Review of the below referenced report on Little Traverse Lake water quality
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Review of

Little Traverse Lake Sampling, Database Development, and Water Quality Data Analysis
Final Report for the Little Traverse Lake Property Owners Association
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I have reviewed the most recent Canale water quality report (December 2021) that is posted on the LTLPOA web site. I did so at the request of Lou Gurthet with the objective of making it more understandable for those interested in the lake water quality but have little or no formal limnology (study of lakes) training. My initial reading of the report was that it was clear, concise, and well documented. From my perspective, I was having some trouble determining why Lou had concerns. Then I realized that most individuals on the lake probably do not fully or only partially understand the plethora of jargon despite the effort Dr. Canale made in his report to do just that. Moreover, this understanding extends to what, e.g., a given value of total phosphorus or Secchi disk depth really indicates about the quality of the lake's water. Hence, below I will comment on the report in general, yet include some details when necessary, in an attempt to, as Lou suggested, "put it in English". It would be impossible for me to evaluate this report without injecting some personal opinions of mine with regard to the study design and findings. For this, I will attempt to be as unbiased as possible. Below are bullet points that largely reiterate the major findings and conclusions in the report, but in a form that may be more palatable for LTLPOA members and others interested in the lake.

1. First, no data set or study is perfect. However, data included in the report from both the LTLPOA and the Leelanau Conservancy are extensive, continual, well designed, and on point for describing water quality status over the past 30 years. Although there are some conflicting issues (e.g., different sets of data, different collectors, times, dates, etc.) the trends are clear and do not detract from identifying the overall quality of the lake. This is quite unusual for lake of this size and we are very lucky to have these data. We are also fortunate to have Dr. Canale finish up the study with a report that interprets the findings and provides a summary mechanism that we can easily build on for years to come.

2. Many of the figures show mean values (little dots) with lines going above and below the mean. These lines are showing the maximum and minimum values for that particular metric found during the study – see Figure 4. Long-term Secchi Depth and Chlorophyll Data as a good example.
3. The data shows trends but does not provide any other statistical treatment. Although I believe the general and overall interpretation of the data is correct, without further analysis, change in our water quality (as measured by our parameters, e.g., Secchi Depth, total phosphorus, etc.) cannot be determined. This single item is probably the greatest limitation of the report as written. However, the data are there, and the statistical analysis can be performed at any time, if warranted.
4. The Excel spreadsheet use by Dr. Canale is easy to input new data and do data comparisons and manipulations provided you have a little training and the correct software installed. This was no easy task and we should appreciate his efforts in that regard.
5. The data needs a good home and held in safe location with back-ups by a knowledgeable Excel user. The LTLPOA web site is a good public place for those so interested, but it should not be the primary storage location.
6. I know some of the text is water quality "jargon". After speaking to several people around the lake, I felt that a clear understanding of some of these terms and how they apply to LTL was needed to avoid misguided conclusions. As an example, lake stratification falls into this category. Hence, I tried to provide some additional clarifications for some of these terms in the glossary below. If the LTLPOA members want a mini course on limnology, I would be happy to present it, particularly as it applies to our data set and what it means.
7. Abstract: an abstract is a short, descriptive paragraph overviewing the entire paper from introduction to the findings or future studies and rarely is longer than a single page. In our case, it is the first item in the report on Page 1. If you wanted that very brief overall perspective of the LTL water quality, this is a good start. **Of note is the second to last sentence in paragraph 5 where Dr. Canale indicates LTL has excellent water quality**. For many of us, this one sentence is all we need or want to know. However, unless we remain diligent in our protection of water quality, The character of the lake could easily change for the worse.
8. Summary: a summary includes information found in the entire report, just in a shorter length and more concise than the entire report. In our report, it is found on pages 2-4. Our summary is well detailed and saves the reader from going through 20 pages (plus graphs and figures) to get much of the same information.
9. Conventional sampling metrics for lakes: These would include nutrient values for phosphate and nitrogen, conductivity, ORP, pH, oxygen, temperature, Secchi disk depth,

and chlorophyll among others. The sampling metrics in this study are the typical ones used to classify lake water quality. From these data, additional information can be generated (e.g., Trophic Status Index, see below)

10. Lake stratification occurs in both the summer and winter on LTL with a spring and fall period when no stratification occurs, meaning LTL is a dimictic lake. The stratification process influences much of the water quality aspects or metrics in the lake, including total phosphorus, nitrogen, secchi disk depth, oxygen levels, and primary productivity (plant growth) among other items.
11. Trophic Status Index (TSI) is a calculated metric that describes the overall quality of the lake with a single value and is based on the amount of biological productivity they sustain. The TSI of a water body is rated on a scale from zero to one hundred. Under the TSI scale, water bodies may be defined as:[1]

    - oligotrophic (TSI 0–40, having the least amount of biological productivity, "good" water quality);
    - mesotrophic (TSI 40–60, having a moderate level of biological productivity, "fair" water quality); or
    - eutrophic to hypereutrophic (TSI 60–100, having the highest amount of biological productivity, "poor" water quality).

