



KEUKA LAKE- MACROPHYTE SURVEY REPORT

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Methods:

Site Selection

Based on the conditions in which aquatic invasive macrophytes inhabit, we surveyed the littoral zone of Keuka Lake. The littoral zone refers to the nearshore part of the water body. There is not a set measurement of depth that determines the littoral zone, but it is an area that is permanently submerged and includes the intertidal zone extending from the high-water mark (Figure 1.) We sampled in the littoral zone with a minimum depth of 10 feet and a maximum depth of 30 feet. The average distance from shore at the sampling points was 20 feet.

The goal of this surveying program was to determine the distribution and quantity of aquatic invasive macrophytes in Keuka Lake. We calculated the distance around the perimeter of Keuka Lake and determined the distance needed between points to be able to both accurately get a representation of the data as well as accomplish the task in one field season (3 months). It was also important to consider that the temperature of the water determines species abundance, so sampling each point twice, one month apart was important to eliminate time as a variable in the distribution and quantity of the aquatic invasive macrophyte. We determined that the appropriate distance between sampling points was 500 meters. This allowed for an accurate representation of the data and was accomplishable within the time constraint of one field season. A total of 119 points surveying points were created at 500m distances. We were able to establish these sites at fixed distances using ArcGIS. In the field, we were able to determine our live locations with respect to sampling points using Avenza. Avenza allowed us to upload a map with all of the sites and site numbers on them and see our live location on it to determine when we were at each sampling point. We input all data in the ArcGIS Survey 123 App. This app allowed us to input the data of the location of the sample, species present, and the quantity of each of the species present at each sampling point.

Survey

To conduct the survey, we hired two interns who would be responsible for the data collection during the field season. The sampling equipment used was two kayaks, two cell phones, and two different sampling rakes (Figure 2). One rake was the traditional rake which zip ties common yard rakes together. The other rake is a newer design created by IDEA collective. We wanted to determine which of these rakes was better at collecting macrophyte survey data in addition to our distribution question.

At each sampling point, within the littoral zone, we did a rake toss with the respective rake types. We made sure the depth of the lake was between 1.5-3 meters in each location and moved closer or farther away from shore to compensate. Once the rake hit the lake bottom, it was pulled to the surface and all of the vegetation was identified and classified as native or invasive. If a species was native, it was entered into the ArcGIS survey, created using ArcGIS Survey 123, as well as the percentage of the rake it covered. If there were no invasive species, the classification of “none” was recorded. Round 1 of the survey was conducted from June 21 to July 18. Round 2 of the survey was conducted from July 20 to August 17. Round 2 of the survey was conducted in the same order as Round 1.

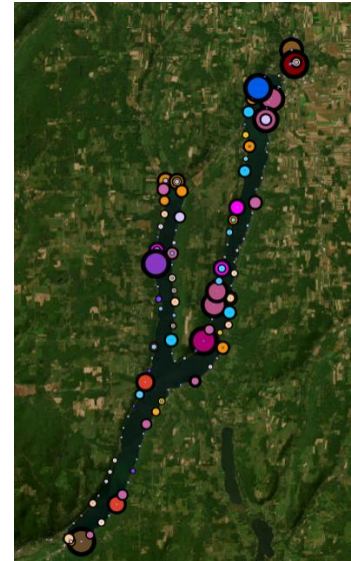
Data Analysis

Once all of the data was collected from both rounds, it was extracted from ArcGIS and formatted in Excel. The data was formatted for each round as well as an average between the rounds to eliminate time as a variable. The species and the percentage of the rake each species occupied were recorded. This data was then added to an ArcGIS map where a Heat Map was created. This Heat Map used the data recorded and displayed each species' location and quantification based on the size and color of the data point. Data was averaged for each round separately, Round 1 and Round 2, and then averaged for the rounds together, Total Average. There was not a significant difference between Round 1 and Round 2 between the species that were present. We did find that the species that were present in Round 1

were also present in Round 2, just at a slightly greater capacity. These maps are displayed via the ArcGIS WebApp that allows all users with the link to access and view the created maps. Information on how to access these maps and how to use them is at the end of this document.

