Exploring Trophic Status of Seneca Lake & Environmental Stewardship

(Background information and images on pages one and two I revised from "Trophic Status of Lakes", Hobart and William Smith Colleges, Finger Lakes Institute, Teacher Center: Lesson Plans. Activity starting on page three is new material created for my Honors Project in collaboration with Nadia Harvieux).

Introduction

Lakes are dynamic and complex ecosystems. To better understand the water quality conditions of a lake, scientists and concerned citizens in New York State work together to conduct monitoring programs aimed at tracking lake health. Water quality monitoring can assist scientists in determining whether a lake is undergoing changes that might impair the uses of the lake for drinking, swimming, or recreation. As water quality changes, so too will the plants and animals that live there, and these changes in the food web also may affect water quality. Water quality monitoring provides a window into the numerous and complex interactions of lakes. Even the most extensive and expensive monitoring program cannot completely assess the health of a lake. However, by looking at some basic chemical, physical, and biological properties, it is possible to gain a greater understanding of the general condition of lakes.

Understanding Trophic States

All lakes and ponds undergo **eutrophication**, an aging process that involves stages of succession in biological productivity and water-quality. Limnologists (scientists who study freshwater systems) divide these stages into **trophic** states.

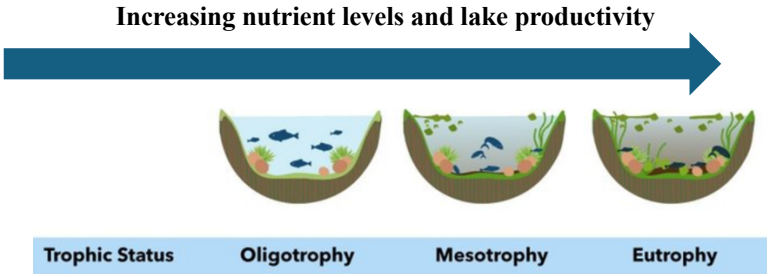


Figure 1. Three trophic states of a lake. Modified from Raj & Jamwal (2020).

Each trophic state can represent a wide range of biological, physical, and chemical characteristics and any lake may be categorized within any of these trophic states. In general, the increase in productivity and decrease in clarity corresponds to an enrichment of nutrients, plant and animal life. Lakes with low biological productivity and clear water are considered **oligotrophic**. Highly productive lakes with low clarity are considered **eutrophic**. Lakes that are **mesotrophic** have intermediate or moderate productivity and clarity. It is important to remember that eutrophication is a natural process and is not necessarily indicative of human pollution.

However, when human activities accelerate lake eutrophication, it can lead to eutrophication and is referred to as **cultural eutrophication.** Cultural eutrophication may result from shoreline erosion, agricultural and urban runoff, wastewater discharges or septic seepage, and other non-

point source pollution sources. For most lakes in New York State, cultural eutrophication represents the most significant source of pollutants and threat to water-quality.

Classifying a Lake's Trophic Status

A lake's trophic state is important because it provides lake managers with a reference point to view changes in a lake's water quality and they begin to understand how these changes may cause use impairments (threaten the use of a lake for swimming, drinking water, or fishing).

Three important measures of **eutrophication** in most New York State lakes are: **total phosphorus**, **chlorophyll *a*** (estimating the amount of algae), and **Secchi disk transparency**. Because these parameters are closely linked to the growth of weeds and algae, they provide insight into "how the lake looks" and its suitability for recreation and aesthetics. Figure 2 below shows the parameters used to measure a lake's trophic status:

Trophic Status	Oligotrophy	Mesotrophy	Eutrophy
Secchi depth (m)	>5	1.6 - 5	0.7 - 1.6
Chlorophyll A(µg/L)	<2	2 - 10	10 - 30
Total phosphorus (µg/L)	<10	10 - 30	30 - 60

Figure 2. Parameters for measuring trophic status in a lake. Modified from Raj & Jamwal (2020).

1.) Investigating the *Science on Seneca* Database: Secchi disk depth in Seneca Lake

First, you will navigate the *SOS* database to gather and analyze data for Secchi disk depth, one of the measures of trophic status.

