Status of Les Cheneaux Water Quality: 2020

R.A.Smith

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Les Cheneaux Watershed Council

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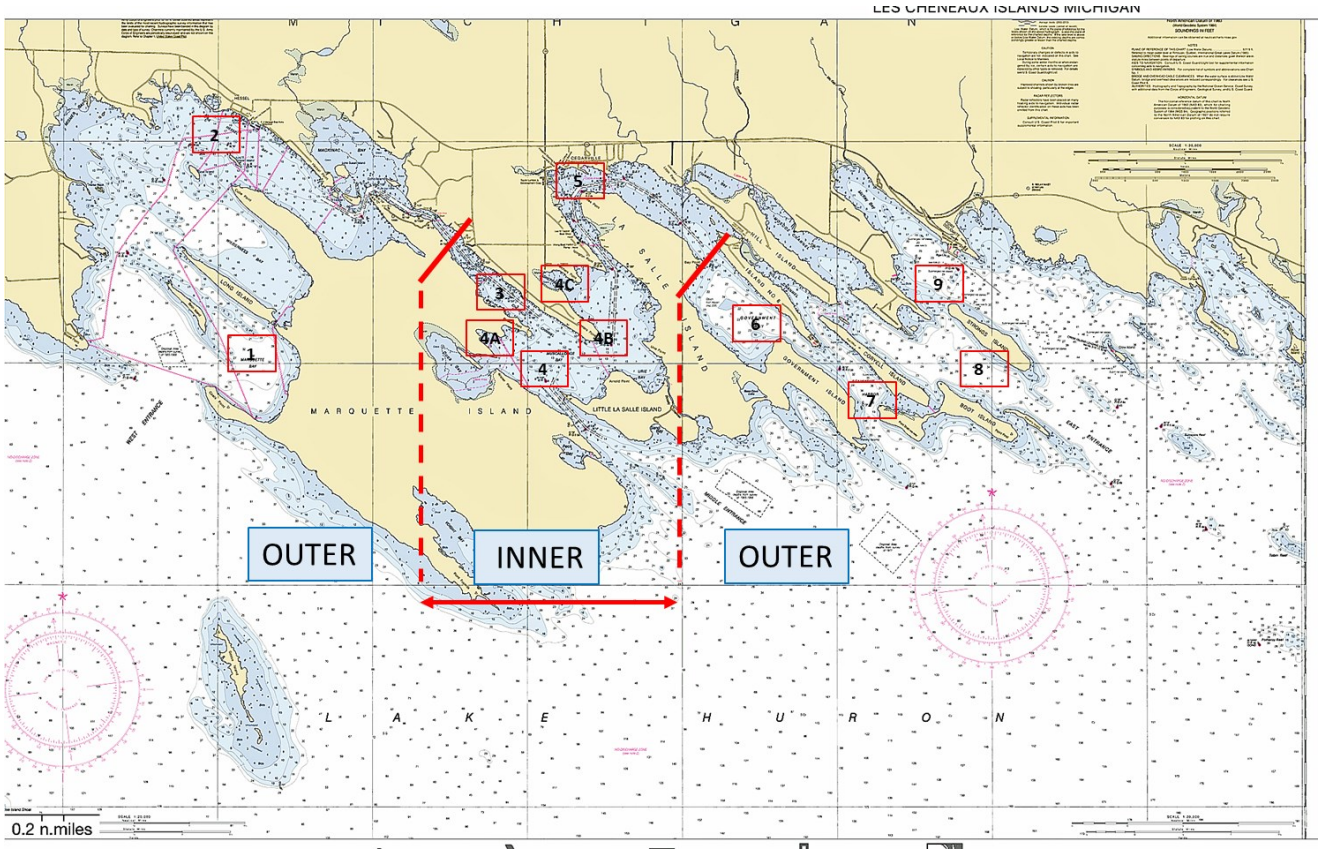
Abstract: The low phosphorus and low planktonic algae levels recorded during seasonal Les Cheneaux water monitoring were similar in productivity range, or trophic rating, to the open waters of Lakes Huron and Superior which are considered pristine waters with low nutrients and lower algal biomass. Levels of Total Phosphorus, Soluble Reactive Phosphorus and Chlorophyll-a were recovered in expected proportions relative to one another for waters of this nature at each of twelve stations monitored. Those proportions were also consistent for the Outer Island Zone of lower algal productivity and for the Inner Island Zone of higher algal productivity. Although the levels of phosphorus and plankton varied among the twelve sites, peak growth periods for most sites were during Jun and Aug. Given the varied concentrations of phosphorus and plankton among the sites, the net seasonal change was essentially balanced, resulting in a net neutral change for the 2020 season. Barring major environmental changes, the Les Cheneaux waters can be expected to remain desirable in quality of the fishery and for recreational activities for coming years.