Results: *These results are based on the Total Average (Average of Round 1 and Round 2)*

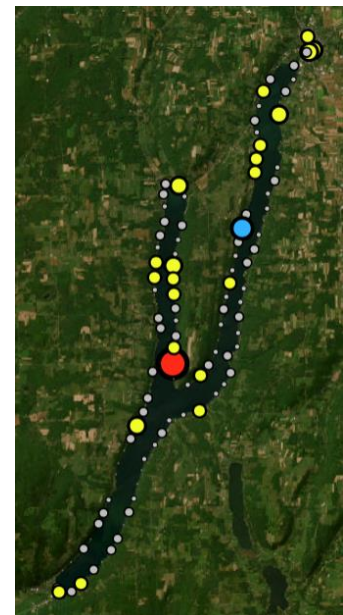
There was a total of five aquatic invasive macrophytes that were found to be present in Keuka Lake based on this survey. These were Fanwort (*Caboma caroliniana*), Brittle Naiad (*Najas minor*), Curly Leaf Pondweed (*Potamogeton crispus*), Eurasian Watermilfoil (*Myriophyllum spicatum*), and Starry Stonewort (*Nitellopsis obtusa*). All of these species were already known to be present in the lake. The maps shown in each section show the distribution of each of these species. The darker the color and larger the dot indicates a greater distribution of that species.



You can view these maps with a legend following the instructions at the end of the document.

Number of species

Most of the sampling points contained one species on the rake. There were very few sampling points where more than two species were found. This tells us that most of these populations of aquatic invasive macrophytes have been established for a longer period of time and have choked out all of the other vegetation, or the invasive is intermixed with native species, which were not quantified. Based on our qualitative observations, the latter of the options seems to be the case. For every rake toss that was performed, about 80% of the rakes also contained native species.



The area that had the most species at the single sampling point was the point of the bluff. This makes sense as this is where the current of the lake moves back and forth before moving north to exit through the outlet. This allows the macrophytes to be collected and prosper here. This is also a high-traffic point on the lake for those who travel between branches. Although this is where the highest number of species were found, these species were not in high abundance.

Fanwort (FW)

Fanwort (*Cabomba caroliniana*) is native in the Southern United States and is a popular aquarium plant. This is a tier 2 invasive species, meaning it is regionally invasive in the Finger Lakes Region. It prefers to grow in water in acidic lakes, ponds, and slow-moving streams. Fanwort is a submerged perennial with fan-like leaves that branch and attach to the stem of the plant in a whorled-looking pattern. The flowers are small and white and appear in late summer. There is very little information on fanwort biology or management as mechanical removal, water level manipulation, and chemical applications have been tried in the Northeast with limited success.



In Keuka Lake, fanwort is the least of the top five species present in terms of coverage. There is a large population in the west branch near the Pulteney area. It is located sporadically throughout the northern area of the west branch, and some is present in the northern area of the east branch. I would not classify this as a species of concern for Keuka Lake given the little amount that is present.

Brittle Naiad (BN)

Brittle naiad, also known as water nymph, is native to Europe, Africa, and Asia. It is an herbaceous annual that grows in dense clusters. It is a tier 4 species within the Finger Lakes region, so it is very widespread, so localized treatment is the best option for control. The leaves have visible notches or serrations and are very long and pointed. There are many branches that are oppositely arranged on

the stem of each other. It prefers to grow in ponds, lakes, reservoirs, and slow-moving streams in depths of 2-15 feet. Brittle naiad inhibits the growth of other aquatic plants and can make recreation very difficult. This plant gets its name from the brittle stems that break off very easily, so it is spread very well by boats, waterfowl, and water currents. It has been observed that waterfowl will eat this plant and move it from waterbody to waterbody. Prevention is the most effective control for this species as there are no other known management strategies.



In Keuka Lake, brittle naiad is mostly present in the eastern branch. The largest population of brittle naiad is near the tip of the outlet. Most of the observations of this plant were on the western shore of the east branch. The west branch has a few small populations of brittle naiad, with most being located near the point of the bluff and a few miles past. The south end of the lake didn't have any presence of brittle naiad. I would not rank this as a major species of concern for Keuka Lake based on the distribution of this survey. However, this is a species to keep an eye on since it does spread very easily.

