2.017 Final Presentation

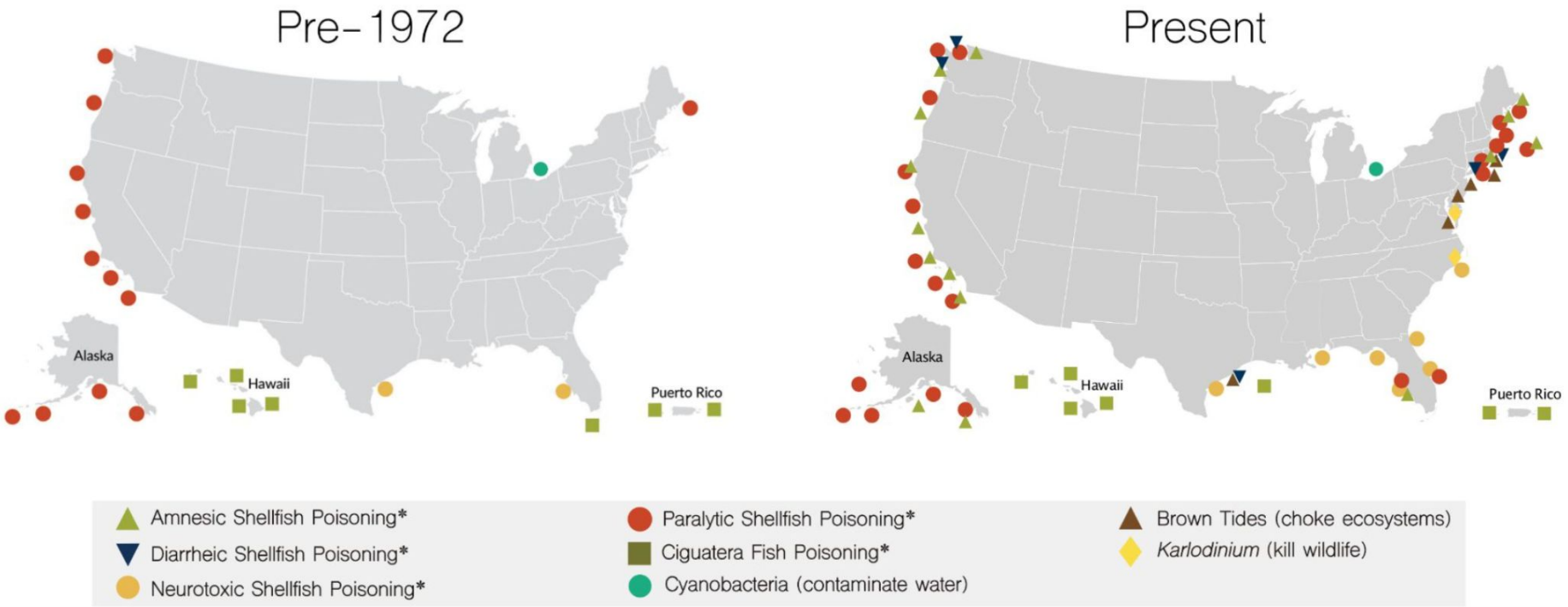
Twin Pickles - ASV with a Sediment Sampling System

Part 1:
Why it matters

Harmful Algal Blooms

Alexandrium monilatum bloom in the York River. Photo by W. Vogelbein, VIMS

HABs are getting worse



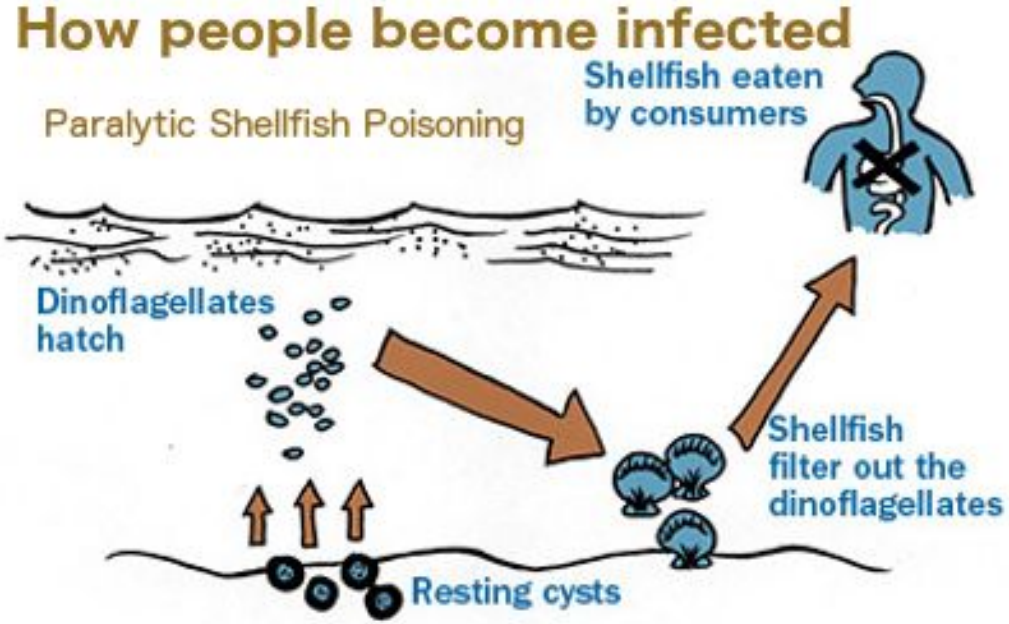
*Make people sick; learn more at: https://www.cdc.gov/habs/index.html