Introduction: Seasonal water quality studies have been conducted throughout the Les Cheneaux Islands by the Watershed Council (LCWC) under the sponsorship of the Islands Association (LCIA) over the past 20 years. General trophic, or nutrient, patterns have been observed during that time. Observed 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 concentration and conditions such as temperature and sunlight penetration to support growth are minimal, and an Inner Island Zone (IIZ) in which higher nutrient levels and conditions are available to support more dense growth (Fig. 1). Study sites between the OIZ and the IIZ are considered Transition Zones (TZ) with intermediate levels of growth-supporting nutrients.

Fig. 1. Nutrient and productivity zones of the Les Cheneaux Islands.

The Inner Island Zone (higher nutrient and higher plant/animal productivity) is shown between the vertical/angled red lines and the Outer Island Zones (lower nutrients and less productive) is shown East and West of the Inner Island Zone. Boxed numbers signify sample sites.



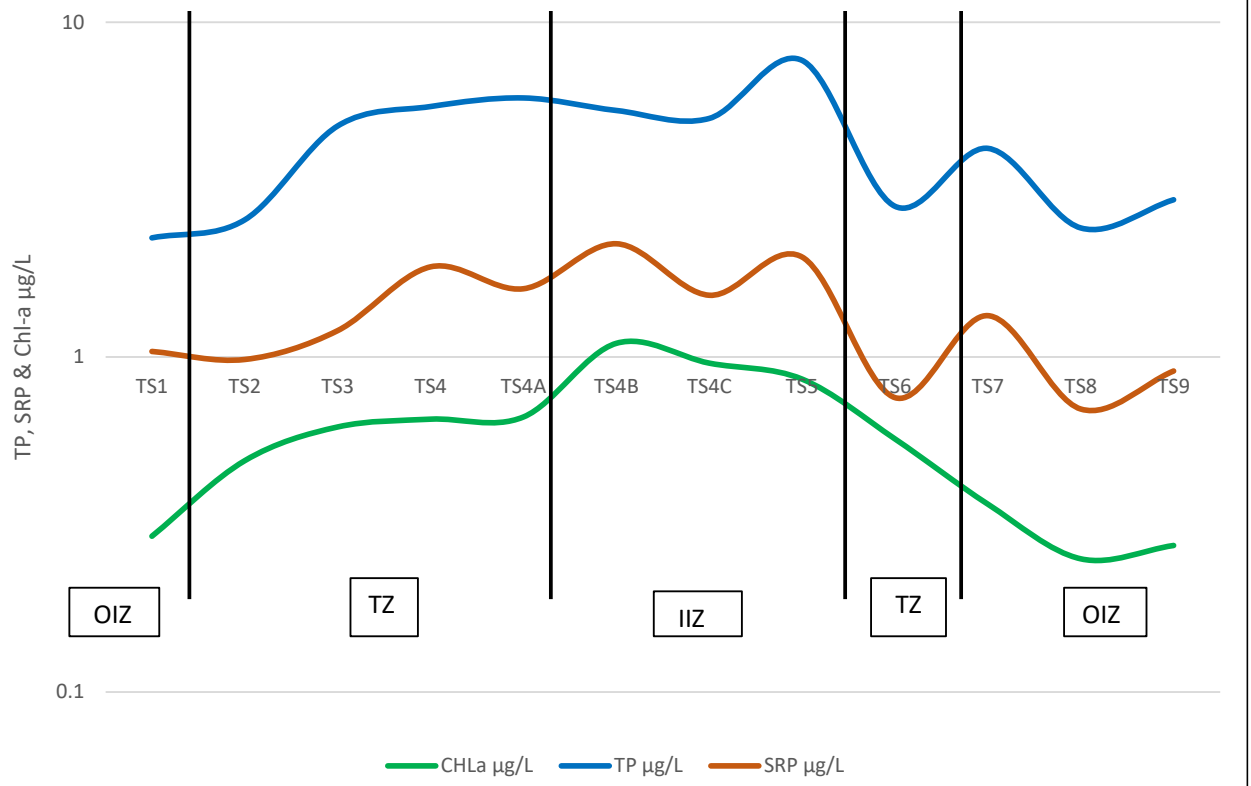
Results and Discussion:

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) 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).

Chlorophyll-a (Chl-a) is reported as an indicator of plankton concentration. It is an indirect estimation of plankton density in that the photosynthetic pigment, Chlorophyll-a, is extracted from a plankton sample and then analyzed using photometric methods. In a balanced, healthy aquatic system the Chl-a levels are lower than the TP and SRP.

Fig. 2 curves reflect a healthy aquatic ecosystem across the Les Cheneaux sample station spectrum in that the TP, SRP and Chl-a, relative to one another, are at expected levels for each station. That is: concentrations of TP were higher than SRP which, in turn, were higher than levels of Chl-a. Also, these variables were uniformly recovered in higher concentrations in the previously described IIZ than in the OIZ (Fig. 3). Intermediate concentrations of each variable were recorded in the TZ areas (Fig. 2). Note that Chl-a is plotted on the right, vertical axis to better display changes among sample sites.