Starry Stonewort (SSW)

Starry stonewort is a macroalgae native to Europe and Western Asia. This macroalgae is green with star-shaped rhizoids that form from late fall through winter. The star-shaped bulbils are where this invasive gets its name. Starry stonewort can live in fresh or brackish water and can live in very harsh conditions such as low light with low nutrient levels and salinity conditions. It usually grows in depths of 3-20 feet but has been observed to be growing in 30-foot depths. Starry stonewort is known to form dense mats on lake and river bottoms as it outcompetes other native species. It is also a preferred substrate for zebra mussels to cling to, which further extends their invasion as well. Mechanical removal of starry stonewort is not recommended as it spreads the fragments and rhizoids. Diver Assisted Suction

Harvesting (DASH) has been shown to be effective in reducing the invasion of starry stonewort. Studies on the use of copper-based algaecides have also shown a positive result in the short term for reduction in cover, but no positive long-term results.

In Keuka Lake, starry stonewort is present mostly in the eastern branch. The outlet houses a very dense patch of it. The northern end of the west branch also has a significant population, but very little starry stonewort is present in the rest of the western branch. The southern end of the lake also has a very dense population. We noticed through this survey that there were very dense patches at most of the marinas, heavy boat traffic areas, and lakefront restaurants. This species has the potential to be a very serious problem. It is not advised to do any kind of mechanical treatment that creates fragments, as this seems to be the main way of spreading for this species in Keuka Lake.



Eurasian Watermilfoil (EWM)

Eurasian watermilfoil is a submerged perennial that is native to Europe and Asia. It looks like many other aquatic plants, but this species specifically has four feathery leaves that are whorled around the stem. Each of the leaves are very finely divided and have greater than nine leaflets. Each stem of this plant can reach 20 feet in length. In late summer, small pink flowers can develop and show near the surface of the water. This species is very resilient and grows in a vast amount of habitat conditions. It spreads via fragmentation and is easily transported from waterbody to waterbody via boats and gear. Once this species becomes established, it is very difficult to control. Many lakes use various mechanical, biological, and chemical techniques to try to control it. Skaneateles Lake Association has an extensive benthic mat operation which they use to control milfoil on their lake.

In Keuka Lake, Eurasian watermilfoil is present in the middle of the western side of the lake, in the outlet, and in the south end. There are some scattered throughout the western and eastern branches, but not a significant amount. It is encouraging that this species is not well-established in the lake. It is most dense in the outlet, which makes sense as this is a heavy boat traffic area. It would be worth keeping a close eye on this species and its distribution as it is a high-risk invasive, but since there are few populations in the lake, immediate control measures are not necessary. However, early detection and rapid response of this species is crucial for reducing the chance of establishment.



Curly Leaf Pondweed (CLP)

Curly-leaf pondweed is a submerged perennial that is native to Europe, Africa, and Australia. It looks very similar to native pondweeds, so it is important to make sure to pay close attention when identifying this species. Curly-leaf pondweed is rigid, reddish-green, and has oblong leaves that have finely toothed wavy edges. Each stem can grow up to 16 feet in length. This species is very tolerant and grows in a variety of conditions. This species is different from other aquatic invasives as it can form under ice cover during late winter and dies off mid-summer, which causes a loss of oxygen. Many studies have been conducted on physical, mechanical, and chemical removal techniques. However, it is not advised to treat this species as it looks very much like native pondweeds.



In Keuka Lake, this species was the most prevalent. This could be due to various reasons. One is that since it is difficult to identify, all pondweeds whether native or non-native were identified as curly-

leaf pondweed. Another reason could be that the timing of the survey that was conducted could have collected data when this species was the only one present in the water at that time due to the early growing season. This species was very heavily present in the eastern branch of the lake. The western branch of the lake had some large populations near the middle of the branch. Less is present in the south portion of the lake. It is not advised to do any sort of treatment for this species despite the appearance of very dense populations throughout the lake. This is again because of the difficulty of identification and the impact of this invasive species is relatively low in comparison to others.

Conclusions:

We determined there to be five prevalent aquatic invasive species within Keuka Lake: fanwort, brittle naiad, starry stonewort, Eurasian watermilfoil, and curly-leaf pondweed. All of these species were previously reported to be in Keuka Lake. Of the five species that were found the major species of concern in terms of management are starry stonewort and Eurasian watermilfoil due to their high risk of spread via fragmentation. These species should be monitored yearly, if possible, but definitely every other year to ensure that more established populations are not going unnoticed. The entire lake survey should be done every three to five years to monitor the development of these macrophytes.

