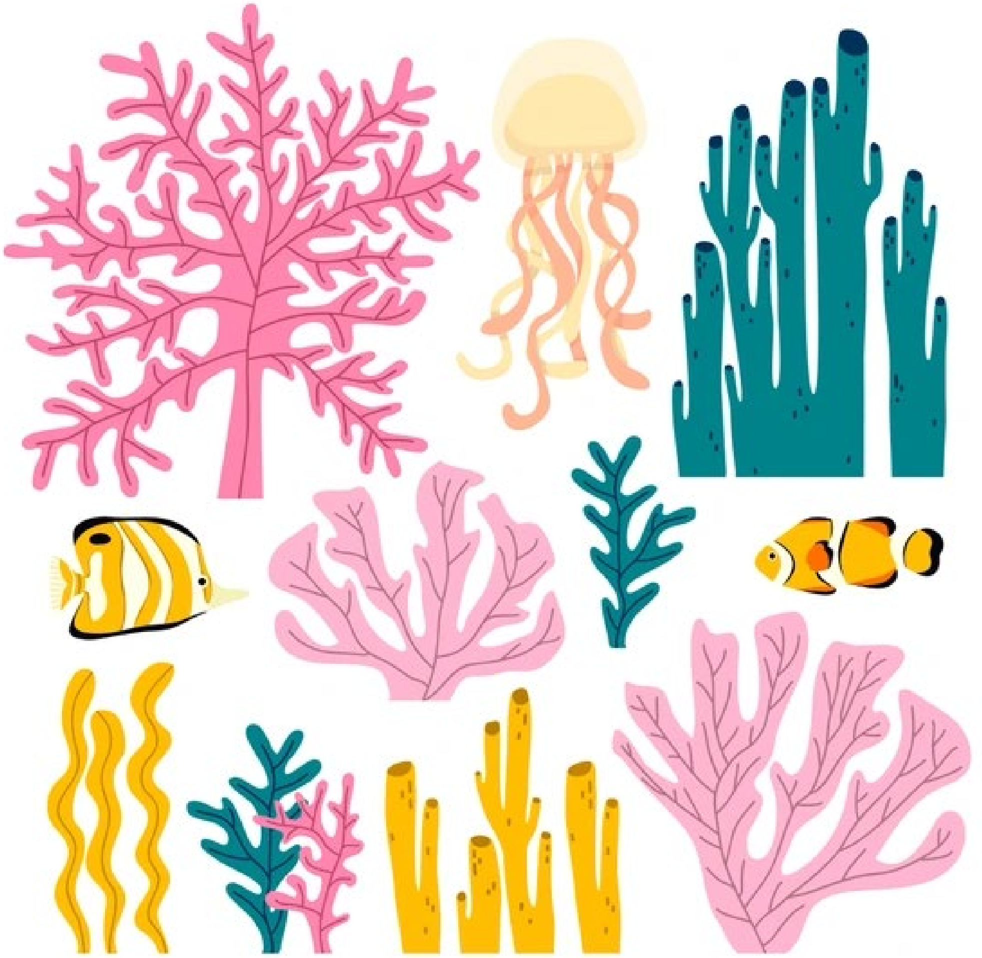
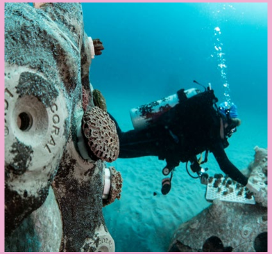


Underwater Coral Restoration Bot

Noah, Apurva, Nico

Problem


[3]

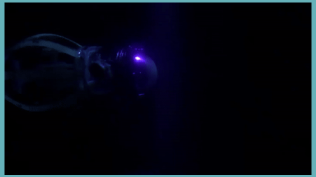
Coral restoration currently requires manual effort from scuba divers, which is difficult, time-consuming, and costly. [1]

Remote monitoring of coral reefs is unreliable, and conventional propellers for locomotion disturb marine creatures. [2]

[1] C. Erbe et al., "The effects of ship noise on marine mammals-A Review," Frontiers, https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2019.00606/full (accessed Nov. 6, 2024).
[2] J. D. Hedley et al., "Remote sensing of coral reefs for monitoring and management: A Review," MDPI, https://www.mdpi.com/2072-4292/8/2/118 (accessed Nov. 6, 2024).
[3] Ocean Rescue Alliance International, https://www.oceanrescuealliance.org/ (accessed Nov. 6, 2024).

