Artificial Reef for Life Detection

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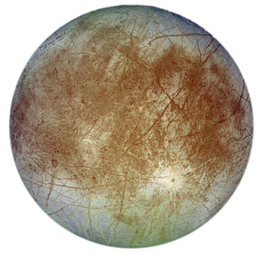
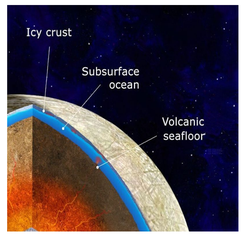


Possibility of Life on Europa

The discovery of life beyond Earth would mark a transformative milestone in our understanding of evolution, planetary habitability, and adaptation to extreme environments. Jupiter's moon Europa has strong potential for extraterrestrial life with its key requirements for life: liquid water, essential chemistry (CHNOPS), and a source of energy. Together, these conditions suggest a strong possibility for life to exist beneath its icy surface in microbial form or large scale.



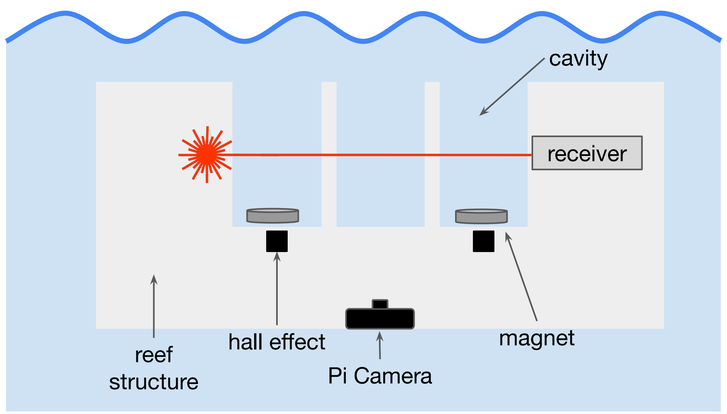
Finding Life Under Uncertainty

The system shall:

- detect life from 10s of millimeters to centimeters
- validate life detection through capturing pictures
- be durable and autonomous for extended remote deployment

Reefs for Detecting Life

Living organisms on Earth tend to inhabit structures placed in their environment. If this is a general property of life, offering homes and hiding places can enable the detection of life elsewhere.

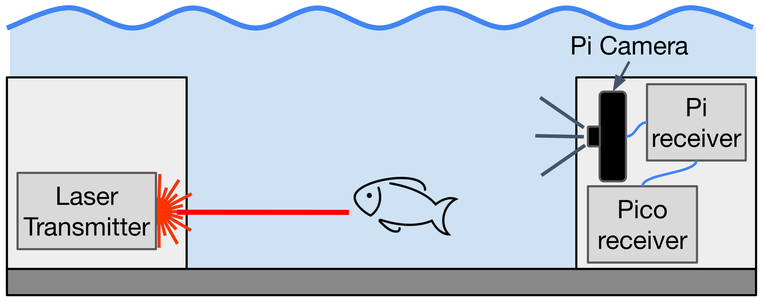


2 main detection systems were explored:

- Beam break system using a laser and photoresistors
- Motion detection system using hall effect sensors and magnets

For proof the system accurately detects life, a Pi Camera is installed to capture images when a detection system is triggered.

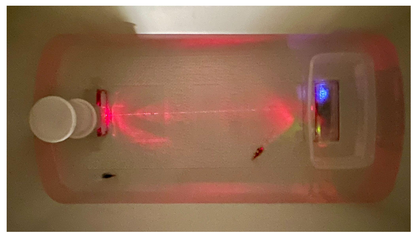
Detection of Reef Visitors

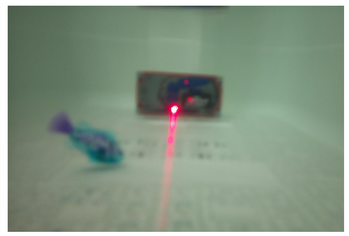


The reef consists of 2 waterproof enclosures mounted on an acrylic base.

- Enclosure 1: laser diode transmitter
- Enclosure 2: photoresistor-based receiver, Pico, Pi Camera, Pi 4

Under significant changes in light intensity, the Pico will signal the Pi 4 to capture an image.





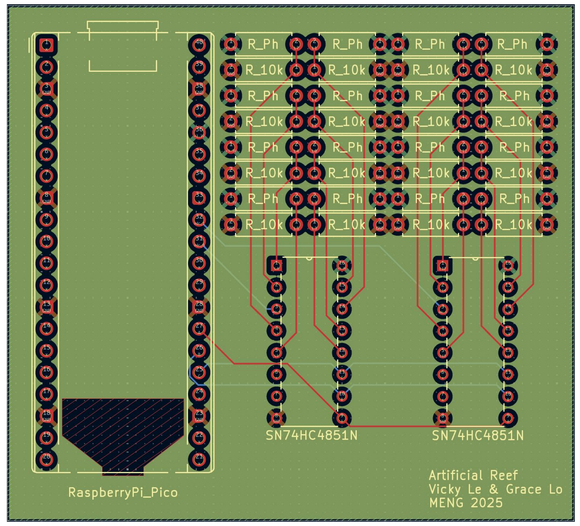
A 3-hour underwater test of the artificial reef was completed at a distance of 4 feet & depth of 1 foot. The system successfully detects life in light, dark, and turbulent conditions with captured images showing the presence of fish. Light refraction due to turbulence can be reduced by increasing the system's depth.

Condition	Average Current (mA)
Bookworm Lite	488.47
Bullseye Full (running off of desktop)	480.57
Headless via SSH	452.85
Headless + Disabling USB	454.02

The Pi Camera is the most power-intensive component and turns on briefly when triggered by a detection system. Power tests were completed for the ideal setup. The largest power reduction came from running a headless system by removing peripherals and further disabling input ports did not show much difference. For a 3-hour test, the entire system consumed ~2000 mAh of power.

Printed Circuit Board

In open air, the photoresistors can accurately measure laser beams from 18.5 ft away in both light and dark conditions. A 66 mm x 60 mm PCB with a tightly-packed photoresistor array was designed to improve the measurement distance and address laser attenuation underwater.



Conclusions

An artificial reef capable of life detection on the centimeter scale under light, dark, and turbulent conditions was constructed, with results confirmed through pictures.

Next Steps

- Add redundancy to increase probability of detection
- Construct reef structure to include hall effect sensor chambers
- Integrate life attractor systems (eg. light, low-frequency sound)
- Implement self-sustaining energy (eg. solar or tidal)
- Develop long distance communication (eg. wave morse code)
- Explore cellular-scale life detection

Acknowledgements

We would like to thank Professor Hunter Adams for his guidance, feedback, and support throughout this project and Professor Skovira for providing supplies that were essential to the development process. Lastly, we would like to thank our dearest friend Anne for checking in on us during our underwater tests.