How to View the Maps:

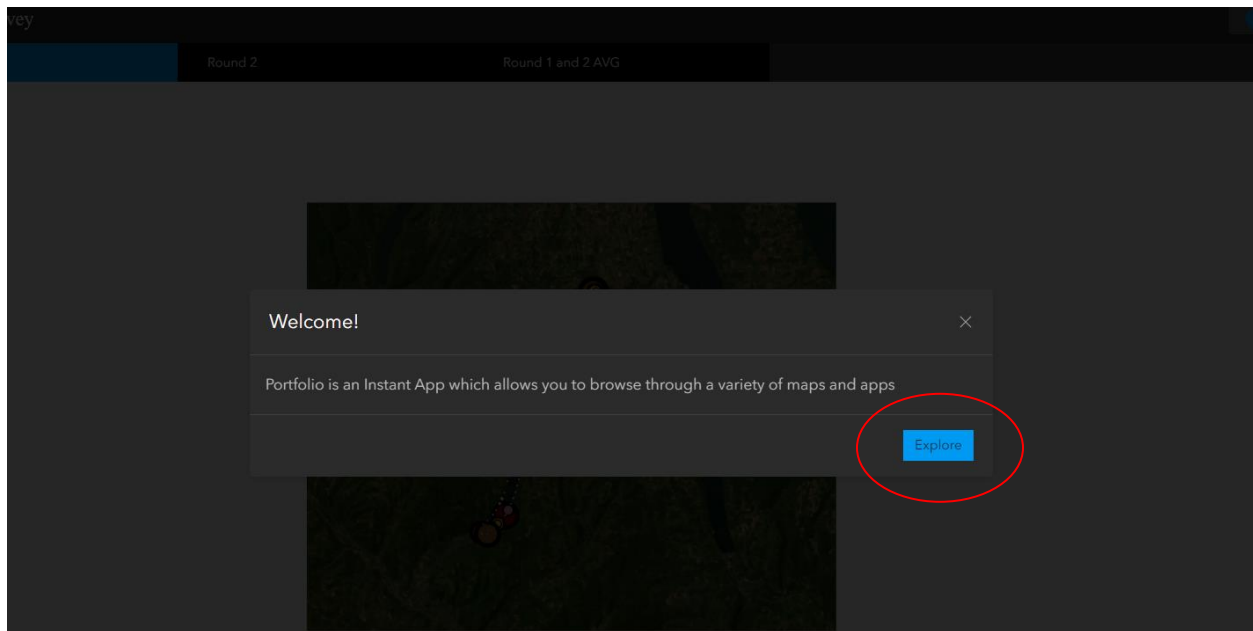
These instructions are based on how to view it on your computer. You can also view it on your phone, but it will look a little different.

Step 1: Click this link or scan QR Code:

