Decreased algae density in Les Cheneaux Island waters is attributed to cooler water temperatures resulting from seven years of continuous rise in Lake Huron water level of over five feet.

R.A. Smith

April 2020

OVERVIEW:

From 2013 through 2019 water levels in the Les Cheneaux Islands have risen 63 inches (160 cm). During the same period, average water temperatures dropped 3.5^{o} to 4.5 ^{o} Centigrade (8^{o} Fahrenheit).

It was expected that these shifts in conditions would result in a related downward shift in phosphorus concentrations that are monitored each summer as part of our water quality program. This was not the case, however. Phosphorus values appeared to change little.

Neither did it make sense that, while phosphorus concentrations remained level, the algae population densities decreased. Phosphorus is a primary food source for algae and if the phosphorus levels remained level, then algae concentrations would have been expected to remain within a constant range as well. Algae populations measured were phytoplankton, the free-living plankton that are found dispersed in the water column.

The following paper examines this apparent disconnect between the expected and the actual.

ACKNOWLEDGMENTS:

Sincere appreciation is expressed to several people involved during this lengthy study, they include:

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- Sample collection: Scott Myers, Lynn Wolters, Neil Williams, Mark Clymer, Mike & Laurel Jellison, Fred and Joyce Moore, Barb Smith, Mary Baker, Dave Dunn.

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ABSTRACT:

Monitoring seasonal fluctuation of primary aquatic nutrients in waters of the Les Cheneaux Islands (LCI) during a seven-year period indicated flat slopes for Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP) whereas the Chlorophyll-a (Chl-a) slope was slightly downward. Lake Huron (LH) water level increased 63 inches (160 cm) from 2013 through 2019. Closer data examination revealed that, while TP and SRP actually increased slightly in years following the record low LH level in 2013, the Chl-a concentrations decreased. Increased TP and SRP concentrations during a time that nutrient-poor water flowed from LH into the LCI channels can be explained by organics being suspended in the channels from the over 200 miles of LCI shoreline. Chl-a concentrations were likely depressed due to a mean water temperature decrease of 3.5^{o} to 4.5^{o} C during the study. Another possibility is that micronutrients required for phytoplankton metabolism were diluted as a result of LH rise and was reflected as a decrease in Chl-a concentrations. Micronutrient levels in LCI waters will be examined in our 2020 aquatic nutrient studies.

BACKGROUND NOTES:

- Trophic ratings indicate the relative nutrition available in a water body for use by rooted plants, algae and phytoplankton (free-floating algae). Major categories of nutritive levels, from low nutrition to high nutrition are: oligotrophic, mesotrophic and eutrophic.

  L Superior is an example of an oligotrophic lake and Lake Erie is an example of a eutrophic lake. Since the 1970s L Huron has become more oligotrophic.

- Use of ratios for Chl-a/SRP and Chl-a/TP.

  These ratios are used as a matter of convenience to use a single value instead of two numbers to express the relative concentration of the variables.

  (e.g.) a low ratio indicates a wide difference between Chl-a and SRP or TP.

  A ratio of 0.1 indicates 1 part Chl-a for 10 parts SRP or TP.

- Number of measurements used to generate a single data point in figures developed for this report. Values used to derive each data point for each season were comprised of sample results from each of 12 sites which were sampled 5 times each season: May - Sep. Therefore 60 values were used to assign each seasonal value .

INTRODUCTION:

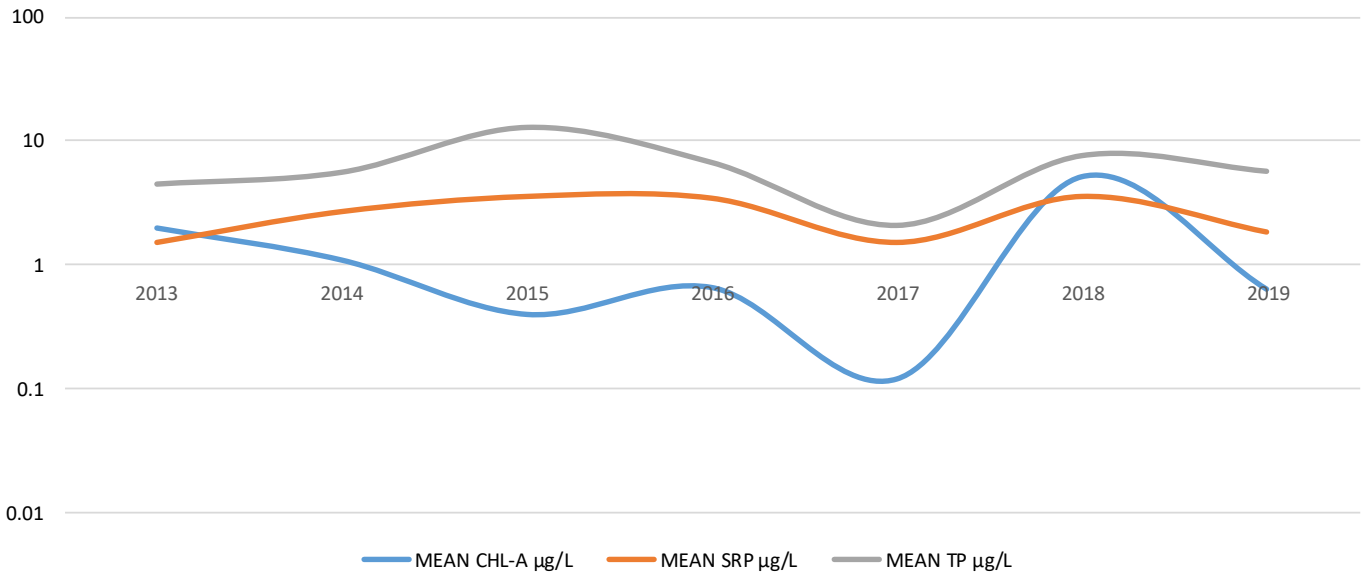
Nutrient balance is important for a healthy wetland ecosystem. Phosphorus is a limiting nutrient in the LCI waters as it is within the Great Lakes Basin. Excess phosphorus in the presence of nitrates can fuel an explosion of phytoplankton (free-floating algae). Inadequate phosphorus results in limited phytoplankton growth. Lakes Erie and Superior, respectively, are examples of excess and limited phosphorus. For purposes of this study, phosphorus will be discussed in two forms: Total phosphorus (TP) and Soluble Reactive Phosphorus (SRP). TP represents a non-metabolizable phosphorus form, Particulate Phosphorus (PP) plus the SRP form. PP must undergo a chemical or biological conversion before it can be metabolized by plants or phytoplankton. Values expressed as SRP indicate phosphorus in a form that is readily utilized by rooted plants or phytoplankton.