Procedure

1. Navigate to the Finger Lakes Institute Education page.
    a. Scroll down to "Science on Seneca (SOS)".
    b. Scroll until you see "Resources" and select: **Databases.**
2. The *Science on Seneca Database* is a collection of the data recorded by students on the boat during *SOS* field trips (where your data will go!). To view the data, click: **Go to the search page**.
3. In "Filters" at the top of the page, select **January 1st, 2021** for the "StartDate" and the **present date** for the "EndDate".
    a. In *Data Requests*, de-select "Latitude" and "Longitude" (leave "Date" selected).
    b. Select **Secchi Depth(m)** in the *Physical Analysis* column.
4. Once you have selected/de-selected these fields, click **Search** at the bottom of the page. The data will populate below the Search button.
    a. Click: **Export Physical Analysis CSV**
5. Open Google Sheets and create a new spreadsheet. Title your new sheet "Seneca Lake Secchi (2021-2023)".
    a. Click "File" (at the top), then "Import", and "Upload". **Browse** your computer and select the CSV you downloaded ("PhysicalAnalysis.csv").
    b. Under "Import location", select "Replace spreadsheet" from the drop-down menu. Once selected, click **Import Data**.
6. To ensure no data points are out of order, select rows 2-54 in both columns (click and drag over the cells), select the **"Data"** tab at the top, then **"Sort range**", and **"Sort range by column A (A to Z)"**.

Now that you have organized your Secchi data in the spreadsheet, the next step is to analyze the data.

Data analysis

1. To calculate an average, scroll down and type "=average" in a cell below the Secchi data and click "AVERAGE" from the drop-down menu.
    a. Select rows 2-54 in the "Secchi Disk Depth (m)" column
    b. Close the parentheses: ")"
    c. Click **Enter/Return** on your keyboard.
    d. In the cell next to your calculated average, type "Average" (to label your value).
2. At the bottom of your spreadsheet, right-click on the tab ("PhysicalAnalysis") and select "Duplicate".
    a. Rename the new sheet by double clicking on the tab. Title it: **"Seasonal Data".**

3. Highlight the data on this sheet (click and drag over both columns).
    a. Copy and paste the data two columns over to the right.

4. **Remove** the spring dates (and data) from the first two columns (select and **backspace**; all data from May), then **remove** the fall dates (and data) from the second two columns (select and **backspace**; all data from September and October).
    a. Rename the "Date" columns: "Fall Dates" and "Spring Dates"
    b. (Your seasonal averages will automatically populate because of the formula you inserted when calculating your overall average.)

	A	B	C	D	E	F
1	Fall Dates	Secchi Disk Depth (m)		Spring Dates	Secchi Disk Depth (m)	
2	9/24/2021					
3	9/24/2021	8.5				
4	9/24/2021					
5	9/24/2021	9				
6	9/27/2021					
7	9/27/2021	4				
8	9/28/2021					
9	9/28/2021	3.5				
10	9/28/2021	7				
11	9/28/2021	7				
12	9/28/2021	6				
13	9/28/2021					
14	9/29/2021	9				
15	9/29/2021					
16	10/6/2021					
17	10/6/2021					
18	10/14/2021	9.5				
19	10/14/2021	9.1				
20	10/14/2021	8				
21	10/21/2021					
22	10/21/2021					
23	10/21/2021					
24				5/20/2022	5.5	
25				5/20/2022	5.5	
26				5/20/2022	4.5	
27				5/24/2022	9.5	
28				5/24/2022	9	
29				5/24/2022	7.4	
30	10/3/2022	4.8				
31	10/3/2022	6.6				
32	10/3/2022	5.5				
33	10/5/2022	5.8				
34	10/5/2022	7.2				
35	10/5/2022	5.8				
36	10/11/2022	9.8				
37	10/11/2022					
38	10/18/2022	5.8				
39	10/24/2022	8.4				
40	10/24/2022	7.8				
41	10/24/2022	7.6				
42	10/26/2022	8.2				
43	10/26/2022	3.1				
44	10/26/2022	5.9				
45				5/12/2023	7.2	
46				5/12/2023	7.5	
47				5/12/2023	6	
48				5/19/2023	8	
49				5/19/2023	8	
50				5/19/2023		
51	10/17/2023	5.2				
52	10/17/2023	5.5				
53	10/17/2023	6.6				
54	10/17/2023	6				
55						
56	Average	6.765517241		Average	7.1	

Your data should look like this at this point!