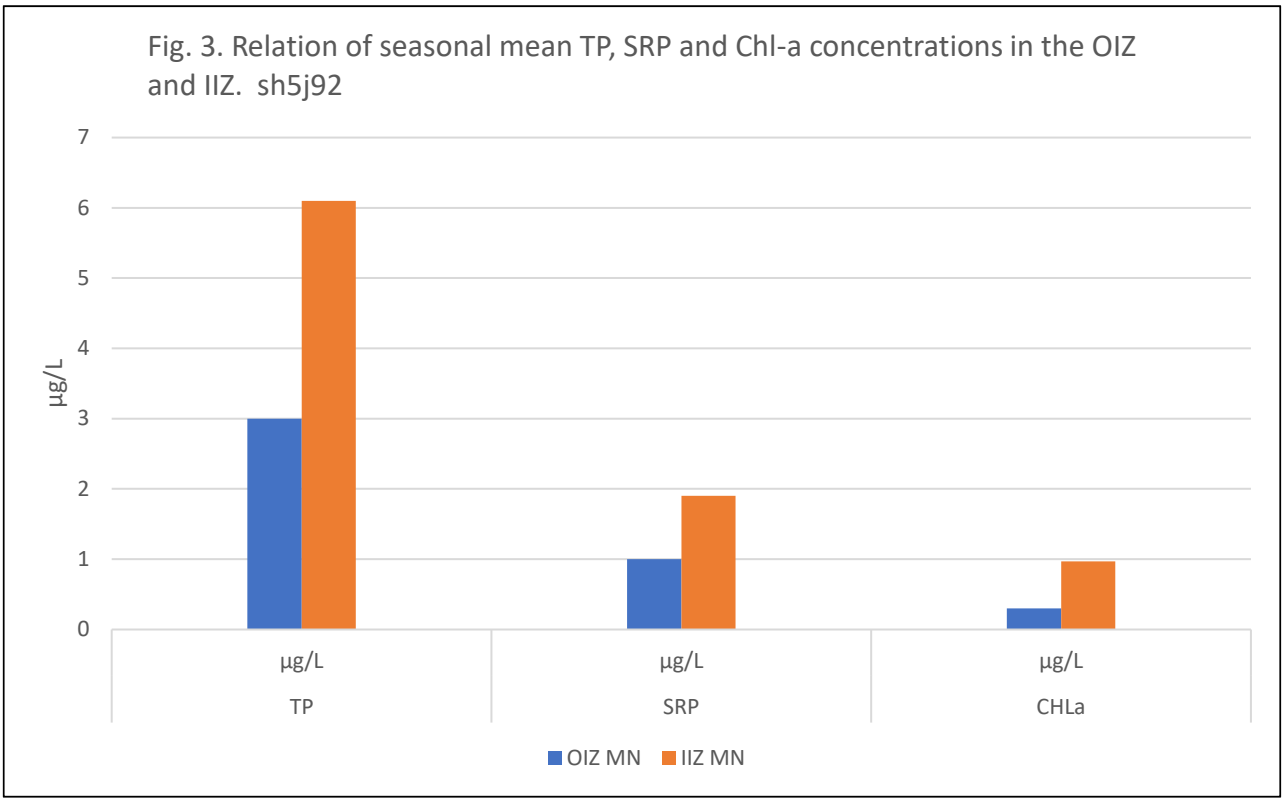
Fig. 2. Island-Wide mean values for Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP) and Chlorophyll-a (Chl-a): May through Sep 2020.
OIZ: Outer Island Zone; IIZ: Inner Island Zone; TZ: Transition Zone <tsidat2020 sht5 ck55>



Note: Alpha-numeric codes at the end of figure titles indicates the raw data source from which the graphs were developed.

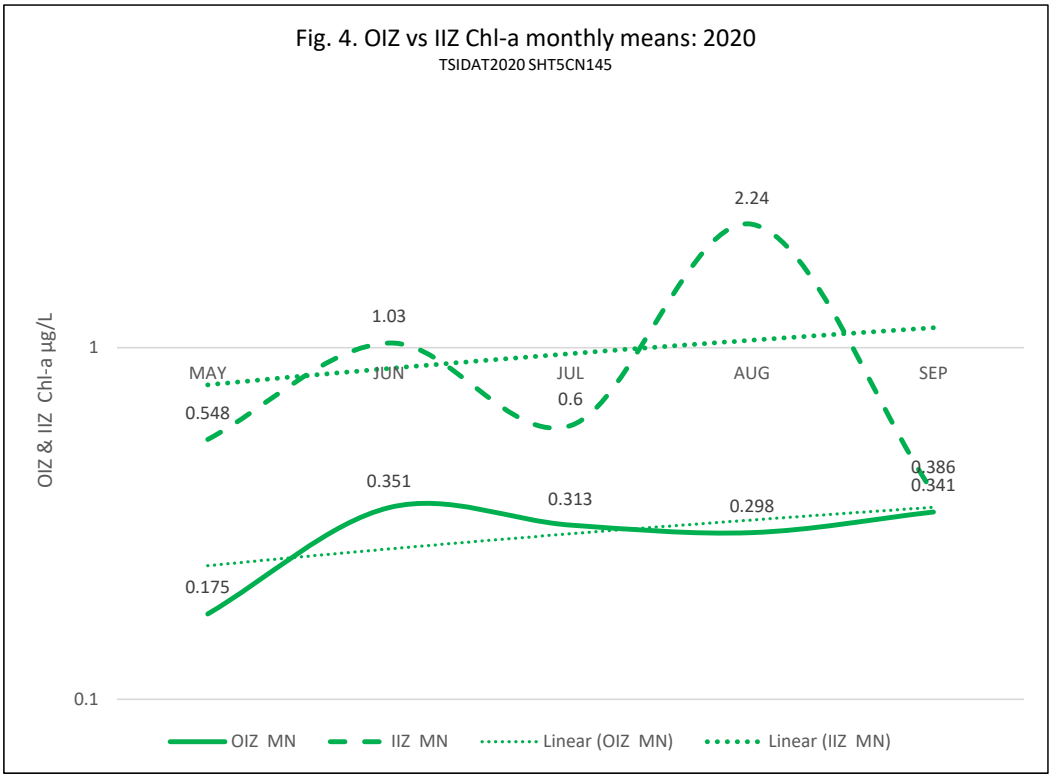
The mean concentration of all three variables was greater in the IIZ than OIZ levels which, from the historical perspective, was expected (Fig. 3). TP and SRP concentrations of the IIZ were 2X greater than OIZ values and the IIZ Chl-a level was 3X greater than the OIZ concentration. Fig.3 reinforces the expectation that higher nutrients promote more robust algae growth conditions in the IIZ than in the OIZ.