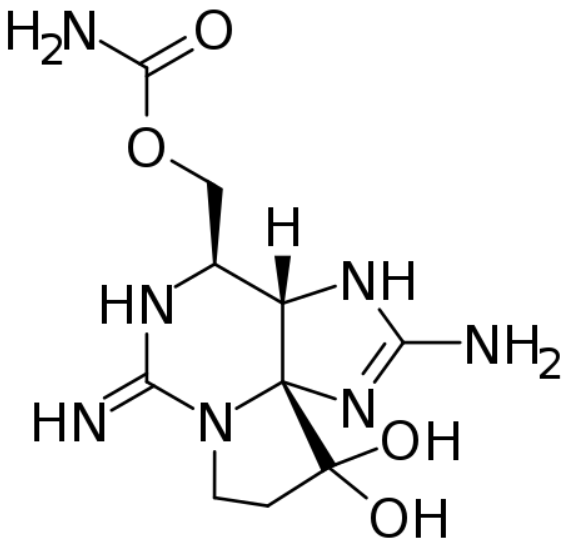
"Present" includes events through 2017. Inland freshwater harmful algal blooms are pervasive across the U.S. but are not shown here

Graphic from the National Office for Harmful Algal Blooms at Woods Hole Oceanographic Institution

Project Focus - *Alexandrium Catenella*

Can cause paralytic shellfish poisoning

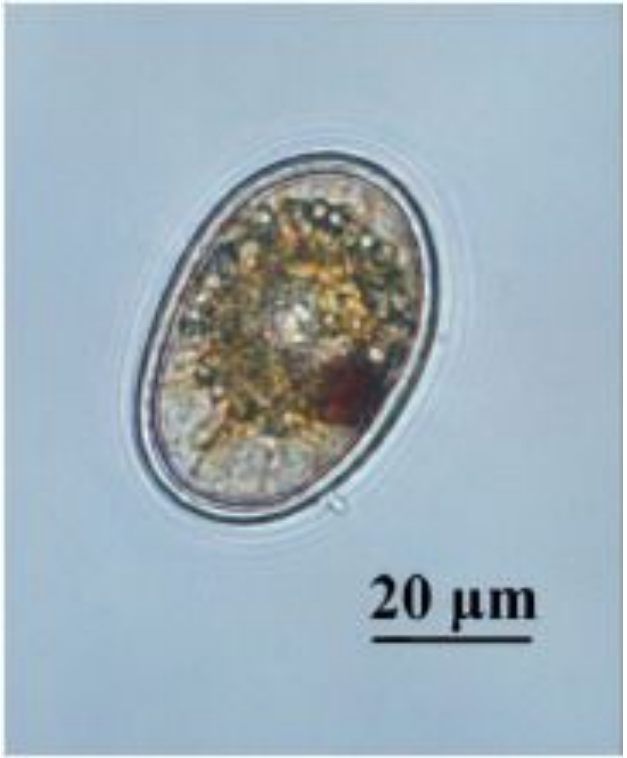




Saxitoxin, the most common PSP molecule

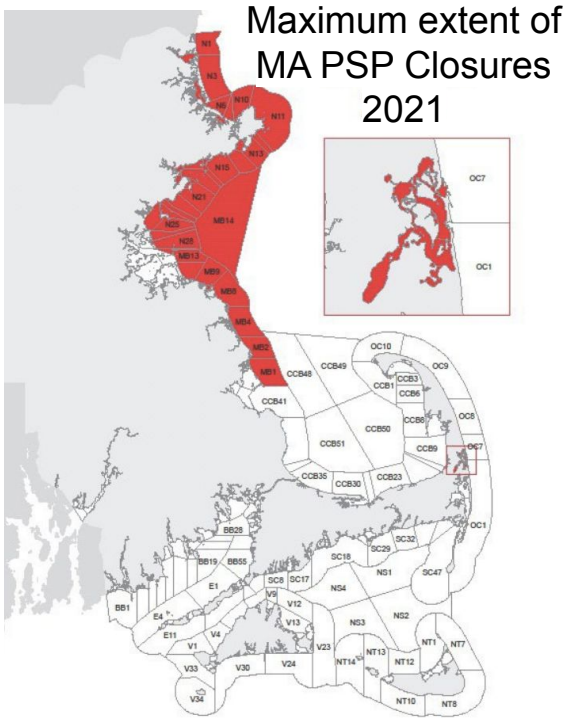
What are cysts?

- A dormant stage of algae
  - What causes cysts to germinate is not well understood
  - Cysts can be detected and studied using soil sampling
- Hope to increase number of soil samples while decreasing the cost of collecting soil samples

