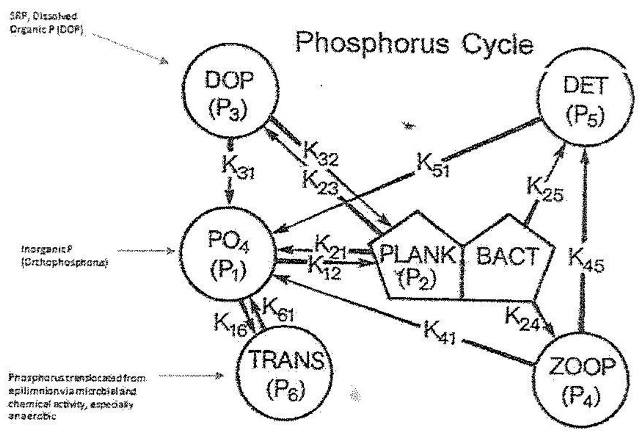
1. Smith, R.A. 2020. Water temperatures declined withing the Les Cheneaux Islands during a period of unprecedented rise in Lake Huron water level.
2. Smith, R.A. 2005. Trophic status of water from selected sites in the Les Cheneaux Islands. 2001-2005.
3. Smith, R.A. 2021. Status of Les Cheneaux water quality.
4. Smith, R.A. 2012. Trophic history of Les Cheneaux waters: 2001-2012.
5. USACE. U.S. Army Corps of Engineers, Detroit.
   <lre.usace.army.mil/missions/great-lakes-information/ great-lakes-information-2/water-level-history.

APPENDIX:

A. Chemistry of the phosphorus cycle.

B. Carlson Trophic Index.

App Plate A. Chemistry of the phosphorus cycle. 2001. NOAA Tech memorandum ERL GLERL-60. A review: Phosphorus-Plankton dynamics and Phosphorus cycling in aquatic systems. SJ Tarapchak. GLERL, Ann Arbor. 1987.



Phos Cycle 2021 from:
NOAA Tech Memorandum ERL GLERL-60
A review: Phosphorus-Plankton dynamics and Phosphorus cycling in aquatic systems.
Stephen J. Tarapchak; GLERL, Ann Arbor. 1987

Figure 1.--A Conceptual diagram of the phosphorus cycle in freshwater lakes (after Rigler, 1973 and Golterman, 1973). Compartments are orthophosphate (P_1), phytoplankton (P_2), dissolved organic phosphorus (P_3), zooplankton (P_4), and detritus (P_5); transport (P_6) out of the epilimnetic zone. Bacteria are considered part of P_2. K's are the rate constants for phosphorus movement among compartments.

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Plate B. Carlson Trophic State Index