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A Submerged Buoy to Extend Data Collection Period in Lake Erie

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SEECS, Scholars of Excellence in Engineering and Computer Science, is a scholarship group funded by the National Science Foundation. We consist of 8 sophomore students with various engineering and computer science majors. This program helps us to develop our engineering skills and prepare for a professional work environment.

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Design and Construction of a Buoy to Extend Period in Lake Erie

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Introduction

In Lake Erie, there are growing levels of algae, which at high levels, can be disruptive to wildlife and harmful to humans who swim in the lake. The current buoys help track the algae's growth, but they are only in the water from May– October, there is a wide amount of missing data that could be used to stop the algae's growth and protect the lake and bay area. The Scholars of Excellence in Engineering and Computer Sciences (SEECS), a multi-semester program at Gannon University, is helping the Regional Science Consortium to engineer a submerged device that extends collection timeline and stores water quality data of Lake Erie. With the data collected from the extended timeline, the conditions under which algae is produced should become clearer and a solution for this problem can be created to save the lake.

Current Buoys and Locations

Figure 1. Current Buoy Image

Both figures were taken from the Regional Science Consortium website. In Figure 1, the current data collecting buoy is shown on the water during weather-permitting months. In Figure 2, the location of these buoys around Presque Isle State Park are mapped with a satellite image of Lake Erie.

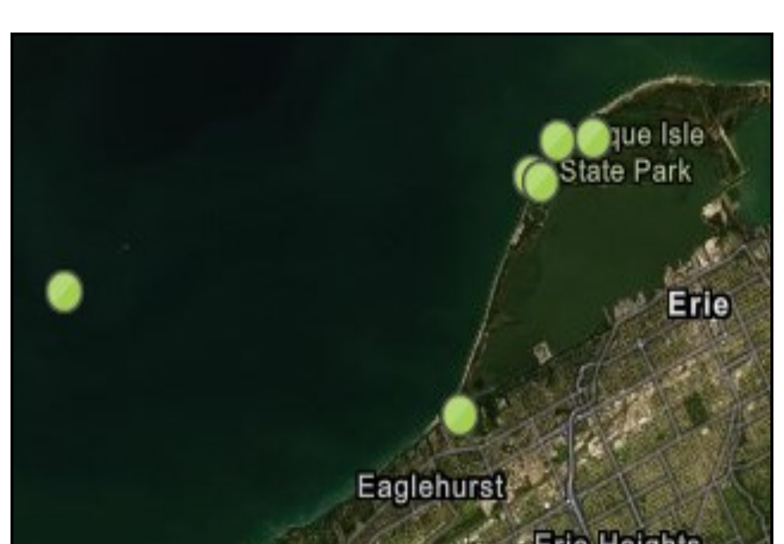

Figure 2. Current Buoy Locations

Technology

The measurement systems consist of an Arduino Pro Mini microcontroller and various circuit boards, shown in Figure 3. There is an SD card reader/writer, a resistive temperature measurement chip, a dissolved oxygen measurement chip, and a real time clock. The Arduino Pro Mini was physically altered to get immensely low power drain, it's power LED was cut, making it significantly less power hungry. The goal of this design was to maintain an immensely low sleep drain. Approximately 6 mA of draw during the sleep cycle, which lasts for 15 minutes as specified by the stakeholders. The system has two 36 Amp Hour batteries, shown in Figure 4, meaning that at its average current drain, it will last for 7-8 months of continuous operation before requiring a recharge. This allows for the system to autonomously collect data, track time, and maintain storage while completely isolated from external manipulation for a lengthy duration, which accomplishes the desired goal of this design.