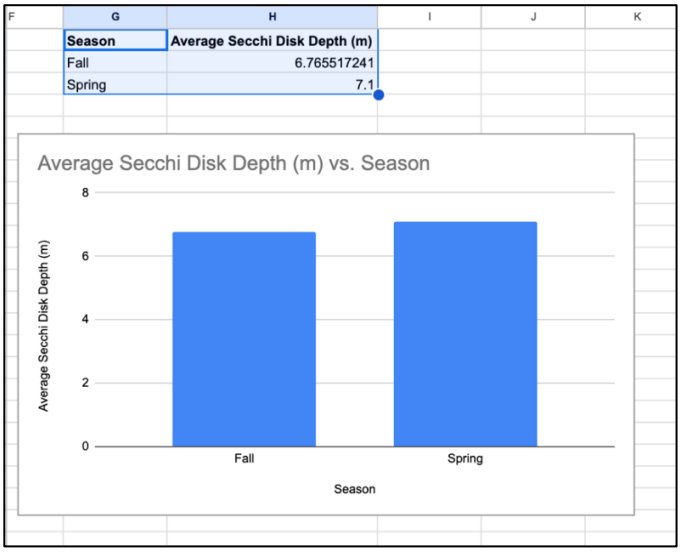
5. Now that you have your fall and spring average Secchi disk depths, create a new "table" to the right of your fall and spring columns. This will be used to make your graph. It will look like this:

	D	E	F	G	H
1	g Dates	Secchi Disk Depth (m)		**Season**	**Average Secchi Disk Depth (m)**
2				Fall	
3				Spring	
4					
5					
6					
7					
8					
9					

6. Copy and paste the averages into the correct spaces. You will have to click the **Clipboard icon** and select **"Paste values only**" from the drop-down menu.

D	E	F	G	H
pring Dates	Secchi Disk Depth (m)		**Season**	**Average Secchi Disk Depth (m)**
			Fall	6.765517241
			Spring	7.1

7. You are now ready to make a graph to represent your data. Highlight the entire table you created and select the "Insert" tab.
    a. Select "Chart" and change the *Chart type* to "Column" (choose the first option). You will now have a **bar chart** that should look like the graph pictured below:



Discuss findings

1. Which season has the greater Secchi disk depth? Why do you think this is?

2. Note the differences in the amount of data available for fall versus spring. How could we improve the reliability of our findings?

3. What was the overall average Secchi disk depth in Seneca Lake for 2021-2023? Using the average you calculated in Step 1 of the *Data analysis*, determine if Seneca Lake is oligotrophic, mesotrophic, or eutrophic.

2.) Chlorophyll *a*, Total Phosphorous, and Secchi disk depth in Seneca Lake

In the section above, you explored and analyzed a data set to examine just one variable that is used to determine trophic status of lakes. Now, we will put all three variables together (chlorophyll *a*, total phosphorous, and Secchi disk depth) in an investigation of the trophic status of Seneca Lake.

Procedure

1. Navigate to the CSLAP Dashboard.
    a. Click: **"Go to CSLAP Reports"** → "2023 Reports"
    b. Search "Seneca Lake" and select: **Seneca Lake – CSL11** (click "View")
    c. Scroll down and click on the grey box that reads **"Trophic State"**.
2. Read the following text and associated graphs and answer the following questions.

Discuss findings

1. Study the plot for **Annual and Seasonal Chlorophyll a Concentrations**. Chlorophyll *a* is on the y-axis. What is the range of the data?

    a. Read the caption to the right of the chart. What is the median concentration?

    b. Based on these results, is Seneca Lake oligotrophic, mesotrophic, or eutrophic?

2. Study the plot for **Annual and Seasonal Total Phosphorous Concentrations**. Total phosphorous is on the y-axis. What is the range of the data?

    a. Read the caption to the right of the chart. What is the median concentration?

    b. Based on these results, is Seneca Lake oligotrophic, mesotrophic, or eutrophic?

3. Study the plot for **Annual and Seasonal Secchi Depth Measurements.** Secchi disk depth is on the y-axis. What is the range of the data?

    a. Read the caption to the right of the chart. What is the median concentration?

    b. Based on these results, is Seneca Lake oligotrophic, mesotrophic, or eutrophic?

4. Synthesizing the results from all three data sources, what would be the trophic status of Seneca Lake? Defend your response using data the chlorophyll *a*, total phosphorous, and Secchi disk data.

    a. What could cause trophic status to change?

3.) Environmental Stewardship

Determining the trophic status not only deepens our understanding of the physical, chemical, and biological features of a lake, but it highlights the vital role we play in maintaining the health of our local ecosystems. The following exercise will help you to consider ways to practice environmental stewardship in your own daily life.

1. Visit the Lake Friendly Living webpage and scroll down to the bottom of the page where it says, “Please visit *YOUR* lake association’s LFL page”.
    a. Select the image for the Finger Lake located closest to your community.

Explore the resources provided to you. Pick **two solutions** to investigate that would improve water quality. Using what you’ve learned, write a paragraph explaining actions you could take to improve *your* lake through water stewardship.