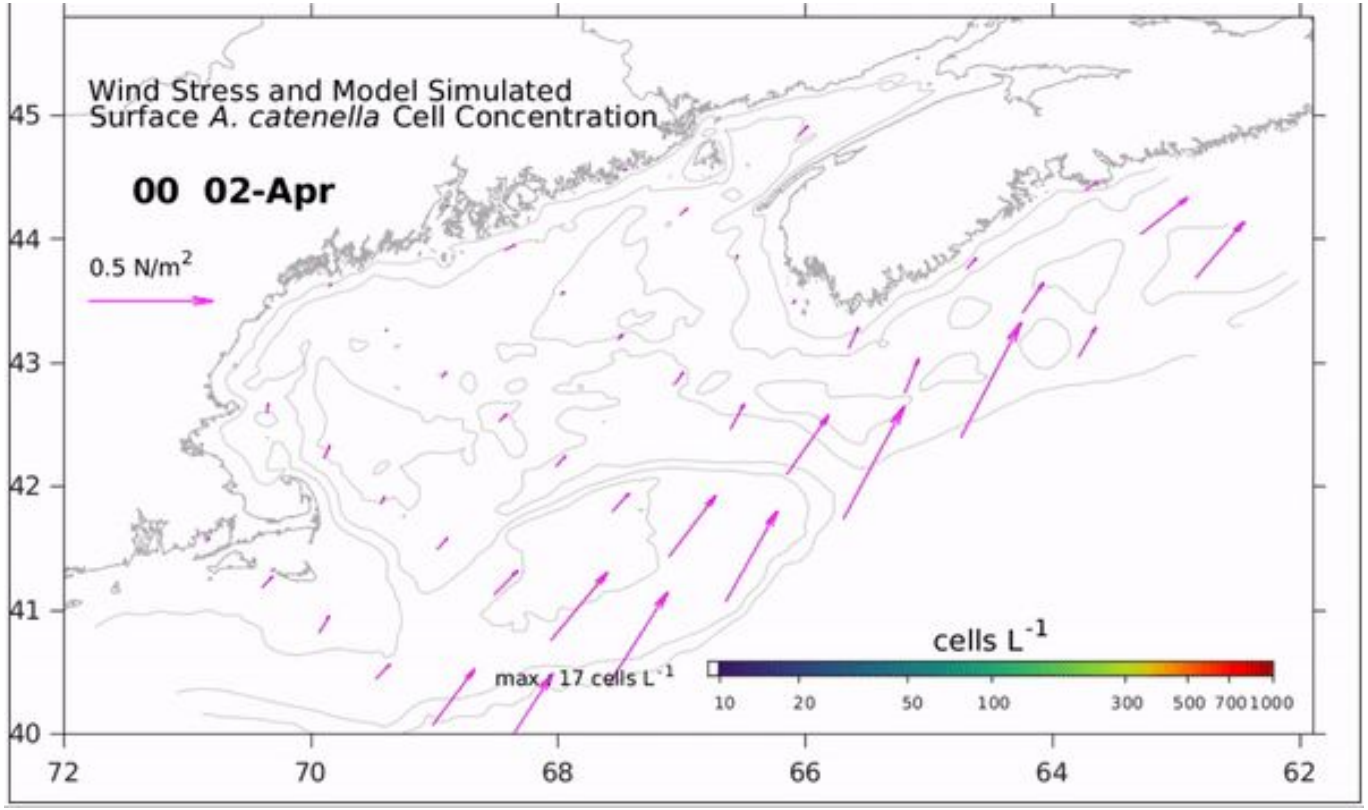


Forecasting of *Alexandrium Catenella* is important to

- Protect food sources
- Warn aquafarmers
  - $840M MA Seafood Market
- Warn regulators
- Warn consumers
- Predict oxygen-depleted dead zones



Department of Fish and Game Massachusetts Division of Marine Fisheries 2021 Annual Report



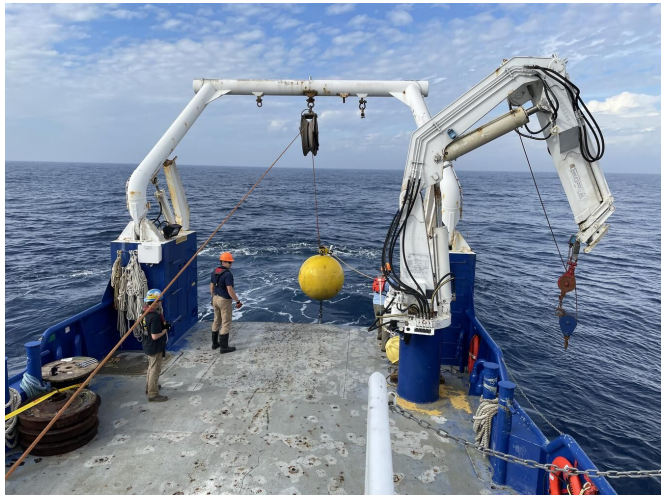
NCCOS Experimental Gulf of Maine harmful algal bloom model

Removing data collection bottleneck to accelerate research

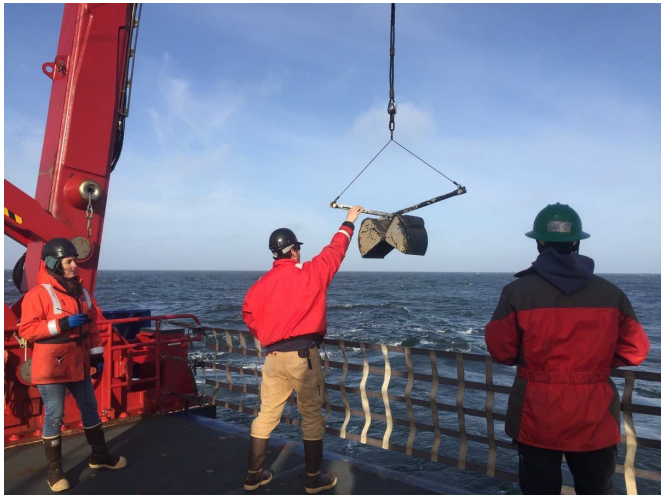
More data collection → Better forecasting → Better outcomes