When quantifying the phosphorus/Chl-a relationship, a question arises about whether Chl-a/TP ratios or Chl-a/SRP ratios are more representative of seasonal variations in the phosphorus availability vs algae demand scenario. SRP is derived from TP and is, therefore, proportional to TP. The variation of Chl-a/SRP is less than the variation of Chl-a/TP (App C). However, plotting both ratios for the remainder of this paper clutters the figures and adds nothing to conclusions. Since the Chl-a/TP ratios are closely reflective of the Chl-a/SRP ratios, for simplicity sake, only the Chl-a/TP ratios will be presented in remaining figures for this paper.

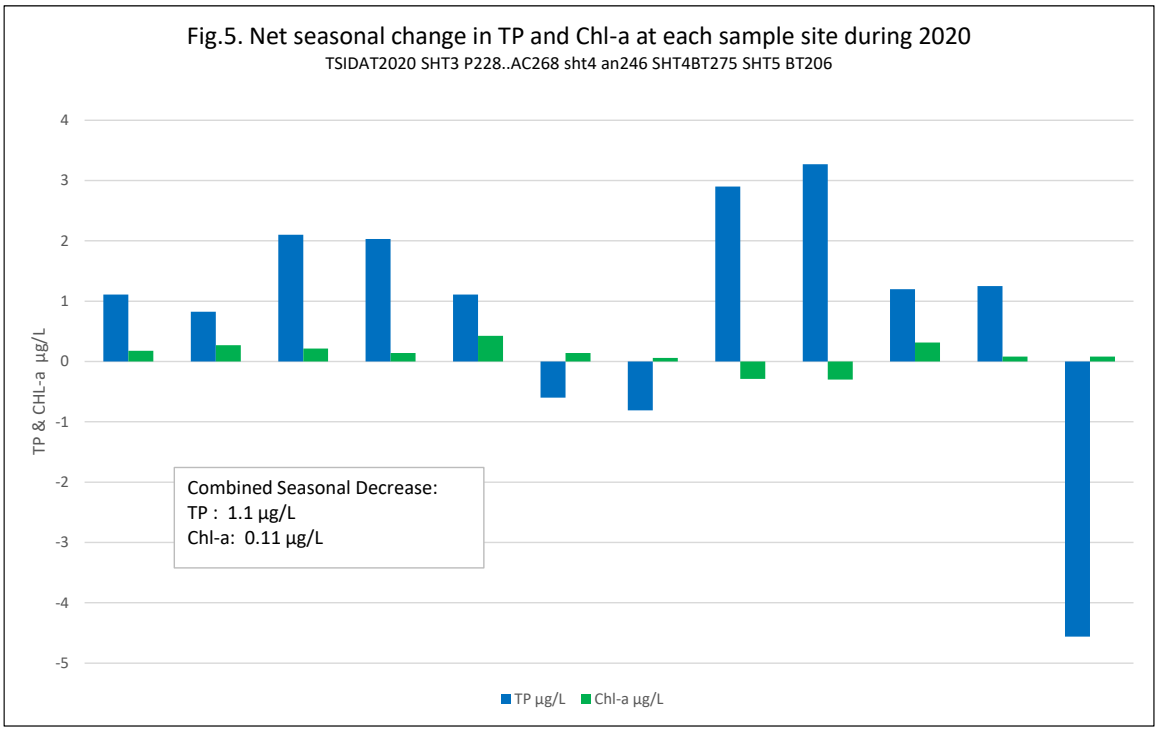


The OIZ Chl-a level increased during May, peaked in Jun, then maintained a concentration of about 0.34 µg/L for the remainder of the season (Fig. 4). Chl-a increased during May in the IIZ as it did in the OIZ, showed a small growth spurt in Jun and a major bloom to 2.2 µg/L in Aug. The IIZ bimodal curve indicates pulsed growth in the presence of higher nutrients and better plankton growth conditions than in the OIZ. Maximum Chl-a concentration in the IIZ was 7X greater than in the OIZ. Trendlines in Fig. 4 indicate the Chl-a level increased in both the OIZ and in the IIZ during 2020. Chl-a concentration was plotted on both the left and right axes. It was plotted on the right axis to better observe the seasonal variation, and it was plotted on the left axis to visually indicate how more robust the IIZ Chl-a levels were than the OIZ levels. The lower dotted curve in Fig. 4 shows Chl-a concentrations in the OIZ on the same scale as the IIZ plot.