Approach

Our solution is to develop an underwater robot powered by a fluidic actuation system that can monitor coral restoration efforts without disturbing marine life.


[4]

[4] C. Christianson et al., "Cephalopod-inspired robot capable of cyclic jet propulsion through shape change," Bioinspiration & Biomimetics, vol. 16, no. 1, p. 016014, Jan. 2020, doi: https://doi.org/10.1088/1748-3190/abbc72.

Results

We've achieved successful tethered underwater motion with a robot built from a linear actuator, four flexible TPU beams, acrylic plates top and bottom plates, and a thin flexible outer membrane.

A future goal would be to integrate the control system into the body for fully untethered locomotion, possibly using a ring oscillator to reduce the necessary electronics.


[5]

Impact

Our underwater robot would help researchers gather more data on coral reefs using less invasive/disruptive methods by eliminating the need for propellers in a cost-effective and easy to replicate robotic solution

[5] T. Conversation, "Biodiversity helps coral reefs thrive – and could be part of strategies to save them," Raw Story - Celebrating 20 Years of Independent Journalism, https://www.rawstory.com/2019/06/biodiversity-helps-coral-reefs-thrive-and-could-be-part-of-strategies-to-save-them (accessed Nov. 6, 2024).

Initial Research

Literature: "Cephalopod-inspired robot capable of cyclic jet propulsion through shape change" by Christianson et. al [4]

Key takeaways:

- Underwater locomotion strategy– fillable cavity covered with membrane that rapidly shrinks and forces water out
- Reference experiment uses hard rack-and-pinion actuator

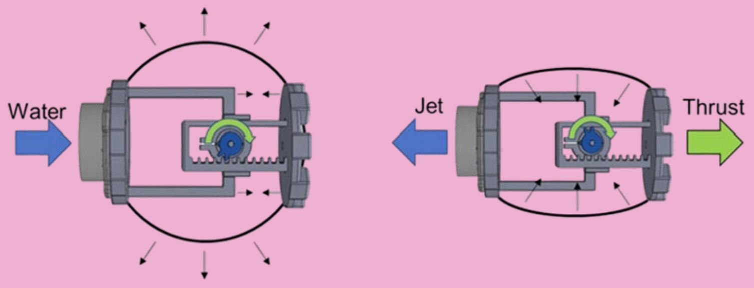


Figure 1: hard-robotics-based jet propulsion approach. Adapted from [4].

Literature: "An experimental study of bellows-type fluidic soft bending actuators under external water pressure" by Sun et. al

Key takeaways:

- Hydrostatic pressure neutrally or positively affects fluidic actuator behavior → good for underwater use
- Informed our switch to a soft fluidic linear actuation as the primary actuation mechanism

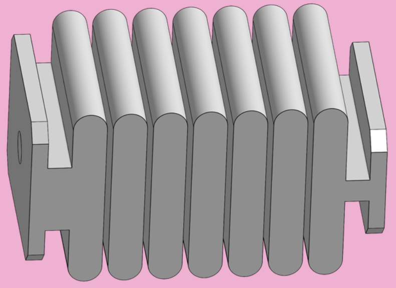
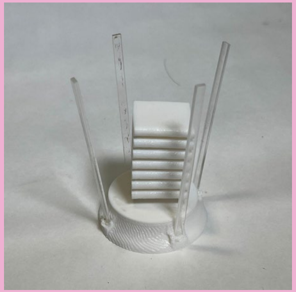


Figure 2: our linear bellows-style actuator design

[4] C. Christianson et al., "Cephalopod-inspired robot capable of cyclic jet propulsion through shape change," Bioinspiration & Biomimetics, vol. 16, no. 1, p. 016014, Jan. 2020, doi: https://doi.org/10.1088/1748-3190/abbc72.

[6] E. Sun et al., "An experimental study of bellows-type fluidic soft bending actuators under external water pressure," Smart Materials and Structures. vol 29, July 2020, doi: https://doi.org/10.1088/1361-665X/ab9518 .