Therefore, when over five feet of nutrient-poor LH water flowed into the LCI channels, one would expect both the nutrient to decrease and phytoplankton levels to decrease (1,2). As noted in the abstract, that was not the case.

RESULTS:

Trendlines of mean seasonal values for TP, SRP and Chl-a from 2013 through 2019 had almost no slope whereas the Chl-a trend was slightly downward (Fig.1). Mean SRP was lower than Chl-a in 2013 and, possibly in 2018, suggesting strong phyto-plankton demand for SRP. Without additional information, this range in values represents fluctuations during a seven-year period, to include the upward excursion of Chl-a in 2018.

Fig. 1. Island-wide shifts in TP, SRP & Chl-a. Mean values are shown for each sample station throughout the season. Each plotted value represents 60 data points. TSIDAT 2019 UMBS RAW 091219 (VERSION1) SHT6 AA70 C90 .



Although the correlation between Chl-a/SRP and Chl-a/TP ratios is highly favorable (r = 0.8)for this period, the respective trend lines are opposite (Fig. 2). The Chl-a/TP trend is downward vs the Chl-a/SRP trend is upward. Chl-a/SRP ratios had a better correlation of r=0.727 than the Chl-a/TP ratios of r = 0.568, thereby making the Chl-a/SRP relationship the better indicator of phytoplankton density (Fig. 3). Barbiero *et al* (3) found that an average of spring and summer Chl-a/TP ratios for the open waters of L Huron was 0.6. The close agreement between our Chl-a/TP findings and Barbiero *et al* for L Huron reinforces our data that suggest the Chl-a/SRP relationship is a better indicator of phytoplankton/nutrient trends.

Fig. 2. Chl-a/TP and Chl-a/SRP ratios plotted from seasonal means of 12 sample stations from 2013 through 2019. SHT6 AA173 **C90**