Whereas the primary variables of TP and Chl-a increased, the amounts were not significant relative to the overall concentration of phosphorus as a nutrient nor of Chl-a as an indicator or plankton density. As seen in the Carlson Index (App A), both TP and Chl-a concentrations recorded in 2020 are in the oligotrophic range, indicative of low nutrient and low plant productivity waters.



The island-wide change in TP and Chl-a during the 2020 season is shown in Fig. 5. The value shown for each variable is the amount of change during the season. That is, the net seasonal TP change for all sample sites is shown by a downward trendline to be 1.1 µg/L. The trendline slightly downward net change for Chl-a was 0.11 µg/L. Although decreases were recorded, the minimal decrease is not a concern. These shifts could be considered neutral over the course of the 2020 sampling season. Even with the decreases observed, our waters are still ranked as oligotrophic, a highly desirable low nutrient and low growth for algae and rooted plants.



Summary: The low nutrient (phosphorus), low planktonic algae (Chl-a) levels recorded for seasonal Les Cheneaux samples in 2020 are similar in a productivity range, or trophic rating, to the open waters of Lakes Huron and Superior, which are known for their pristine (oligotrophic: low nutrient, low biomass) waters. By comparison, Lake Erie concentrations of phosphorus and Chl-a are higher by at least tenfold which results in the production of significantly greater biomass and a eutrophic water quality rating (Fig. 6.). Barring major environmental changes, the Les Cheneaux waters, can be expected to remain in a highly desirable range for recreational activities for years to come.

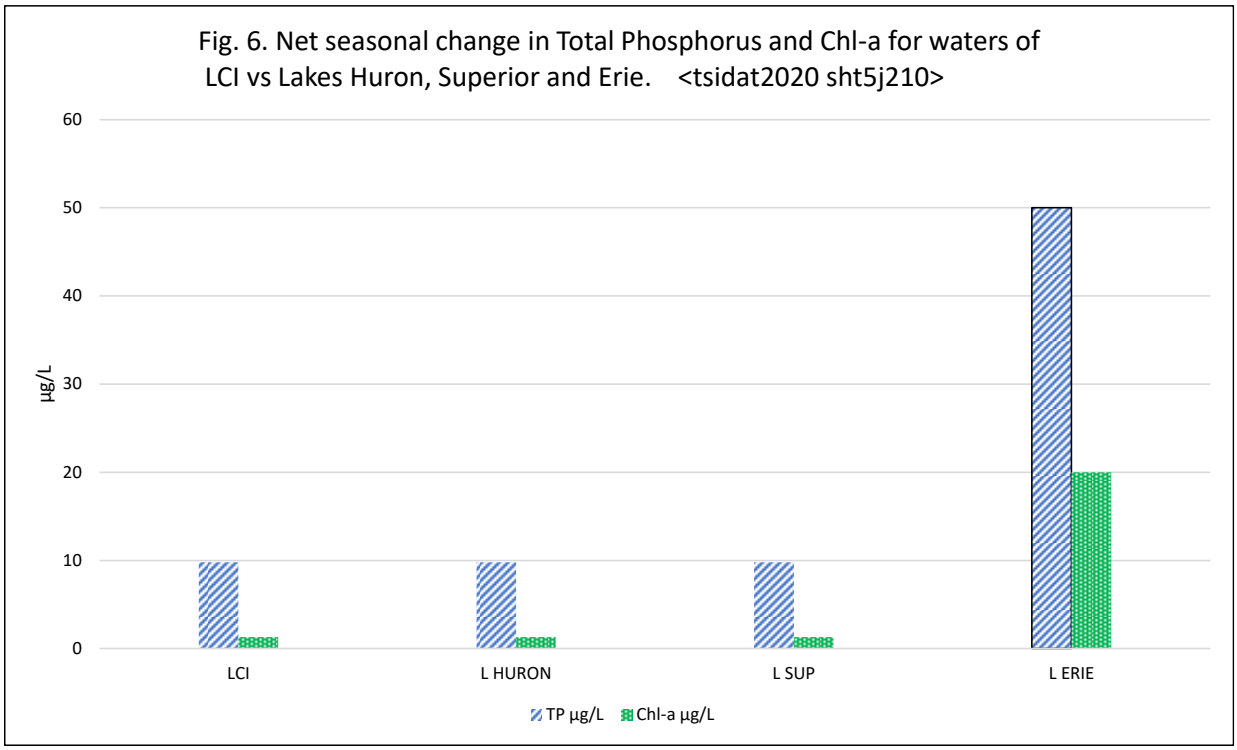


Fig. 6. Net seasonal change in Total Phosphorus and Chl-a for waters of LCI vs Lakes Huron, Superior and Erie. <tsidat2020 sht5j210>