    The quantities of nitrogen, phosphorus, and other biologically useful nutrients are the primary determinants of a water body's TSI. Little Traverse Lake has a TSI value that shows it is in the oligotrophic range.

12. The lake is oligotrophic, meaning there is low productivity and not much is growing in the lake. Generally, that is a good thing for most of our lake uses. It means we have clear, clean water, and limited nutrients that enhance plant growth. However, if you wanted our lake to grow a lot of big, fat fish, you will probably be out of luck since limited plant growth means limited food availability up through the food chain.
13. The data show one perturbation in the last 30 years, that being the invasion by zebra mussels. This single organism altered much of the balance in the lake's ecosystem as evidenced by several metrics, including an increase in Secchi disk depth (clearer water) and a reduction in chlorophyll (less plant-type growth). Although there is little we can do about zebra mussels, this invasion indicates the power of all invasive species and how they can change the quality and character of our lake.
14. The Introduction on pages 5 and 6 details what questions our data set can answer and questions we cannot answer. Current and ongoing monitoring won't delineate how to fix a specific problem, only point out we have one. Further intensive monitoring of nutrient inputs from groundwater, septic systems and inflow from Shetland Creek and outflow from Shalda Creek would be needed to answer the nutrient cycling in the lake, answering a big question that remains unanswered.

15. If the RECOMMENDATIONS (First Priorities) found on pages 18 and 19 are followed, we should be able to readily detect changes in the water quality of LTL in the foreseeable future. These recommendations are not cost prohibitive and many could be done, at least in part, by LTL volunteers.
16. The RECOMMENDATIONS (Advanced) found on page 19 and 20 could not as easily be followed. Most would require additional information be gathered and some may be difficult to get (e.g., Septic Tank Drain Field Survey and Modeling) or may be costly ~~prohibitive~~. These recommendations, if followed however, would provide us a better understanding of not only what are problems may be, but also how to solve them.

GLOSSARY

Algal nutrients – Photosynthetic organisms need sunlight and nutrients to grow. The nutrients are several, but the ones most commonly in short supply (and hence, limiting growth) are phosphate and nitrogen. When a farmer fertilizes their crops, they are typically adding one or both of these nutrients to spur growth. In our lake, phosphate limits growth of plants and plant-like organisms. Faulty septic systems and lawn fertilization can add these two nutrients to the lake, typically causing unwanted plant growth that may degrade water quality.

Benthic organisms – bacteria, plants, animals and other organisms that live their lives primarily associated with the bottom of the lake. In LTL, we see adult mayflies flying around at times during the summer, but the egg, larval, and sub-adult stages live at the bottom of the lake and would fall into the benthic organisms category.

Carlson Trophic Status Index (TSI) - Carlson's Trophic State Index is a common method for characterizing a lake's trophic state or overall health. Carlson's trophic state index mainly uses algal bio mass involving three variables namely chlorophyll a (CA), Secchi disc depth (SD) and total phosphorus (TP).

CFS – Cubic Feet per Second. This refers to the amount of water flowing downstream in a stream or river. It is calculated by determining how many cubic feet of water are passing a single point on the shore in a second. As you might guess, this changes with seasons, rainfall, etc.

Chlorophyll – the compound in photosynthetic organisms that transform sunlight energy into organism (plants, algae, etc.) energy.

Cladophora – A green algae that is found in Little Traverse Lake. It looks like fine green hairs that are branching and is usually attached to hard substrates, like rocks. It normally isn't a problem in oligotrophic lakes like LTL, but it can be an indicator nutrient enrichment like faulty septic systems.

Conductivity - A measure of the ability of water to pass an electrical current. Because dissolved salts and other inorganic chemicals conduct electrical current, conductivity increases as salinity increases. Furthermore, an increase in conductivity may suggest more impurities entering the lake.

Dissolved oxygen – the amount of oxygen dissolved in the water. A "normal" amount at saturation is about 10 ppm (parts per million). However warmer temperatures will hold less oxygen, while colder temperatures hold more. Photosynthesis pumps dissolved oxygen into the water, while animals "breathing" and organisms that are decomposing organic matter (bacteria) take oxygen out of the water.