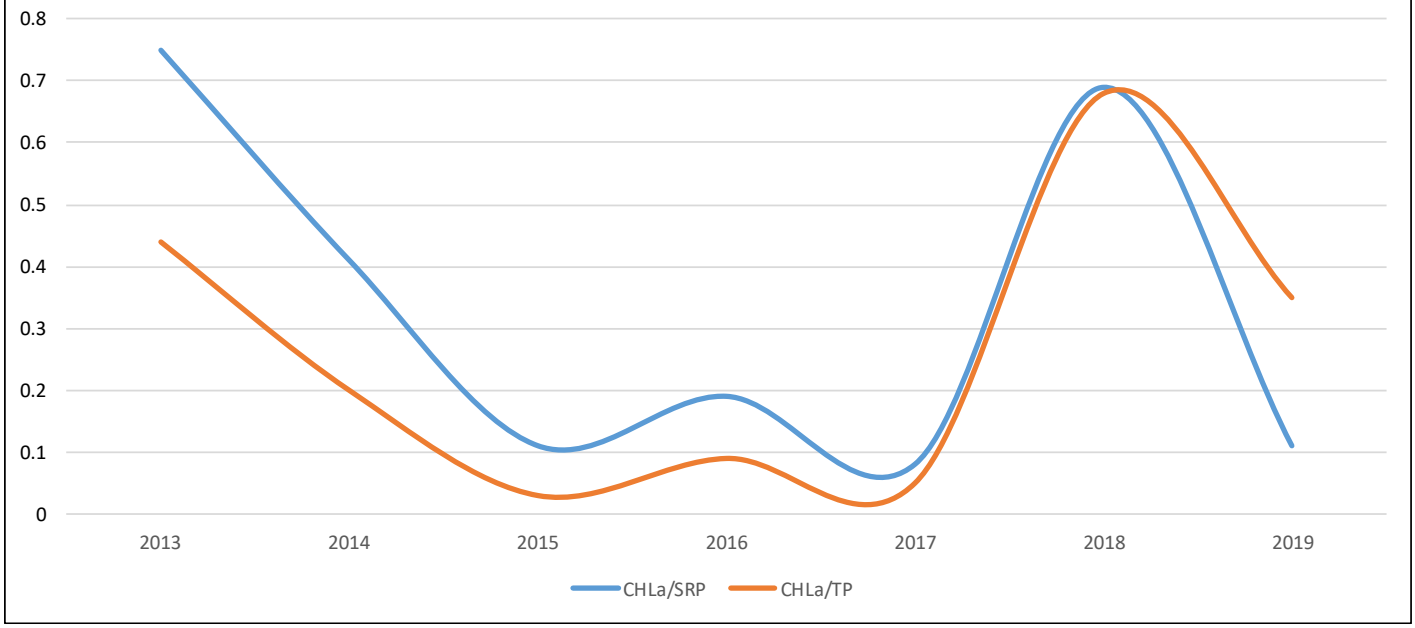
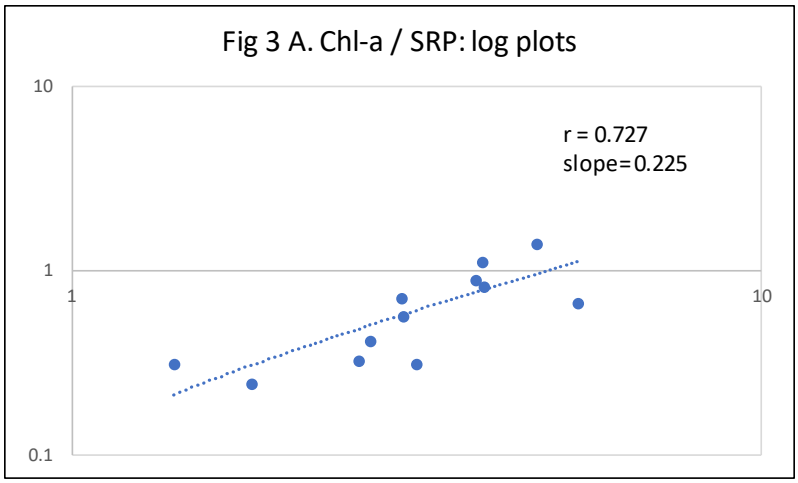
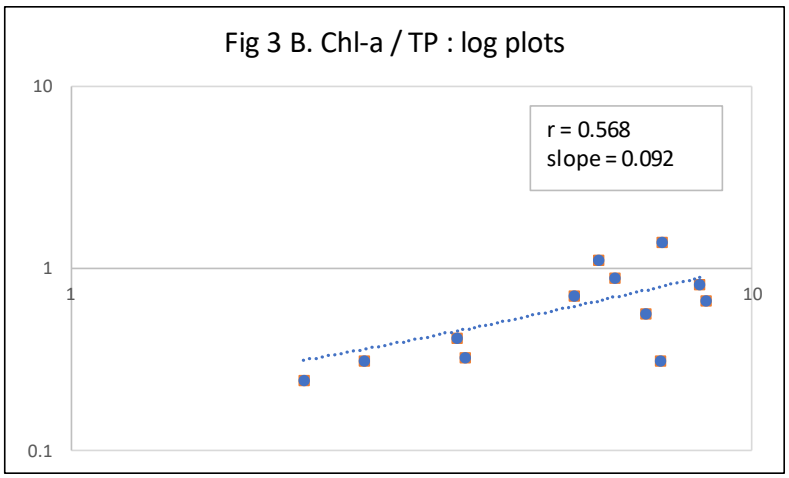
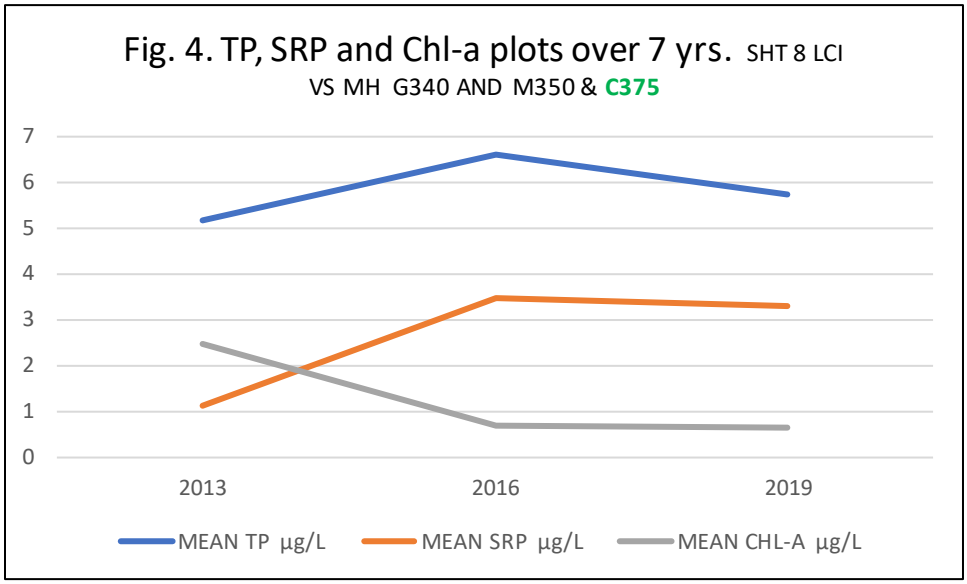