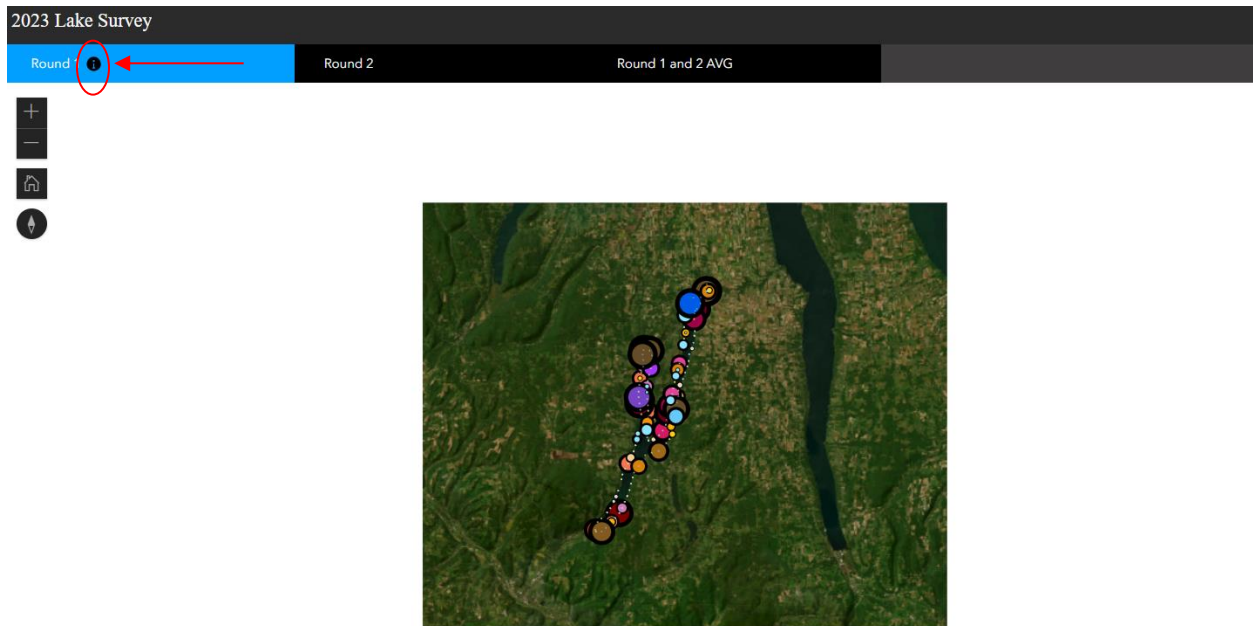
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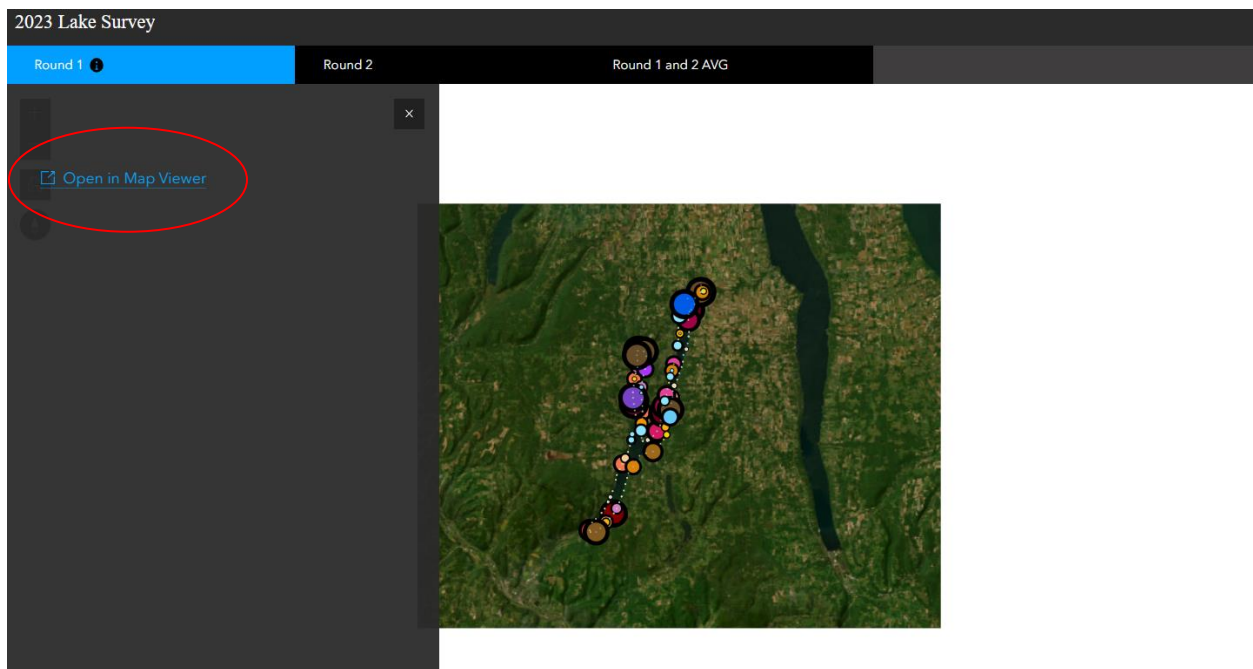
Step 2: Hit “Explore”



Step 3: Hit the “i” icon to the right of “Round 1”



Step 4: Select “Open in Map Viewer”