Current Solutions

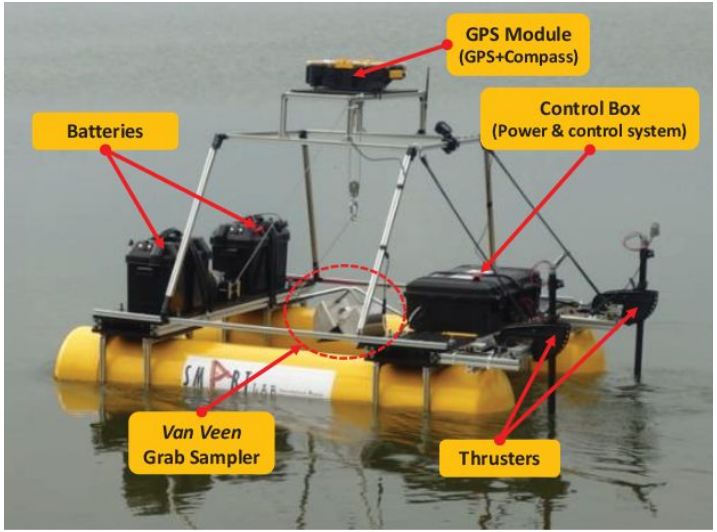
Stationary buoys

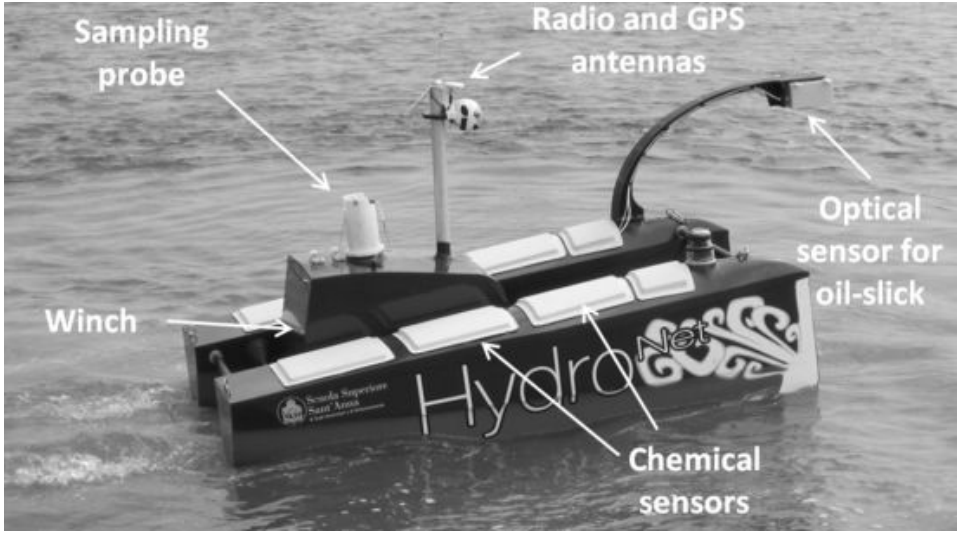


Traditional field testing



Sampling Vehicles





Our Approach

Environmental Challenges

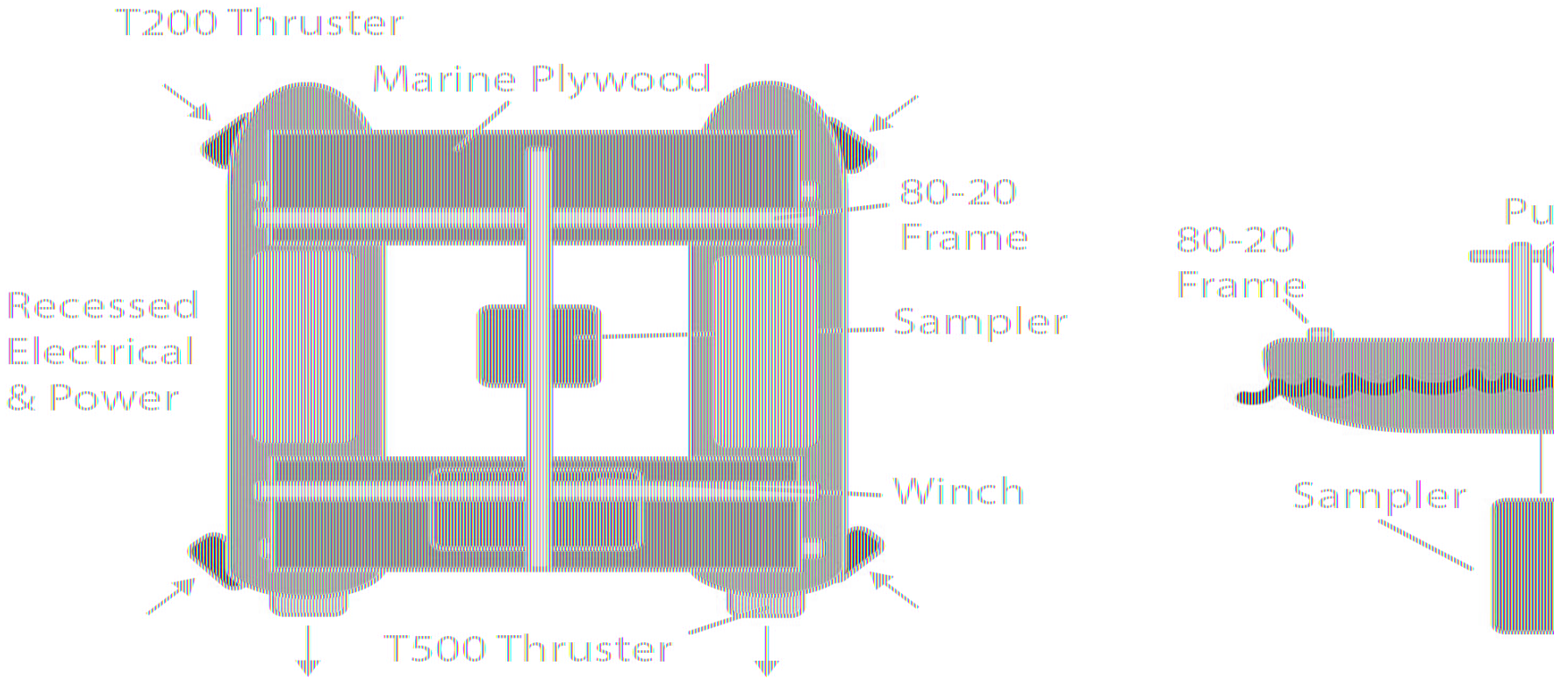
- Navigating foul weather and adverse currents
  - Stationkeeping
- Biofouling
- Various sediment conditions
- Entanglement
- Data quality
  - Cross-contamination
  - Temperature degradation

2.017 Objectives

- Need
  - Collect single sediment sample
  - RC control and stationkeeping
- Stretch Goals
  - Collect in-situ sensor data
  - Detect when safe to deploy
  - Get feedback from tension of cable
  - Integrate autonomy with waypoints