Fig. 3 A & 3 B. Correlation of Chl-a/SRP and Chl-a/TP ratios for 2019 data.
AVG CORRECTED VALUES SHT 3 M440 2019 SHT6 G12 sht7 ac25 **G 140**

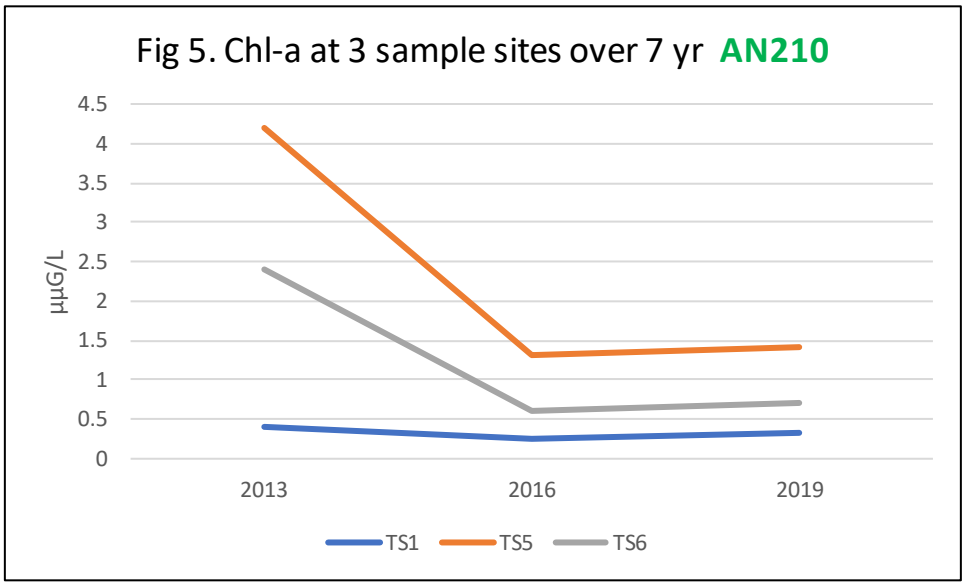




A simpler image appears if data for these variables are compared at three-year intervals during the study period (Fig.4). Mean seasonal values reflect expected relationships among TP,SRP and Chl-a, in that TP values were greater than SRP, and SRP values were greater than Chl-a, with the exception of 2013. The low SRP level in 2013 was very likely less than Chl-a due to a strong demand for SRP by a dense phytoplankton population. Both TP and SRP were elevated in 2016 & 2019. The elevated SRP was consistent with recording of lower Chl-a during those same seasons.



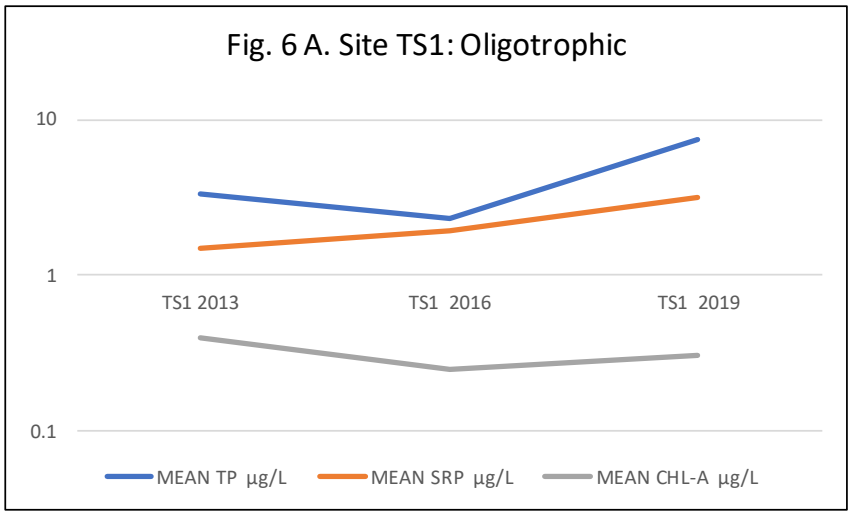
To consider if one or two sites with extreme values might have skewed results, one site representing each of three trophic ranges: oligotrophic (TS1), mesotrophic (TS6) and eutrophic (TS5) was selected. TS designations represent sample sites as depicted in Fig 7. Chl-a, SRT & TP values for these sample sites were compared at 3-yr intervals for these sample sites (Fig. 5).