APPENDIX

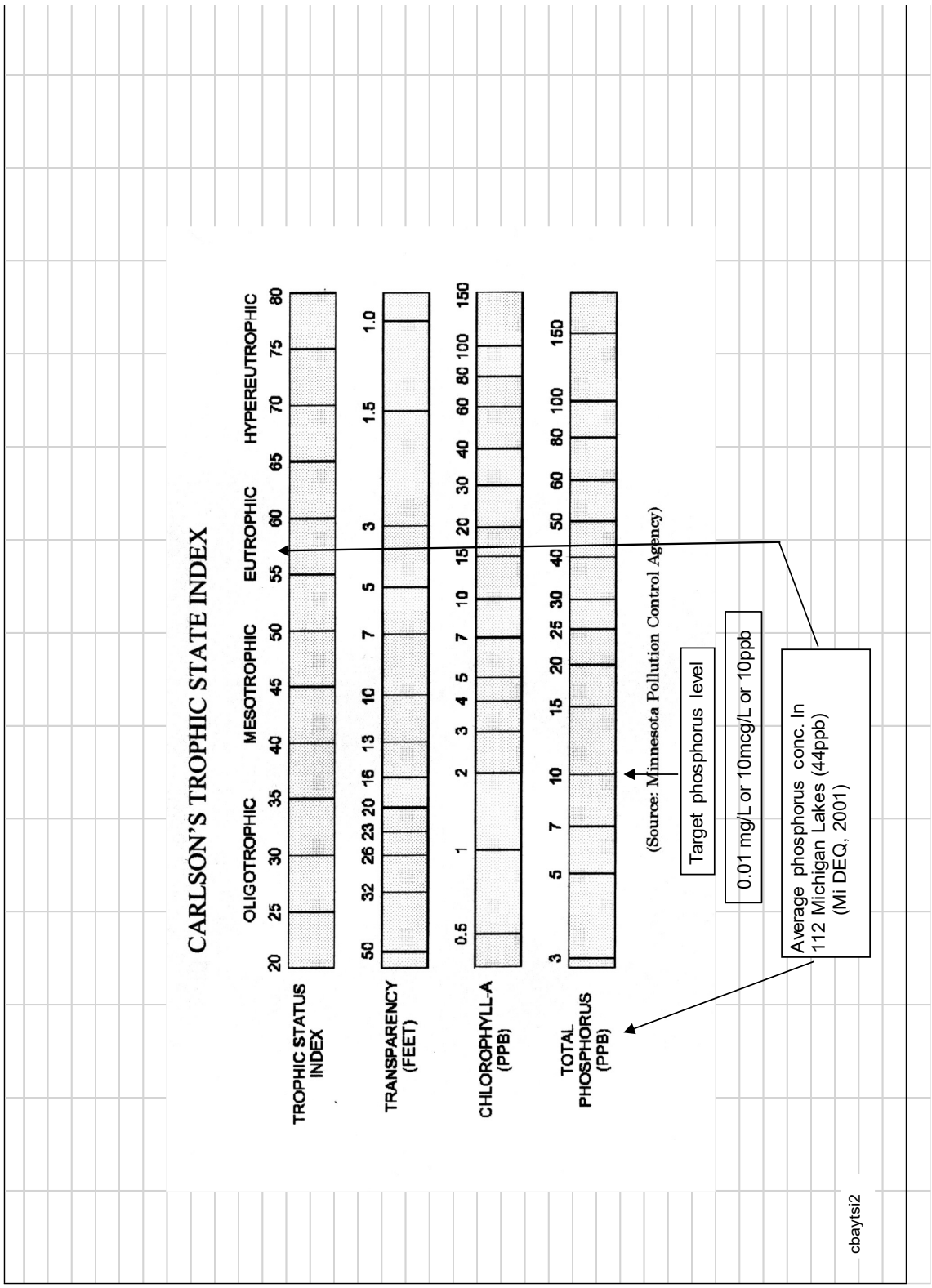
A. Carlson Trophic State Index.

