

Ocean Acidification Tank Controller

PCB Redesign

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ABSTRACT

The focus of this project was to create a custom PCB for the Open Acidification Project's Original Tank Controller. This project was developed as components from the original controller have become obsolete. To accomplish this, parts compatible with the Raspberry Pi Pico 2 W board were selected. Pins from the Pico were allocated for these parts and then connected on a schematic. From this, the parts were placed on a four-layer printed circuit board (PCB), and the tracks were routed and optimized. The testing of the board included both physical and software examination. This design aims to provide scientists with a reliable and economic tool to research the effects of ocean acidification for many years to come.

INTRODUCTION

Beneath the waves, a silent threat that could reshape life in the sea and beyond is intensifying. As human activity grows, so does the amount of CO₂ pumped into the environment. When CO₂ is released, the ocean water absorbs a portion of it, lowering the water's pH [1]. This process, known as ocean acidification, has significant effects on marine ecosystems [1]. While this may be the case, it remains largely under-researched because testing equipment that monitors and replicates the environment in a controlled aquarium tank is very expensive.

To combat this issue, Dr. Kirk Onthank in the Biology Department at Walla Walla University proposed a solution. With help from various departments, an open-source and cost-effective device was created. This instrument, which can be seen in Figure 1, is known as a tank controller; it combines both software and hardware to monitor and control pH and temperature in an aquarium tank[2]. This controller belongs to a larger group of projects known as the Open Acidification Project.

A new project arose from the original Open Acidification Tank Controller Project [2] because certain components were discontinued or had become outdated, which made sourcing more difficult and more expensive. This new undertaking required the original tank controller's custom PCB to be designed.



Figure 1. Original Tank Controller [2]

DESIGN PROCEDURE

This project consisted of redesigning the original PCB using KiCad. One major goal was to swap out the current 120V-5V and 120V-9V buck converters with an affordable, readily available, and reputable power supply module. The Arduino Mega 2560 also needed to be swapped with another microcontroller as it is now considered obsolete. To accommodate this, the Pi Pico 2 W was selected, but due to the limited number of pins, several other components needed to be redesigned.

Along with these changes, the audio jack used for the temperature sensor was requested to be exchanged for a BNC connector. Another objective was to design the PCB with an emphasis on surface modules and components. This will simplify the process of assembling the board, as the surface-mounted components can be soldered onto the PCB during manufacturing.

RESULTS

The new PCB design was created with the Raspberry Pi Pico 2 W at the heart of it, as seen in Figure 2. From here, the different goals outlined in the design procedure were implemented. This included changing the audio jack to a BNC connector, which also required replacing the temperature sensor from a PT-100 to a PT-1000, and the temperature circuit was substituted from Adafruit to Atlas Scientific. Additionally, the Ethernet and SD card shield from the original project needed to be changed. To resolve this issue, this new project uses built-in WIFI with the option to use Ethernet instead. There is also a surface-mounted SD card socket.