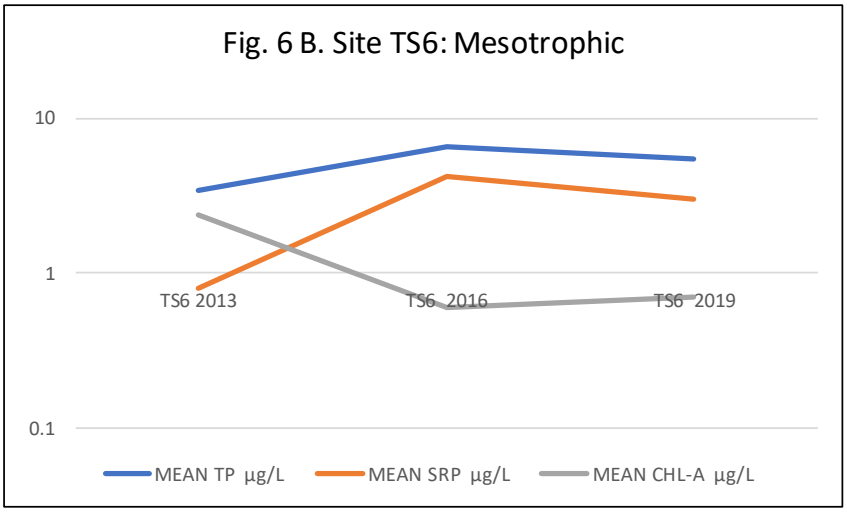


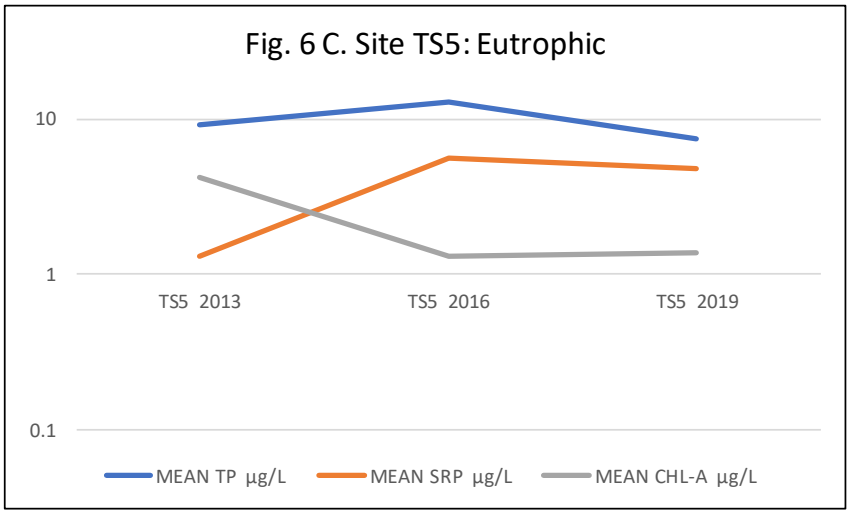
As anticipated, Chl-a concentration was low and remained low during the seven-year study at the oligotrophic site (TS1). In contrast, Chl-a levels at the mesotrophic and eutrophic sites, TS6 and TS5 respectively, decreased 3x-4x between 2013 and 2016 then remained at those concentrations through 2019. Given the precipitous L Huron rise of 160 cm (63 in) between 2013 and 2019 it is possible that TP and SRP concentrations were diluted and, therefore, contributed to the observed decrease in phytoplankton density.

SRP was exhausted at sites TS5 and TS6 in 2013 but, with apparent lower demand from plankton, appeared as a higher concentration in 2016 and 2019 (Fig.6A,B,C). Low plankton demand for SRP at TS1 apparently did not deplete the SRP in 2013 as shown in the same figure. All sites decreased in Chl-a from 2013 to 2016, but a greater Chl-a decline was observed at the mesotrophic site (TS6) and at the eutrophic site (TS5) than at the oligotrophic site (TS1). Chl-a remained essentially unchanged between 2016 and 2019 at all three sites.

Figs 6A,6B,6C: Relation of TP, SRP and Chl-a at sites with varied trophic ratings. M350 **W215**