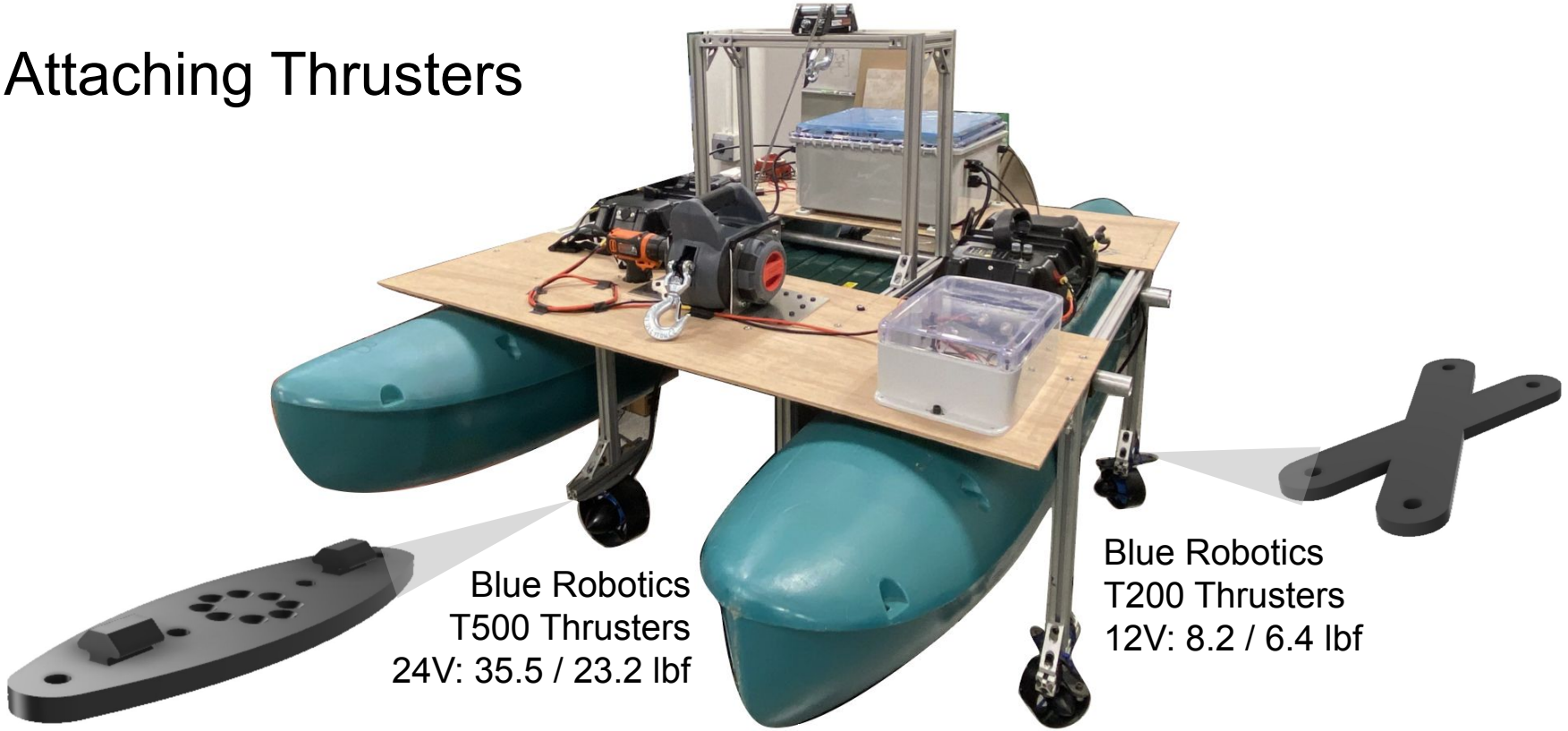
Part 2:
How we did it

ASV mechanical design



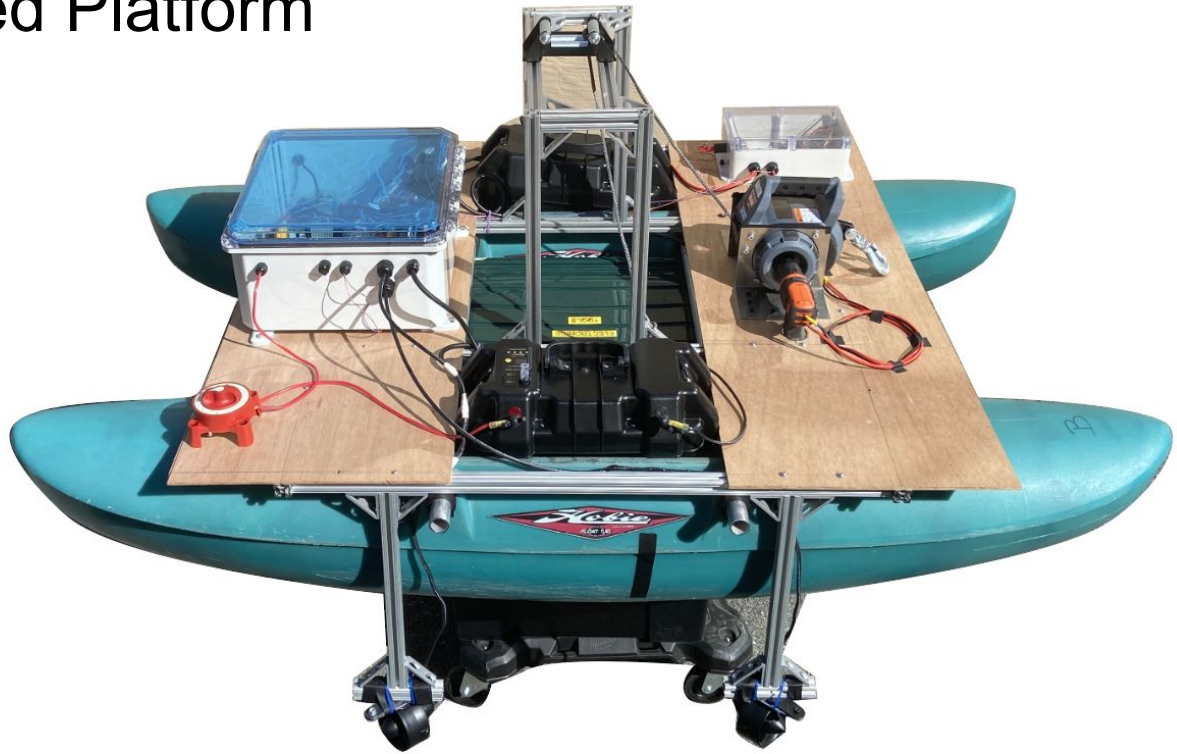
Mounting Platform

Attaching Thrusters



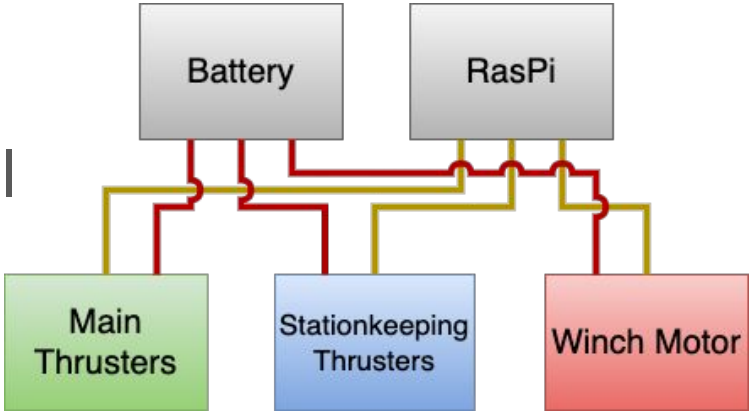

Warn Drill Winch
750 lb capacity
Black and Decker
12V Cordless Drill
Custom ⅛”
Aluminum
Brackets