B. Fate of phosphorus in Cedarville Bay.

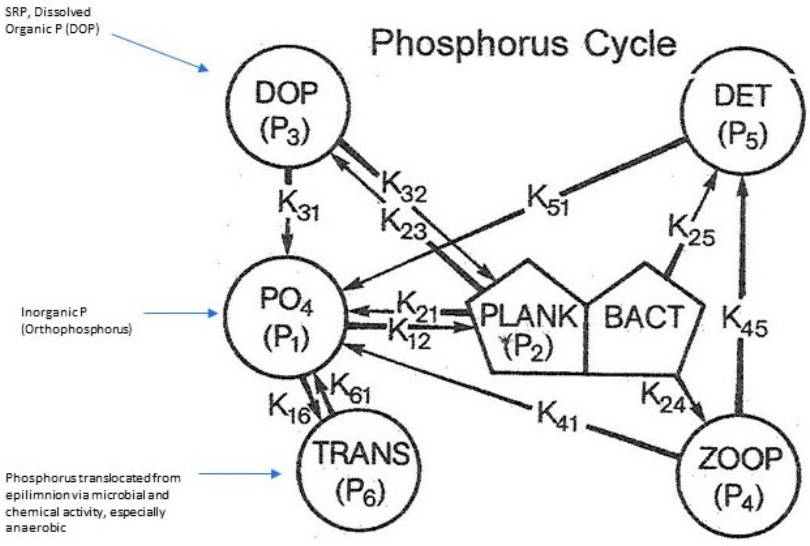
C. Aquatic phosphorus cycle.

D. Comparison of total phosphorus, soluble reactive phosphorus and chlrophyll-a

App Plate A


CARLSON'S TROPHIC STATE INDEX
OLIGOTROPHIC
MESOTROPHIC
EUTROPHIC
HYPEREUTROPHIC
TROPHIC STATUS INDEX
TRANSPARENCY (FEET)
CHLOROPHYLL-A (PPB)
TOTAL PHOSPHORUS (PPB)
(Source: Minnesota Pollution Control Agency)
Target phosphorus level
0.01 mg/L or 10mcg/L or 10ppb
Average phosphorus conc. In 112 Michigan Lakes (44ppb) (Mi DEQ, 2001)
cbaytsi2

App Plate B. 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.



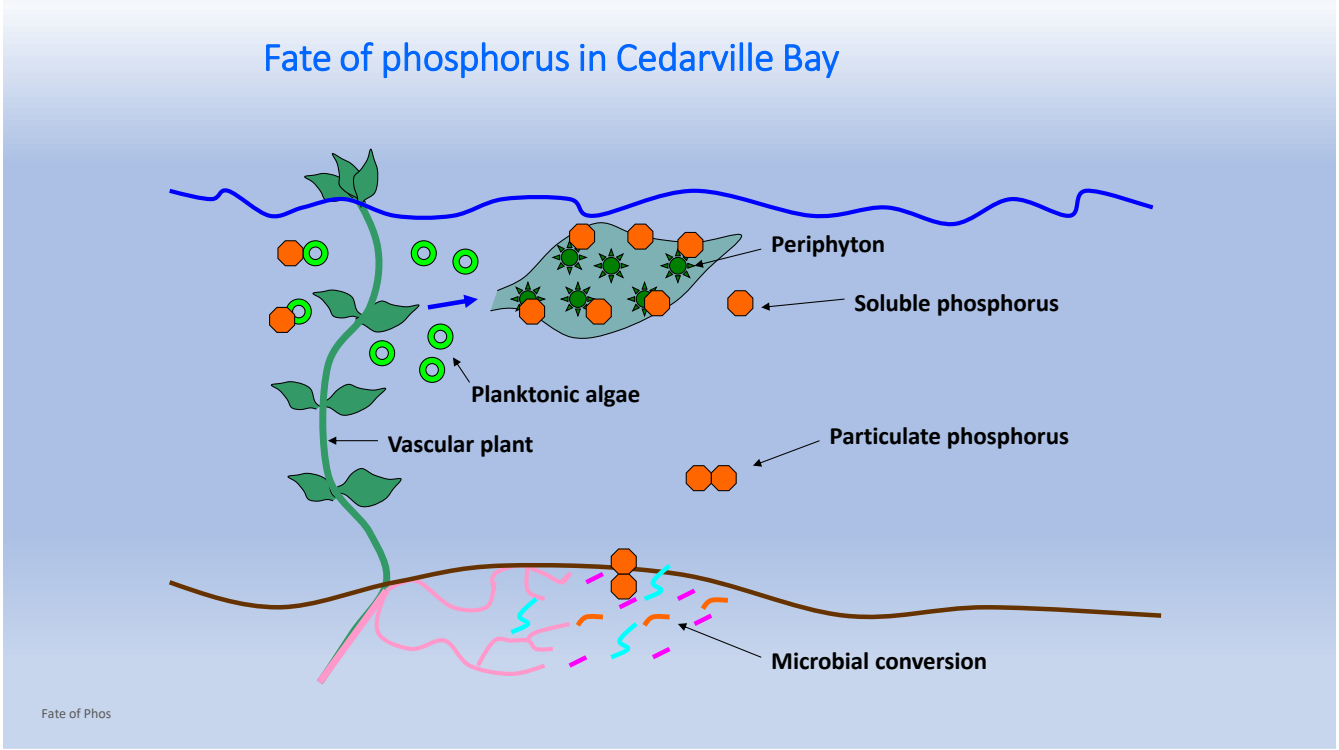
Phos Cycle 2021 from:
NOAA Tech Memorandum ERL GLERL-60
A review: Phosphorus-Plankton dynamics and Phosphorus cycling in aquatic systems.
Stephen J. Tarapchak; GLERL, Ann Arbor. 1987

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.