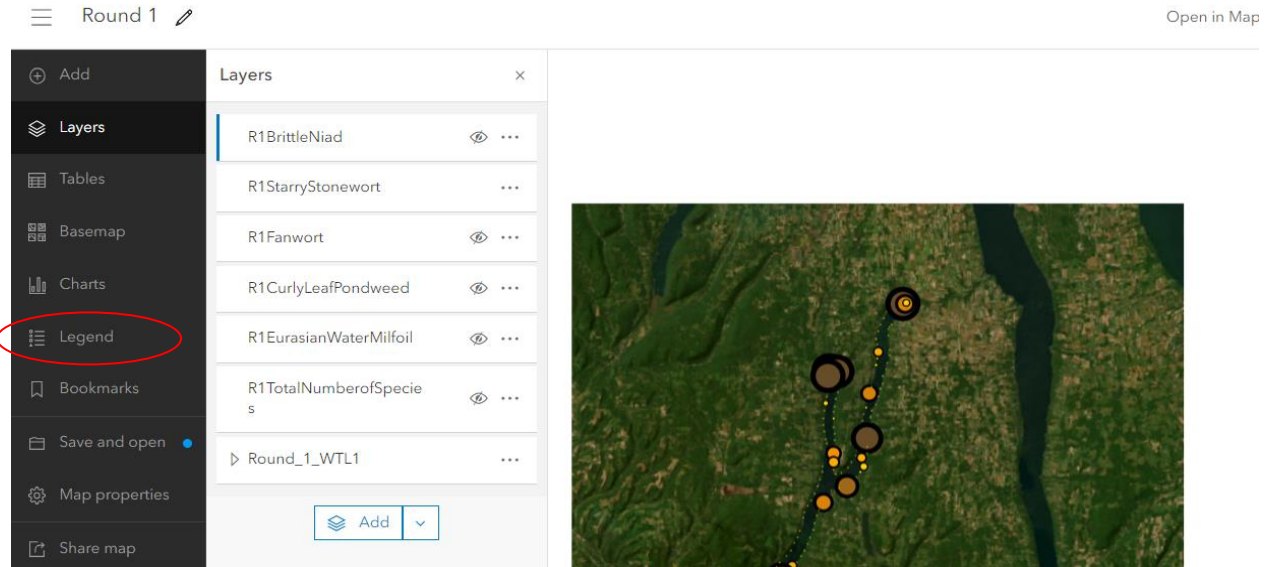
Step 5: Make sure you are on the “Layers” tab on the very left hand side

The screenshot shows the ArcGIS interface. On the left, a dark sidebar contains a menu with options: Add, Layers (highlighted with a red circle and arrow), Tables, Basemap, Charts, Legend, Bookmarks, Save and open, Map properties, Share map, Create app, Print, Information, and Collapse. The main area is split into two panels. The top panel is the 'Layers' panel, titled 'Layers' with a close button 'x'. It lists several layers: R1BrittleNiad, R1StarryStonewort, R1Fanwort, R1CurlyLeafPondweed, R1EurasianWaterMilfoil, R1TotalNumberofSpecies (with an eye icon crossed out), and Round_1_WTL1. Below the list is an 'Add' button with a dropdown arrow. The bottom panel is a map showing a satellite view of a river with a series of colored circles (red, yellow, blue, purple, green) representing species distributions along the riverbank.

Step 6: Turn layers on and off to see specific species distributions. The eye crossed out means the layer is not visible. Click on the eye icon to turn the layers on and off.

The screenshot shows the ArcGIS interface. On the left, the same dark sidebar menu is visible. The main area is split into two panels. The top panel is the 'Layers' panel, titled 'Layers' with a close button 'x'. It lists the same layers as in Step 5. A red oval highlights the eye icons for the layers: R1BrittleNiad, R1StarryStonewort, R1Fanwort, R1CurlyLeafPondweed, R1EurasianWaterMilfoil, and R1TotalNumberofSpecies. The eye icon for R1TotalNumberofSpecies is crossed out. The bottom panel is a map showing a satellite view of a river with a series of colored circles (red, yellow, blue, purple, green) representing species distributions along the riverbank.

Step 7: You can view the Legend by clicking on the Legend tab: the darker the color and larger the size means a greater distribution of that species at that sampling point



Step 8: Return to the “2023 Lake Survey” tab and do the same for Round 2 and Round 1 and 2 AVG