Completed Platform



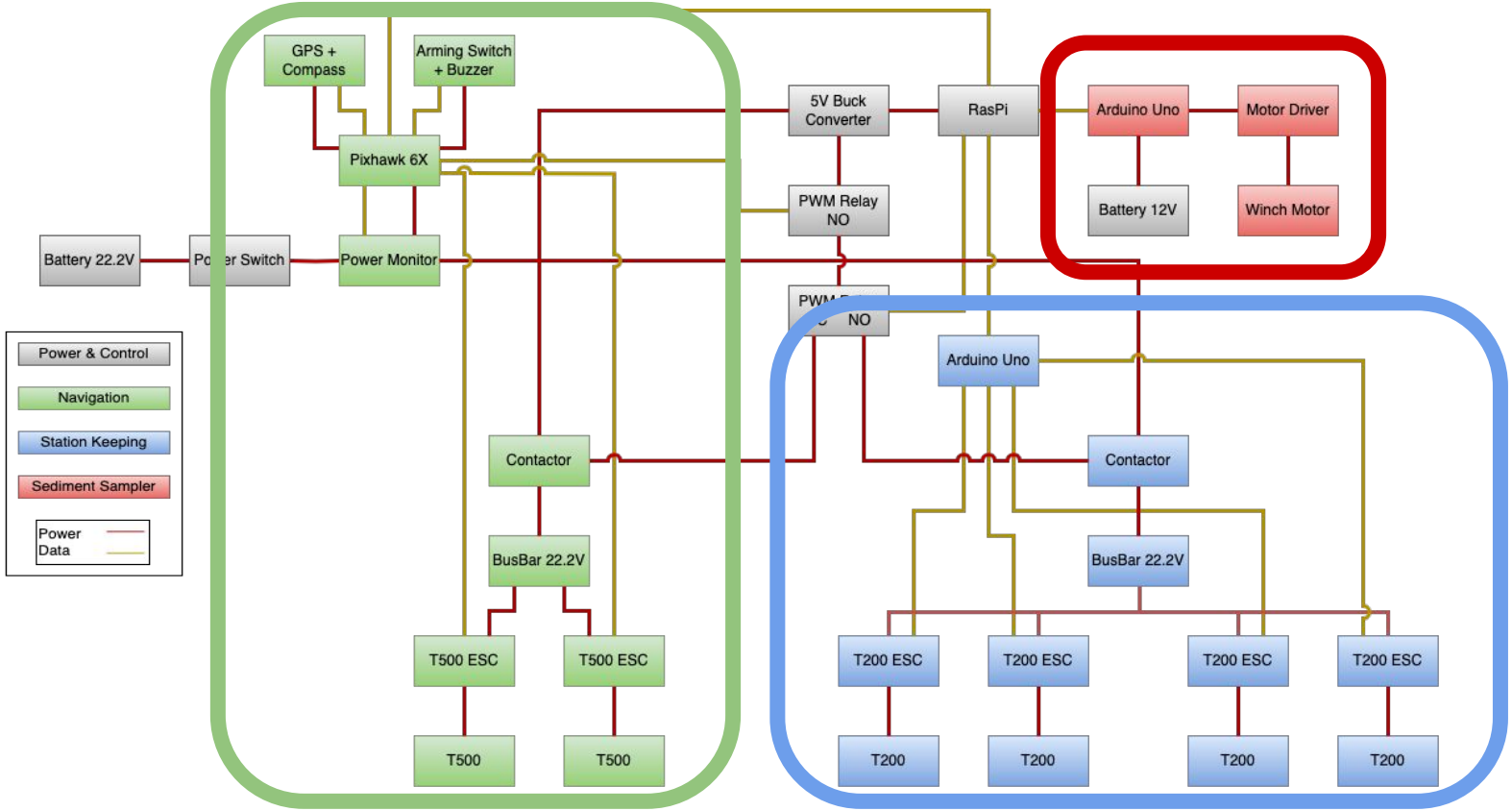
Electronics

Electronic System Goals

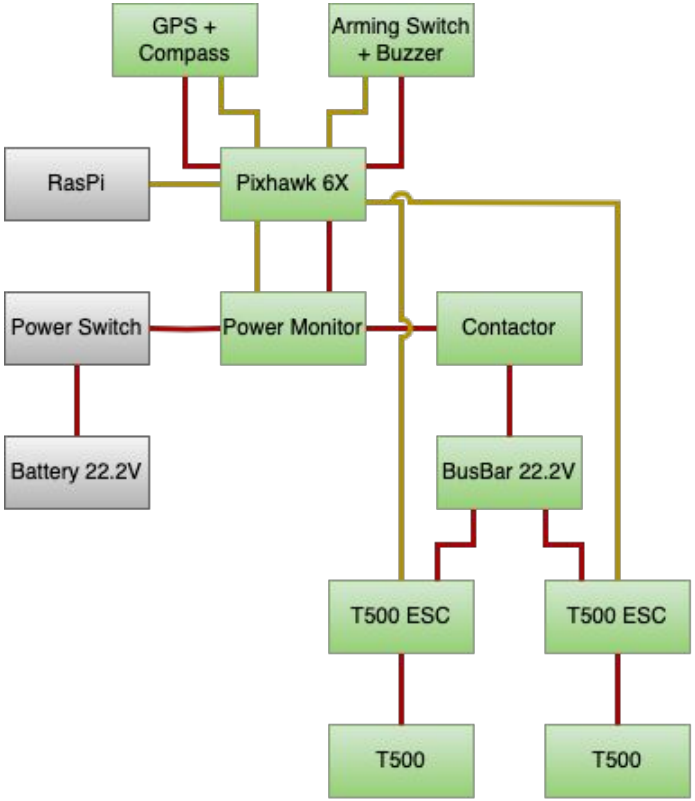


- Power Management and Control
- Propulsion
  - Stationkeeping Thrusters
  - Main Navigation Thrusters
- Sediment Sampler Automated Deployment and Recovery
- Navigational Control and Communications