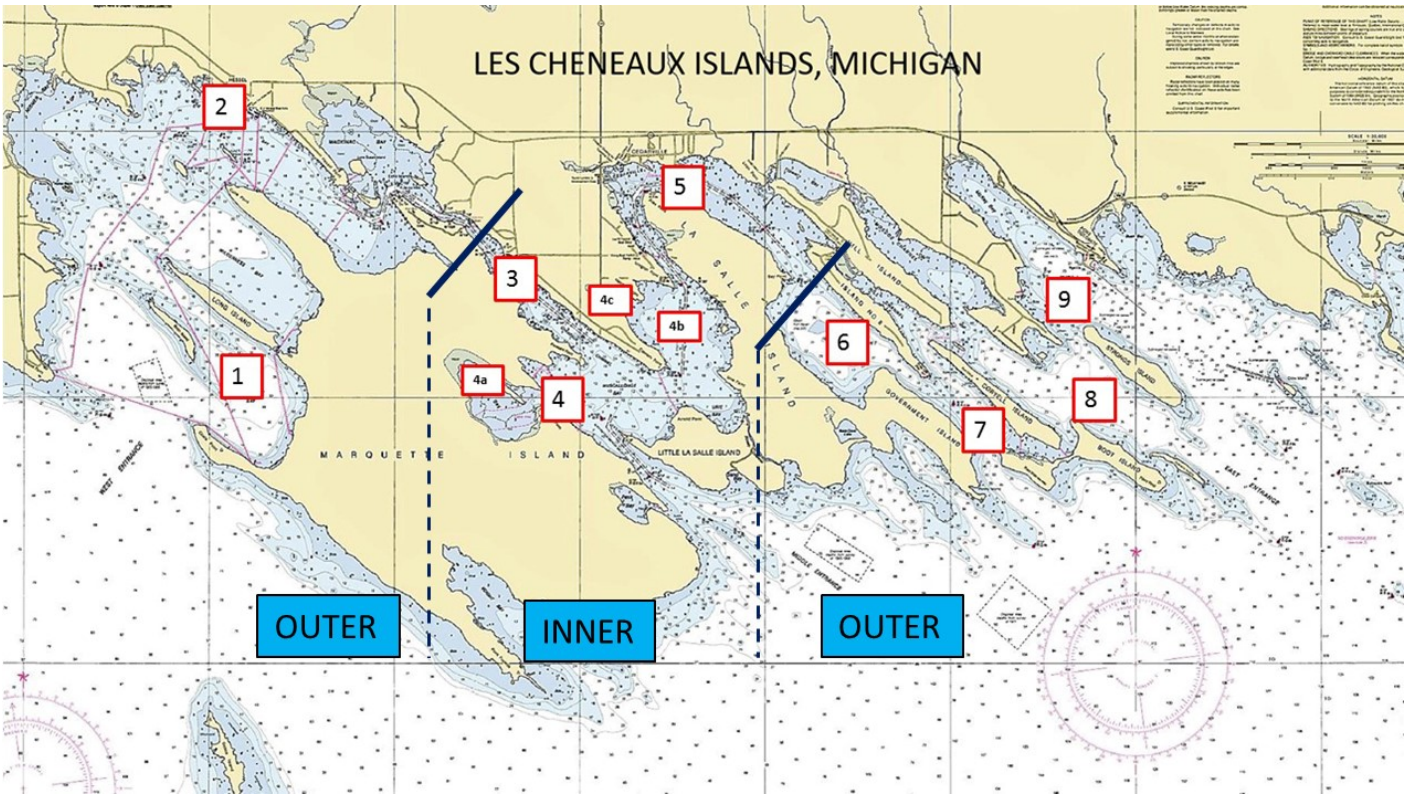




Viewed from a wider scope, one can get a feel for nutrient demand by viewing Chl-a, SRP and TP availability throughout the islands. We can look farther into comparisons of varied trophic zones by looking at the overall trophic map of LCI (Fig. 7). Historically, those sample sites closer to the open waters of L Huron (Outer Island Zone or OIZ) have been rated in the oligo-trophic range vs areas farther from the open lake and which are more nutrient rich have tended toward mesotrophic to eutrophic rankings (Inner Island Zone or IIZ). The OIZ have been rated as having lower nutrient levels (more oligotrophic) than the IIZ which are typically rated with higher nutrient levels (more eutrophic). Also, historically, the OIZ have had lower Chl-a values as well as lower TP and SRP levels vs the IIZ having higher Chl-a, SRP and TP seasonal concentrations.

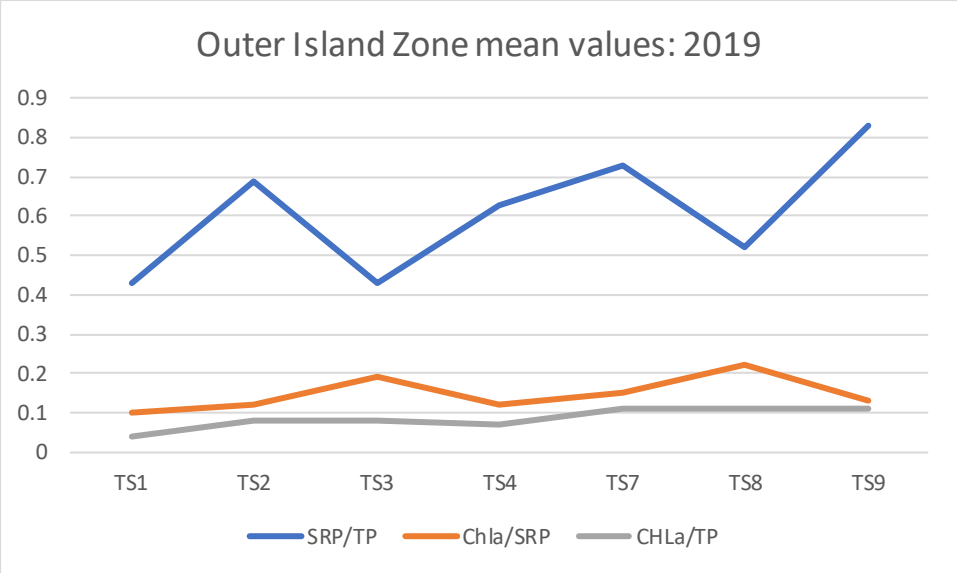
Fig. 7. OUTER ISLAND AND INNER ISLAND ZONES

