Viewing NTL-LTER Data on Zooplankton in Madison, WI Area Lakes using Python

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Intro

Within lake ecosystems, there are many abiotic and biotic factors that interact to influence the overall health of the ecosystem. While factors at upper trophic levels affect those at lower levels via a trophic cascade, factors at lower levels also influence those upstream due to circulation and biomagnification within lakes.

Zooplankton are a group of small, aquatic microorganisms found within aquatic ecosystems. Unlike phytoplankton, they are primary and secondary consumers and serve as an intermediary in the food chain (US EPA, 2013). They are also very sensitive to changes in their ecosystem. In addition, they have the ability to remain inactive during unfavorable conditions and to reestablish communities once the conditions are favorable again (Choi et al., 2023). All of these characteristics make zooplankton a useful indicator of aquatic ecosystem health and a tool that policymakers can reference when deciding best lake management practices.

To understand how different factors influence zooplankton levels in aquatic ecosystems, it is important to have reliable, well-researched data. The North Temperate Lakes Long-Term Ecological Research (NTL-LTER) program at the University of Wisconsin – Madison provides publicly available data on lakes surrounding the Madison, Wisconsin and Trout Lake areas (*NTL-LTER*, n.d.). The long-term data sets cover the five core LTER areas of "primary production, population dynamics and trophic structure, organic matter accumulation and use, inputs and movements of nutrients through the ecosystem, and patterns and frequencies of disturbances." The information available in these datasets allows for understanding and comparison of how differing factors at different moments in time affected each other within these lake ecosystems.

The goal of this research was to use the dataset from NTL-LTER on zooplankton levels in the Madison lakes area from 1997 – current to observe any trends either seasonally or on a larger time scale. The Madison lakes area includes data from Mendota, Monona, Wingra, and Fish Lakes.

Methods

NTL-LTER data on zooplankton in the Madison Lakes area from 1997 – current was downloaded from the EDI data portal (Magnuson et al., 2022). This yielded a dataset with 9,004 observations. VisualStudioCode and Python were used to work with data. Data preprocessing included calculating the density of organisms per cubic meter for each datapoint by dividing the density by the tow depth. Next, the data was refined to a data frame containing only the dates and these newly calculated densities. Missing data was then removed, narrowing the data to 8,994 observations. Pandas was used to convert the "Date" data to datetime objects, and matplotlib was used to plot the data.

To check if the data was stationary, ADF and KPSS tests were performed. The data was then sliced to only include data from 2010-2020. After this, the ADF and KPSS tests were performed again. Next, the newly sliced data was differenced, plotted, and checked for stationary-ness again. The data was then plotted as a time series decomposition to view individual components. Lastly, ACF and PACF plots were created using the data.

Results

Plotting the data from 1990-2020 as a time series with densities of organisms per m^3 yielded a plot that indicated some degree of seasonality (*Figure 1).* The ADF test yielded an ADF statistic of -7.16 and a p-value < 0.05 $p = 0.00$) , indicating stationary data. However, the KPSS test yielded a KPSS statistic of 2.93 and a p-value < 0.05 ($p = 0.01$), indicating non-stationary data. Based on these results, the data was sliced into a smaller time frame (2010-2020, *Figure 2*) and the tests were ran again. The ADF test on the refined data yielded an ADF statistic of -11.53 and a p-value < 0.05 (p = 0.00), indicating stationary data. However, the KPSS test on the refined data yielded a KPSS statistic of 0.59 and a p-value < 0.05 (p = 0.02), indicating non-stationary data.