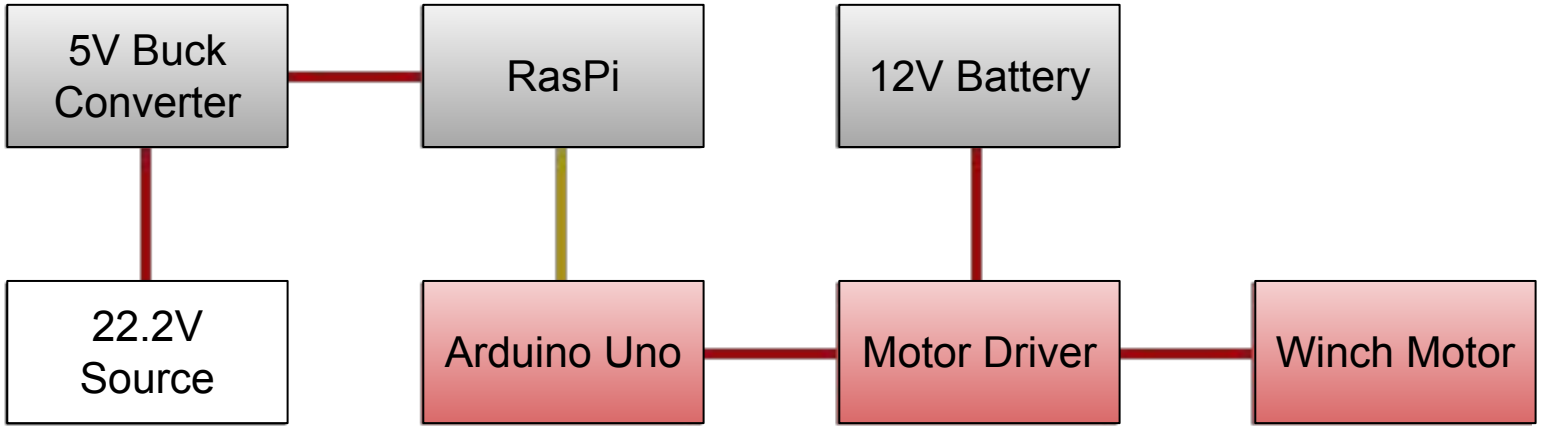
Power and Signal Diagram



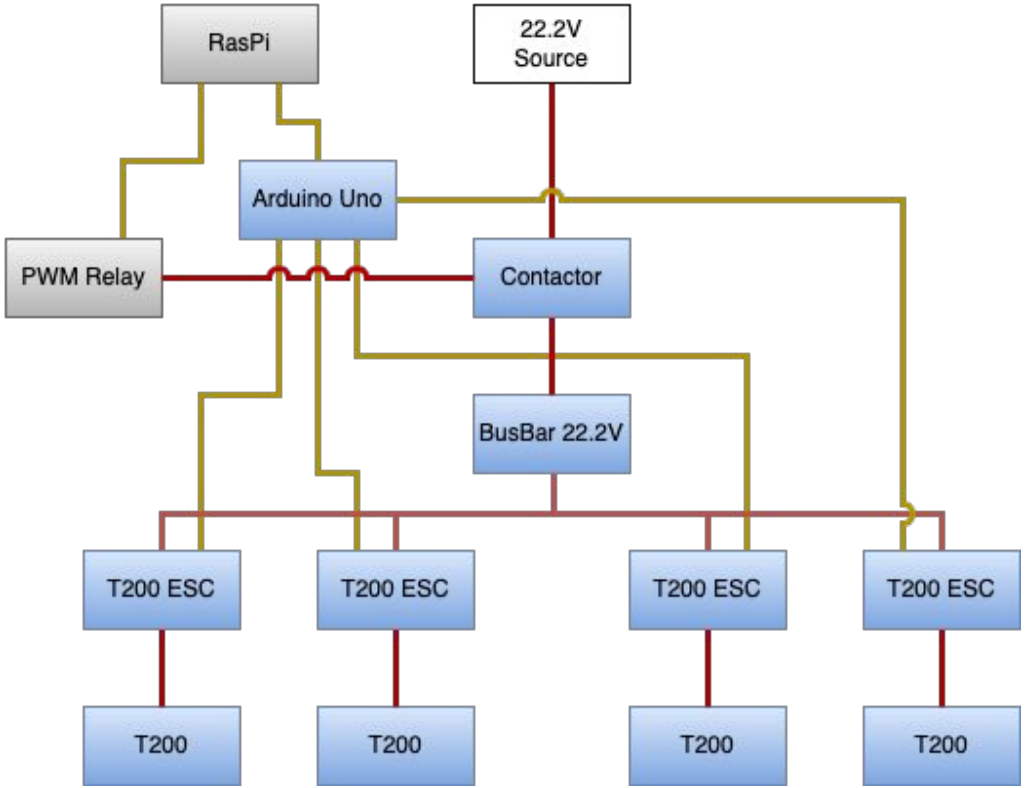
Main Thruster Subsystem



Winch Subsystem



Stationkeeping Subsystem