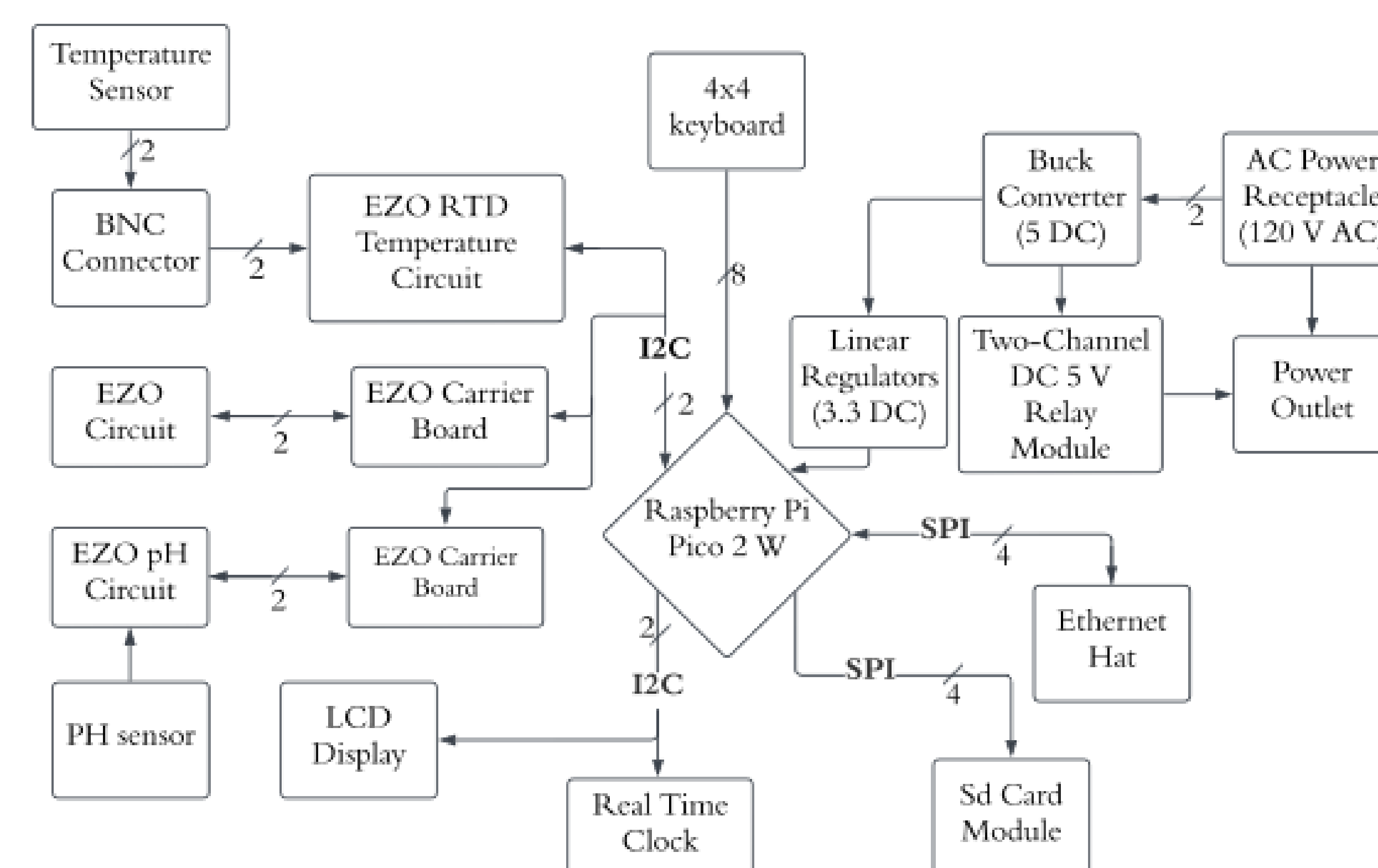


Figure 2. New Tank Controller Diagram [3]

One component that utilized an excessive amount of pins was the LCD display. For this reason, it was exchanged for a display that uses the I2C protocol, which only requires two pins. I2C also allows for peripherals to share the bus, which means multiple modules can be connected to the same pins. Components that were able to be transferred over from the original project include the real-time clock, EZO Carrier Board, EZO pH circuit, pH sensor, 4x4 keyboard, relay module, power receptacle, and power outlets.

RESULTS CONTD.

With these components in place, the power management system was designed. All the components on the new controller use 3.3V except the relay. Considering this, a buck converter that steps down the voltage from 120V to 5V was chosen to power the relay. A linear regulator then steps down the voltage from 5V to 3.3V.

All of these components can be purchased for less than \$250, which ensures this project continues to be a cost-effective solution to research ocean acidification. The completed PCB can be seen in Figure 3.