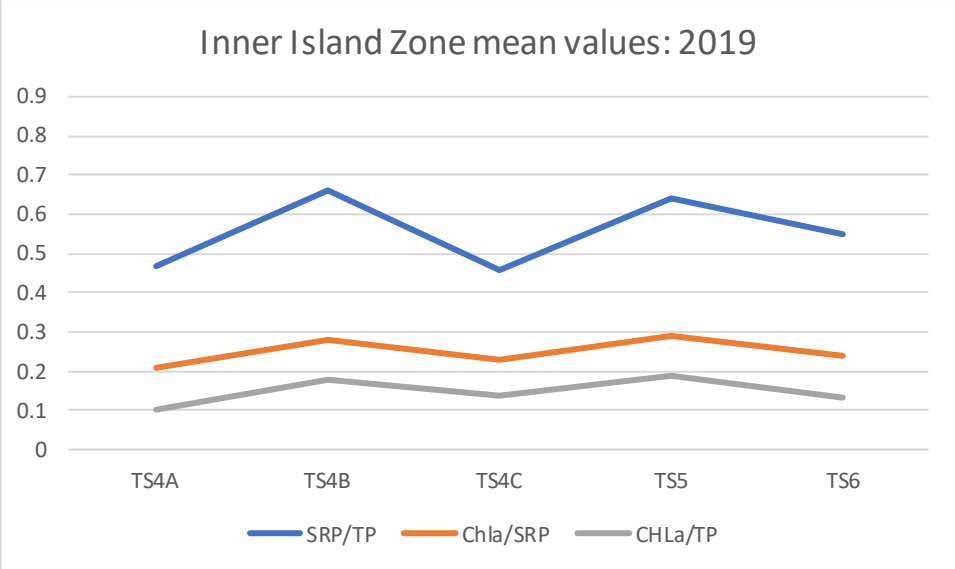
NUMBERS INDICATE SAMPLE SITES [FROM: BACKGROUND INFO FOR UMBS]



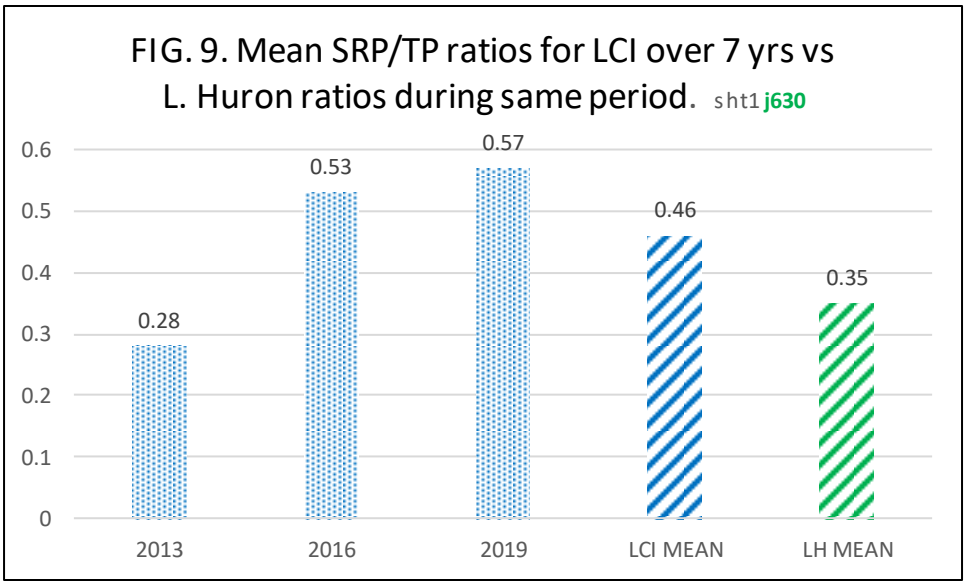
Comparisons of the OIZ and IIZ in 2019 data are instructive in that relative availability of SRP & TP was similar in the OIZ as well as the IIZ (Fig. 8). The SRP/TP ratio of 0.6 was about equal for both zones, however the Chl-a/SRP ratio was about 60% greater than Chl-a/TP in the IIZ (0.148) than in the OIZ (0.086). Finding that the SRP/TP ratio is consistent throughout both the OIZ and the IIZ, yet discovering more Chl-a in the IIZ requires explanation. The consistent SRP/TP ratio indicated that both phosphorus forms were relatively constant throughout the study. Factors that may have contributed to higher phytoplankton (Chl-a) densities in the IIZ include temperature and nutrients. The mean seasonal 2019 temperature for the OIZ was 13^{o}C vs 16^{o}C for the IIZ which could easily explain the higher Chl-a in the IIZ concentration with the warm IIZ temperatures promoting higher phytoplankton metabolism.