V1

V2

V3

V4

Body Design Iterations

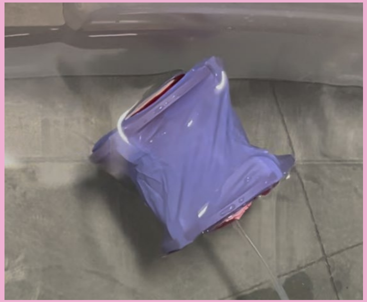
- V1: TPU frame with acrylic beams
    - Acrylic beams not flexible enough
- V2: Acrylic frame with TPU beams
    - Beams too flimsy
    - Hard to connect actuator
- V3: Redesigned actuator with tabs
    - Thicker beams too thick
- V4: Redesigned beams for better flexibility at attachment
    - Tested with different membranes

Membrane Iterations

Balloon

- Hard to stretch over frame
- Too tight – actuator not able to fully extend

Rubber Glove

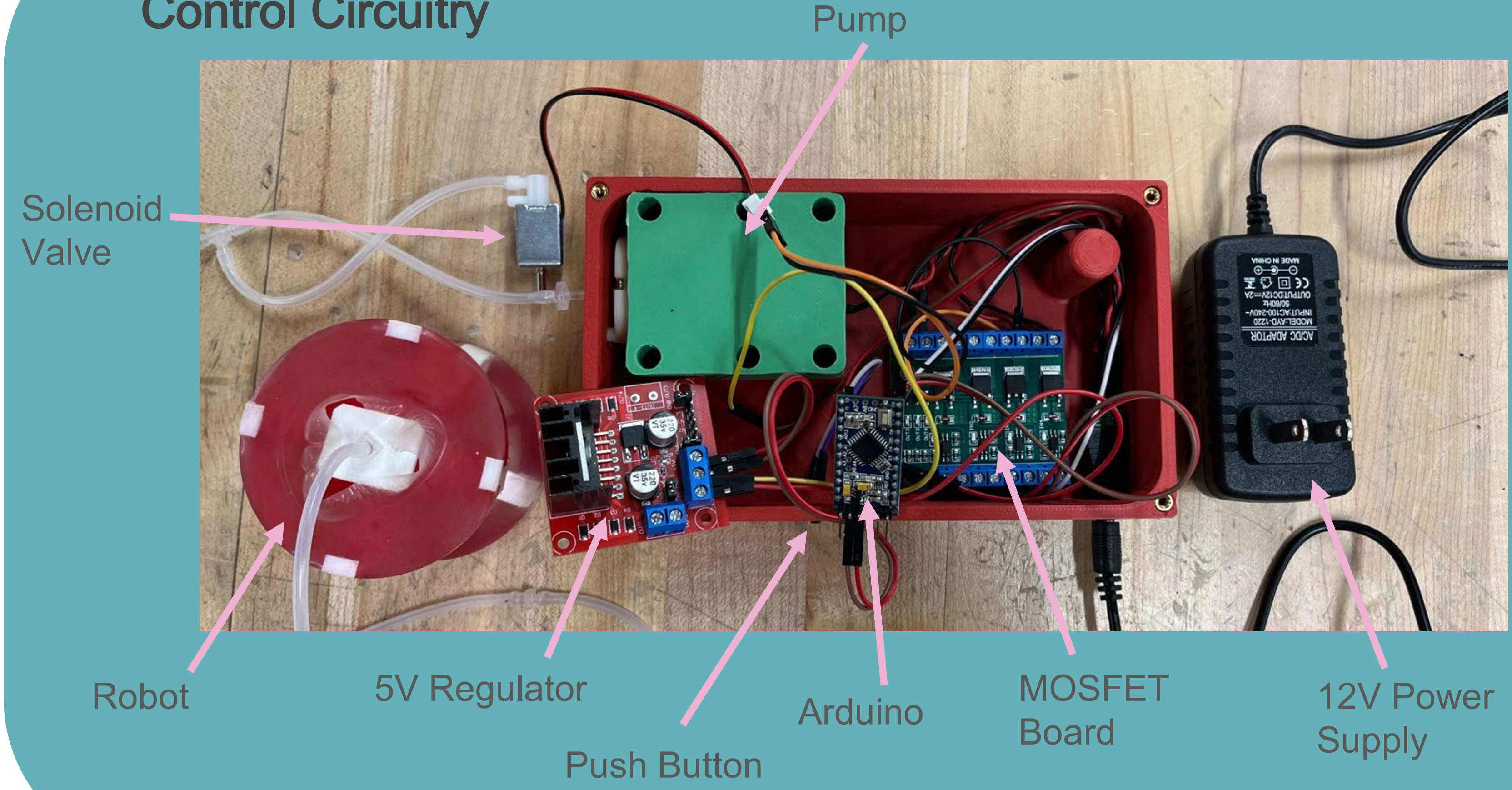


- Easy to apply
- Too loose – less volume change
- Opaque – not cool

Contraceptive Membrane

- Consistent cylindrical shape
- Flexible yet strong
- Plenty of stretch – more volume change