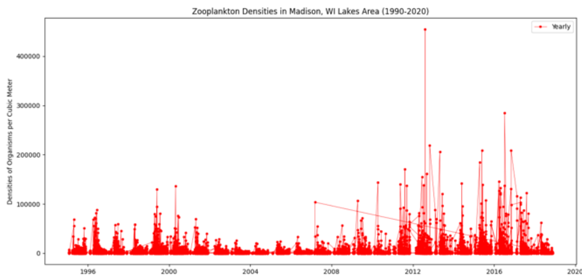

Figure 1

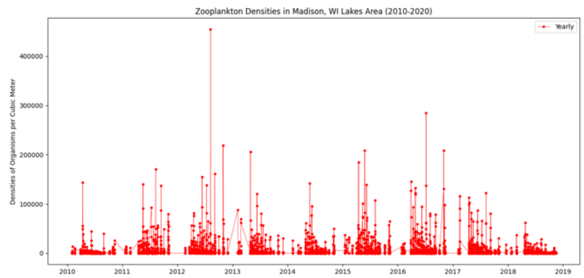

Figure 2

After differencing the 2010-2020 data, a new ADF statistic of -18.04 and p-value < 0.05 (p = 0.00) were obtained. The KPSS statistic for the differenced data was 0.03 with a p-value > 0.05 (p = 0.1), indicating the differencing transformed the data, making it stationary (*Figure 3)*.

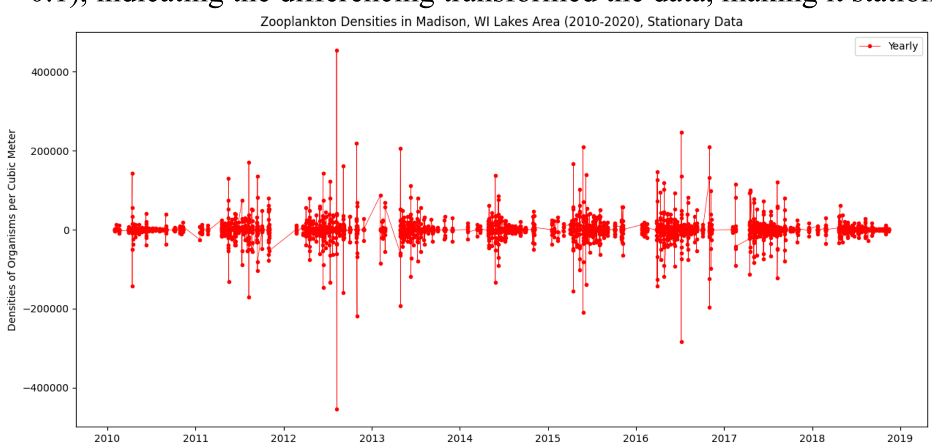

Figure 3

The time series decomposition of the data showed rough seasonal trends in zooplankton density, with spikes in early spring and drops around the fall/winter seasons. No clear trend was indicated (*Figure 4)*.

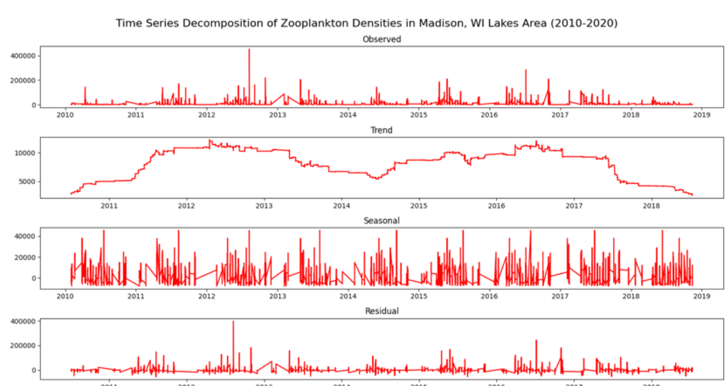

Figure 4

Discussion

The breadth of publicly available data provided by the NTL-LTER data offers a lot of potential for future research. As pollution and climate change continue to be problems facing aquatic ecosystems, it will be important to monitor the organisms within them. The characteristic of zooplankton as an indicator species for aquatic ecosystem health make them a great candidate for further comparative research.

The NTL-LTER project provides data on many more factors within the lakes of interest. This visualization and analysis has simply scratched the surface of what can be done with the available data. Future analyses could include forecasting what densities of zooplankton could look like in the future, as well as analyzing other data sets to check for correlations between dips and rises in density over time.

While every lake ecosystem is unique, understanding the interactions between abiotic and biotic factors within these lakes and their organisms could prove helpful in lake management nationally.

References

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