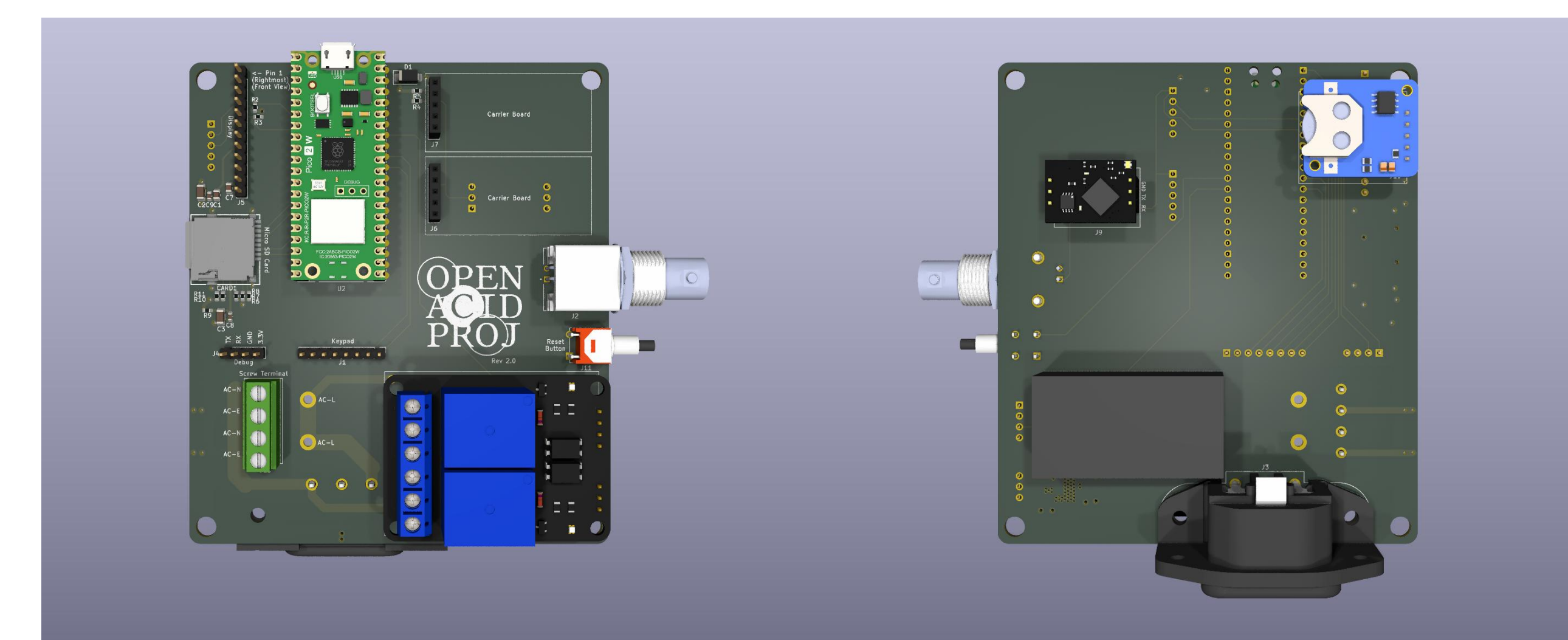


Figure 3. Front (Left) and Back (Right) of New Tank Controller PCB[3]

This project also consisted of a testing stage, which required both physical and software testing. Physical tests include an initial visual inspection of the board to ensure there was no damage during shipping, continuity analysis of signals from the Pi Pico 2 W to their designated output pins on the PCB, and verifying the power outputs of traces. With this completed, testing the basic functions of the components through software was also required. First the functionality of the Pi Pico was tested by blinking the on-board LED. Next both the pH and temperature circuit's protocols were manually switched to I2C and programmed to receive data from their respective sensors. The SD card operation was tested by writing and storing a text file to the micro-SD card. Next, the relays' operation was verified with an audible click noise from each relay when switched on and off. Similar testing procedures were used for the keypad, real time clock, and LCD. Everything was verified to work except the ethernet hat which was improperly placed onto the board during testing. This does not notably impact the project as the Pi Pico 2 W includes built-in Wi-Fi.

SUMMARY

The goal of this project was to revive the Open Acidification Project's Original Tank Controller. This was achieved by creating a custom PCB, which had upgraded parts from reputable sources while also remaining economical. This will ensure the controller's longevity for the foreseeable future.

REFERENCES

- [1] Environmental Protection Agency, "Effects of Ocean and Coastal Acidification on Marine Life," EPA, Oct. 21, 2024.
- [2] K. L. Onthank, J. Foster, and Preston, "The Open Acidification Tank Controller: An Open-Source Device for the Control of pH and Temperature in Ocean Acidification Experiments," HardwareX
- [3] J. Cordova, *Ocean Acidification Tank Controller PCB Redesign*, unpublished manuscript, 2025.