Control Circuitry



Cephalopod in Action

Project/Course Takeaways

Engineering Knowledge

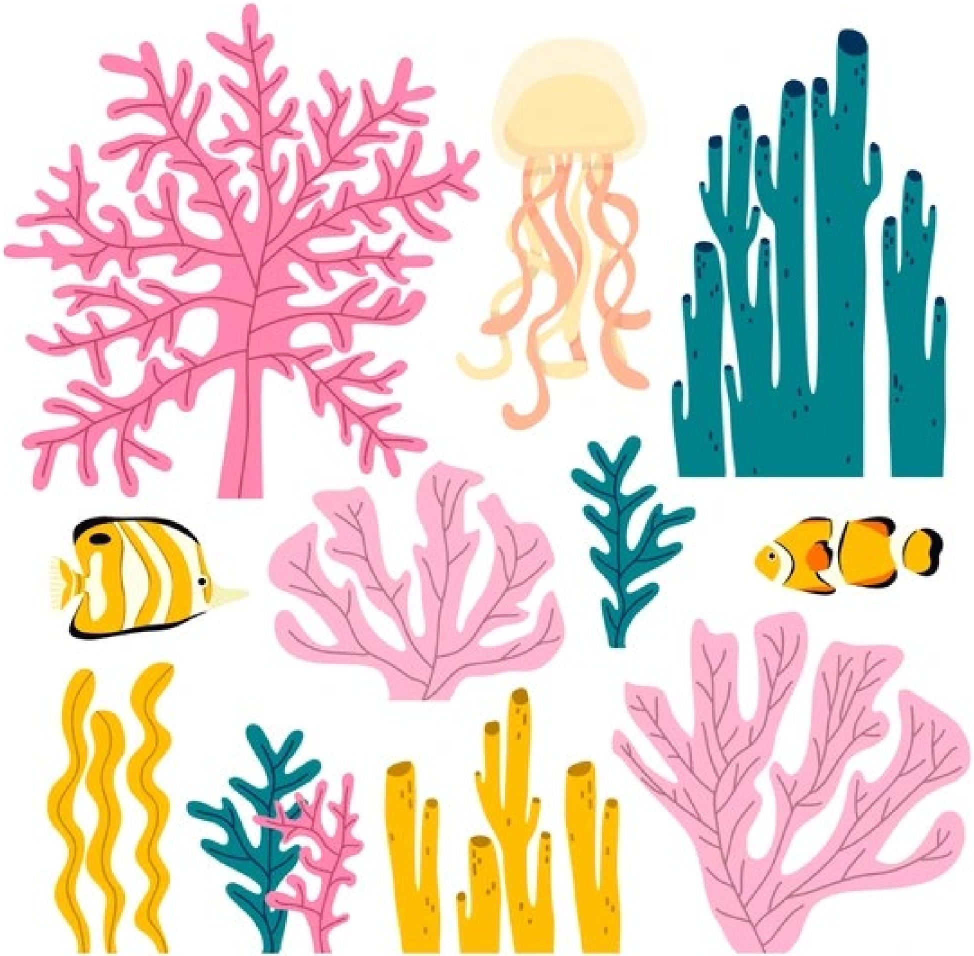
- Learned to think differently about materials and how material properties can be leveraged to produce desired outcomes
- Learned about jet propulsion and the fluid dynamics behind this concept

3D Printing Skills

- Learned how to better design models for successful printing (ie. limiting overhangs and bridges)
- Gained experience working with GCode files & modifying print parameters to produce desired print properties
- Learned how to troubleshoot and repair clogged 3D printers

Project Planning

- Weekly check-ins helped keep us on track and pivot on designs and ideas as needed to develop a successful final prototype
- Learned to balance final project work with other assignments, including planning final project prints around those needed for labs



Thank You!

Questions?