Buoy Images

Figure 3. Inside of buoy

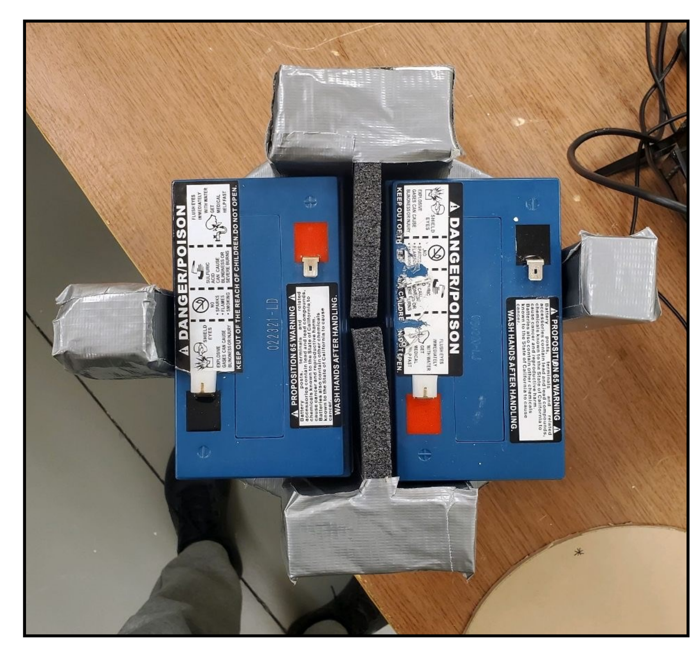

Figure 4. Battery Casing

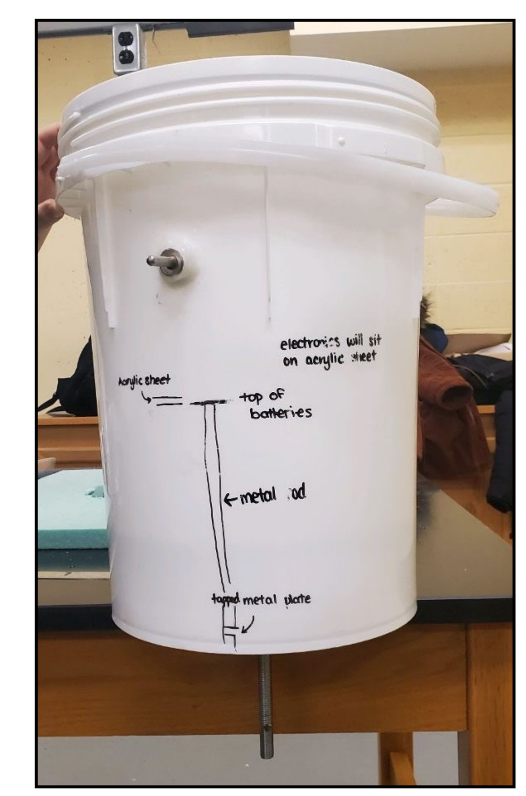

Figure 5. Buoy Containment

Anchorage

The buoy must be fully submerged underwater to keep it safe from possible ice damage. To do this, the plan is to anchor the device down with a metal chain. The length of the chain will be short enough to keep the buoy a safe distance from the surface of the lake to avoid ice. The chain will be connected to the metal rod coming out of the bottom of the buoy, shown is Figure 5, and to concrete blocks in the sand at the bottom of Lake Erie. The Regional Science Consortium already has concrete blocks to anchor the summer buoys that are not used during the time the submerged device will be deployed. Since the Regional Science Consortium has concrete blocks, the plan is to use their blocks to attach the metal chain and device. This also narrows down the anchorage location for the buoy to a location of one of the Regional Science Consortiums summer buoys after it is taken out of the lake.

Containment

The buoy's components are encased in a white bucket, shown in Figure 5. Previously, the components were to be encased within a 3D printed shell, but that idea was abandoned in favor of an existing water-tight material. This bucket has a screw-on lid and has been sealed with a combination of caulk and Flex Seal. The lid is watertight, but can be easily removed. This containment method was chosen as it fits all components easily and contains enough empty space to both float and resist damage due to pressure at its depth in Lake Erie. Likewise, the bucket is easily customizable and easy to drill through to fit each component. The dissolved oxygen probe and thermistor extend out of the bucket to be used for data collection while submerged.

Testing

After drilling holes into it for all the probes, the buoy's waterproofness and buoyancy needed to be tested. To perform these tests, the buoy was kept underwater while being weighed down with weights inside for around an hour. This test proved successful, as no water had managed to get into the bucket itself throughout the test. In addition, the buoy electronics' ability to handle cold temperatures needed to be tested. For this testing, the electronics were placed inside of a refrigerator over the course of a week while checking the internal components each day. In the end, this test proved successful as well, as the components functioned properly. There are also plans to test both qualities at once by placing the buoy inside of an ice bath sometime this semester.

Next Steps

As the project continues, we have several major steps planned. Before implementation, the DO probe and thermistor must be calibrated; current issues with the calibration process have caused the project to need repurchase probes as they have been damaged. The current battery casing is going to be remade. The current casing is made out of styrofoam and covered in duct tape; the new case is going to have a 3D printed shell that will be filled with expanding foam. The hope is that this new casing will have more structural stability. As additions are made to the bucket, primarily additions involving holes drilled into the bucket, waterproof testing must be reconducted to ensure any seals that have been made. A manual has been started and will contain information about how to use the buoy and why each component was chosen for the buoy. One of the final steps is choosing the anchorage for the buoy. The hope is to implement the buoy in the lake by next year's winter season.

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