App Plate: C

The sketch below shows how bioavailable Soluble Phosphorus is readily metabolized by planktonic algae, by algae attached to plant surfaces (periphyton) or by rooted plants themselves. Particulate phosphorus must undergo a microbial or chemical conversion before it becomes a usable, or bioavailable form.

From: LCI Nutrient Dynamics 180218.



Appendix XXXX

Raw Data from 2020 water collections: Excel file: TSI DAT 2020 SHEETS 1 AND 2.

App Plate D. Comparison of TP & SRP ratios with Chl-a

Fig. 1. MEAN CHL-a /TP and CHL-a/SRP RATIOS of 2020 TSI data. <tsidat2020 sht3 cg115 sht4 bf100> sht5 j230

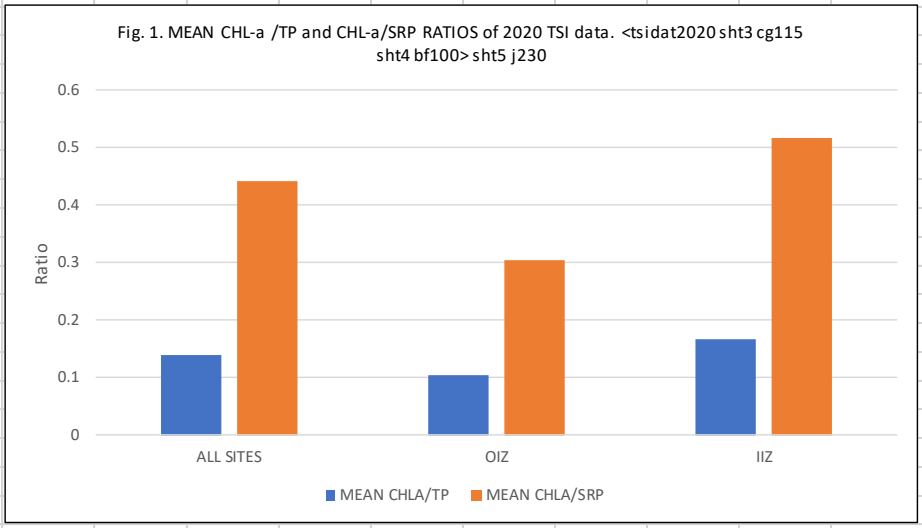
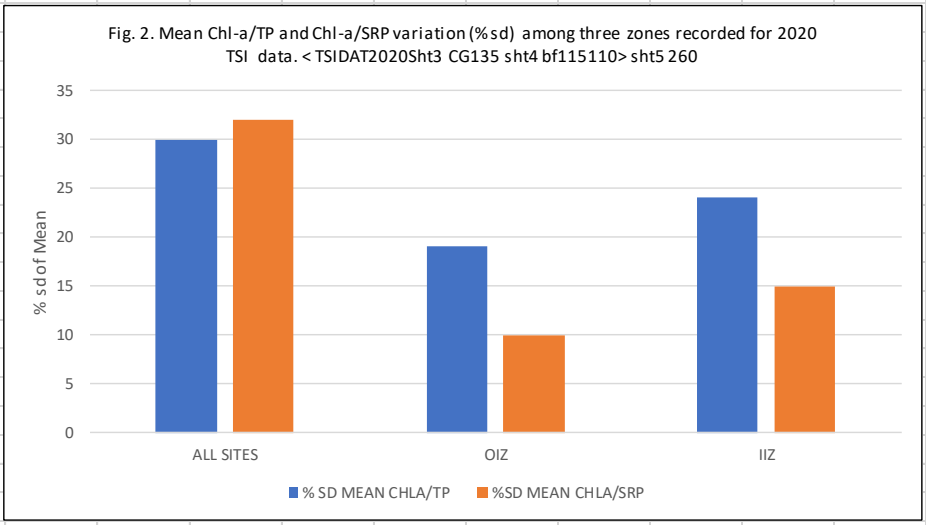


Fig. 2. Mean Chl-a/TP and Chl-a/SRP variation (% sd) among three zones recorded for 2020 TSI data. < TSIDAT2020Sht3 CG135 sht4 bf115110> sht5 260



A question arises about whether Chl-a/TP ratios or Chl-a/SRP ratios are more representative of seasonal variations in the phosphorus availability vs algae demand picture.

From these charts:

1) the Chl-a/TP ratios were uniformly less than the Chl-a/SRP ratios as shown in F1
2) The % sd among all sites was about equal. However when the noise from transition zone sites is removed then it is clear that the Chl-a/SRP relationship is closer than the Chl-a/TP in that:

--OIZ sites had 10% variance in the sd and the IIZ had15 % sd

-- If these 2020 data accurately reflect the Chl-a & TP vs SRP relationship, then it is the Chl-a/SRP relationship that should be more strongly studied.

SRP is derived from TP and, therefore proportional to TP. Since the Chl-a/TP ratios are closely reflective of the Chl-a/SRP ratios, for simplicity sake only the Chl-a/TP ratios will be presented in later figures for this paper.