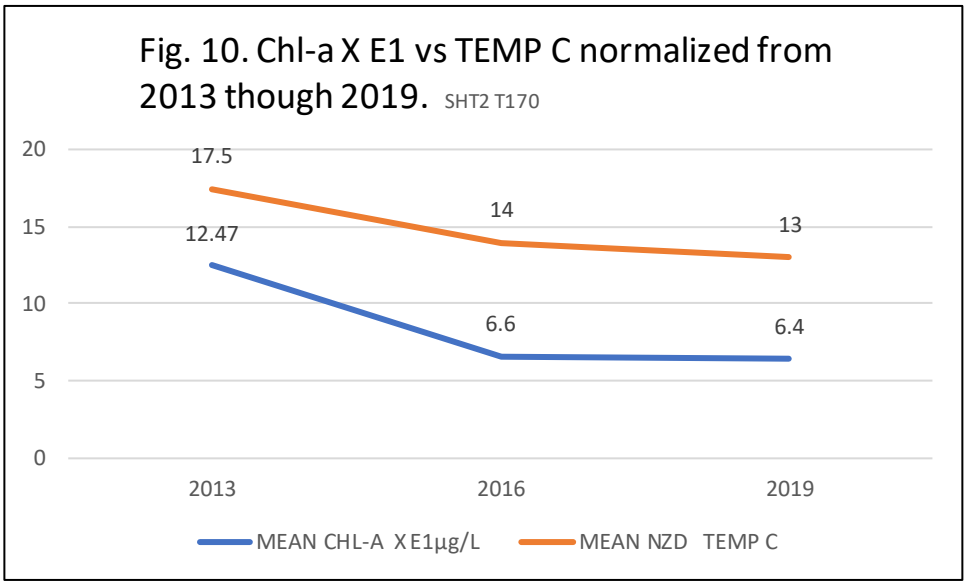
FIG 8. TP, SRP and Chl-a ratios of Outer and Inner Island Zones in 2019.
LCI vs MH DAT SHT 8 / AG 40 LCI VS MH DAT 20MAR20 **C 575**





Phytoplankton growth exhausted SRP in LCI during 2013 but SRP titer increased for 2016 and 2019 (Fig. 4). By comparison, the mean SRP/TP ratio from 2013 through 2019 was ca 25% higher in LCI waters than in offshore surface waters of L H during the same period (Barb et al 2018) (Fig. 9) which is consistent with the protected L Huron wetlands of LCI being more nutritive yet remaining in the oligotrophic-mesotrophic range.





A question remains about both TP and SRP being present at elevated titers in LCI while the Chl-a levels were consistently low during the 2016-2019 period (Fig. 4). The continued rise in L Huron level during this seven-year period can explain both of the following possibilities.

1. Temperature: When seasonal temperatures are considered then the picture becomes clearer (Fig. 10). Note: Chl-a values were multiplied by 10 in Fig. 10 in order for the reader to better visualize the relationship between temperature and Chl-a. Mean LCI seasonal temperatures were 3.5° to 4.5° C cooler in 2016 and 2019 than in 2013. The decrease in Chl-a corresponds with the temperature decline for the same period and is very likely the reason that SRP concentrations remained high during those two periods.

2. Another cause for lower Chl-a levels in 2016 and 2019 could be a decrease in micronutrients due to the influx of nutrient-poor waters from L Huron. Micronutrient levels within LCI waters will be studied during the 2020 season to determine how much, if any, impact they had on Chl-a concentrations from 2016 through 2019.

SUMMARY/ CONCLUSION.

Monitoring seasonal fluctuations of primary aquatic nutrients in waters of the Les Cheneaux Islands (LCI) during a seven-year period indicated flat slopes for Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP) whereas the Chlorophyll-a (Chl-a) slope was slightly downward. The relatively static nutrient values were unexpected during a period when the level of Lake Huron (LH) increased 63 inches (160 cm). Given the inflow of nutrient-poor LH water to the shallow LCI channels, one would anticipate lower TP and SRP concentrations as well as lower Chl-a due to a diluted food supply for phytoplankton. Closer examination of mean values from three of the years: 2013,2016 and 2019, revealed that TP and SRP levels increased after 2013 whereas Chl-a decreased following the same 2013 season. With over five feet of nutrient-poor water inflow from LH one would expect TP and SRP levels to decrease due to a dilution effect and, with fewer nutrients, the Chl-a should decrease as well for the same reason. The stable TP/SRP levels can be explained by organic debris along the over 200 miles of LCI shoreline becoming suspended in the water column as a result of the elevated lake level and, thereby, offsetting the LH nutrient dilution effect. With adequate TP/SRP levels recorded, nutrient dilution does not explain the decrease in Chl-a, an indirect measure of phytoplankton density. Study of temperatures during this period showed that the mean, island-wide temperatures dropped 3.5^{o} to 4.5^{o} C after 2013 and remained low for the duration of the study. Lowered temperatures during this period can explain the lower phytoplankton growth as a result of slower metabolism, despite adequate nutrient sources in the form of TP and SRP. Another possibility is that micronutrients required for phytoplankton metabolism were diluted as a result of LH rise. Micronutrient concentrations in LCI waters will be examined in our 2020 aquatic nutrient studies.

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