English vs Metric. I wish we all used metric measurements in this country rather than English. It would be so much easier to understand and relate to. The lake measurements are in one or the other, depending on the measured item e.g., secchi disk depth (feet-English), and nutrient levels (mg/m^3-metric). See the explanation of mg/m^3 below.

EXCEL - a software program created by Microsoft that uses spreadsheets to organize numbers and data with formulas and functions. Excel analysis is ubiquitous around the world and is the basis for the LTL data storage and analysis.

Lake Stratification: Epilimnion, Mesolimnion (Thermocline), and Hypolimnion These terms refer to temperature stratification in the lake, most obvious in the summer with the warm water (epilimnion) on the surface, the coldest water on the bottom (hypolimnion), with a transition between the two (mesolimnion/thermocline). LTL is a dimictic lake and the temperature profile of the lake changes with the seasons. You might want to check out https://lakemax.org/lake-turnover-and-why-it-matters/#:~:text=The%20downward%20movement%20of%20surface,thermal%20layers%20during%20warm%20weather. for more details.

Mg/m^3 – a measurement unit typically used in describing nutrients and other dissolved substances. There are 454 grams in a pound. There are 1000 milligrams (mg) in a gram. Hence, there are 454,000 mg in a pound. In Little Traverse Lake, there is approximately 5 mg of total phosphorus in a cubic meter (m^3) of water – about the same as in a hot tub. This value is near the detection limit of most water analysis techniques. Relatedly, milligrams/liter or mg/l would be 1000 times the concentration of a mg/m^3, since one liter is 1/1000 of a cubic meter or m^3. Hence, 5 mg/m^3 would equal 0.005 mg/l.

Oligotrophic, Mesotrophic, Eutrophic, Hypereutrophic. These are terms that classify lakes on a broad basis, typically referencing the amount of nutrients in the water. Oligotrophic means low nutrients, Mesotrophic means medium nutrients, and Eutrophic means lots of nutrients. Hypereutrophic means very high levels of nutrients. Little Traverse Lake falls into the oligotrophic classification.

ORP - Oxidation-reduction potential measures the ability of a lake or river to cleanse itself or break down waste products, such as contaminants and dead plants and animals. When the ORP value is high, there is lots of oxygen present in the water. This means that bacteria that decompose dead tissue and contaminants can work more efficiently. In general, the higher the ORP value, the healthier the lake or river is. However, even in healthy lakes and rivers, there is less oxygen (and therefore lower ORP values) as you get closer to the bottom sediments, particularly during summer stratification. This occurs because there is little, or no oxygen being produced in the deep water as the sunlight level is low and photosynthesis by the phytoplankton is much reduced. Moreover, because the lake is stratified, mixing between the upper (high oxygen) and lower (low oxygen) layers of the lake does not occur.

Periphyton – small (often microscopic) organisms growing on the bottom surface of freshwater lakes and streams. Most periphyton are algae, but can be bacteria, mold, fungi, or small animals. The “brown” algae we have seen in LTL in the summers growing in shallow waters would be an example of periphyton. *Cladophora* is also a periphyton organism.

pH - A measure of how acidic or basin the water is. A value of 7 is neutral, with less than 7 acidic and more than 7 basic. Technically, pH is the negative logarithm of the hydrogen ion concentration.

Phytoplankton – Small photosynthetic (plant-like) organisms that float in the water and provide the basis or foundation for much of the food chain in the lakes. Phytoplankton are typically eaten by zooplankton (small animals) which are eaten by other small animals, including fish. Smaller fish are eaten by larger fish, etc. up through the food chain until we get to the big predators. In LTL, these big predators would be things like largemouth bass.

Pseudofeces - This is a by-product of zebra and quagga mussels. When they filter the water for food, some of filtrate (e.g., plankton) gets eaten, ultimately generating waste we know as feces (typical for all animals). Bivalves, like the mussels in LTL, ball up and discharge stuff they don't want to eat (pseudofeces). This pseudofeces may contain both organic and inorganic materials which gets deposited on the bottom of the lake. Hence, filtering by the mussels for food both clears the water and deposits nutrients on the bottom of the lake in the form of feces and pseudofeces.

Secchi Disk Depth - a measure of water clarity using a 9-inch black and white disk that is lowered into the water until it disappears. The "Secchi Disk" depth approximates 15% of the light found at the surface. Two times the Secchi Disk depth approximates about 1% of the light at the surface.

Zebra and quagga mussels – Fingernail sized mollusks that are invasive species from Europe and have been in LTL for 20 years. They each may filter up to a liter of water each day, taking the plankton and other microorganisms out of the water. For LTL, this means we have clearer water.