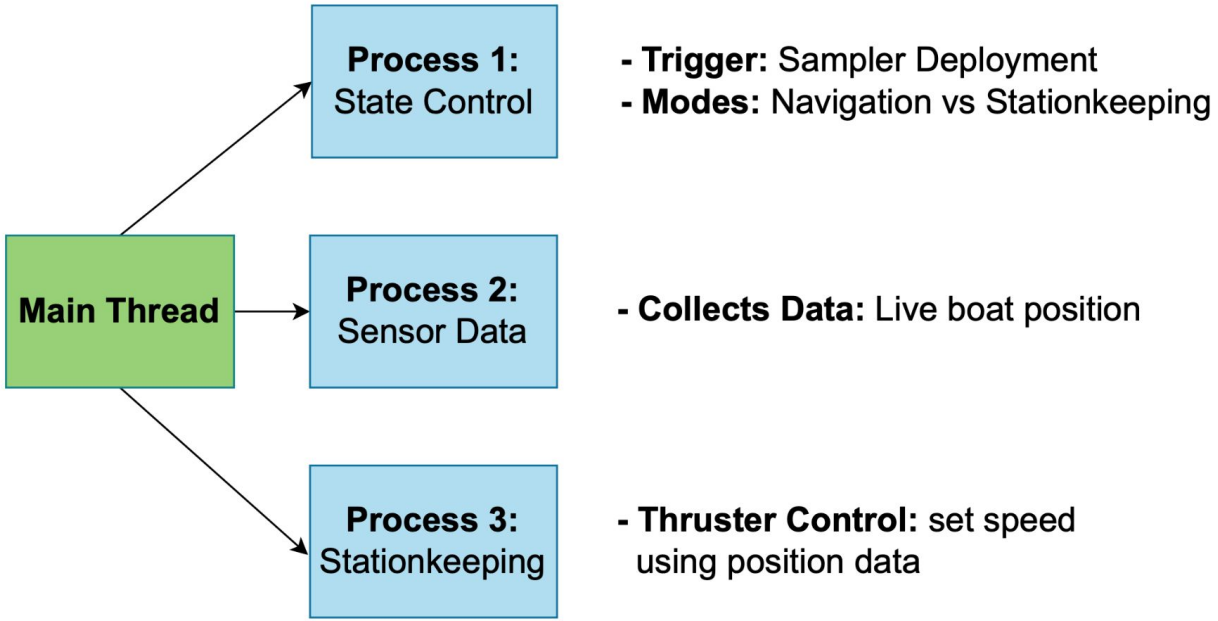
Controls

Control and Autonomy

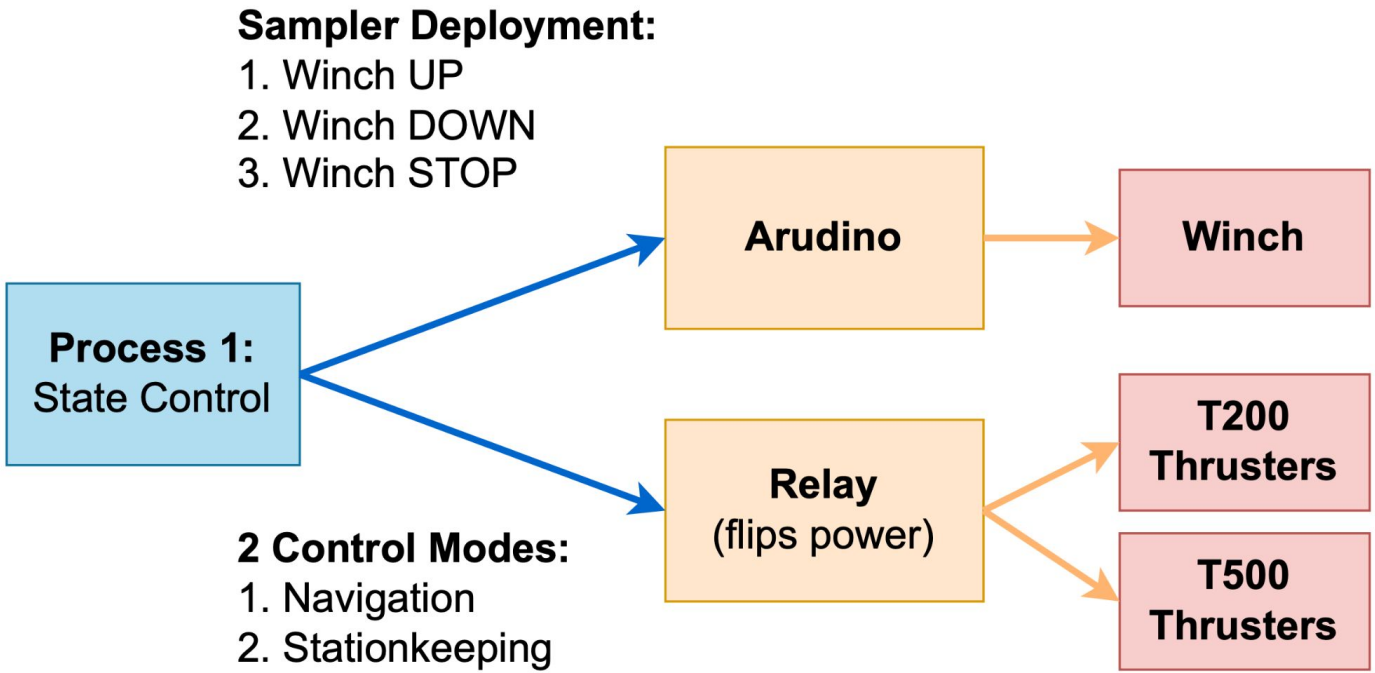
Three key ideal aspects of autonomy:

1. Waypoint Finding
2. **Stationkeeping**
3. **Sampler Deployment**

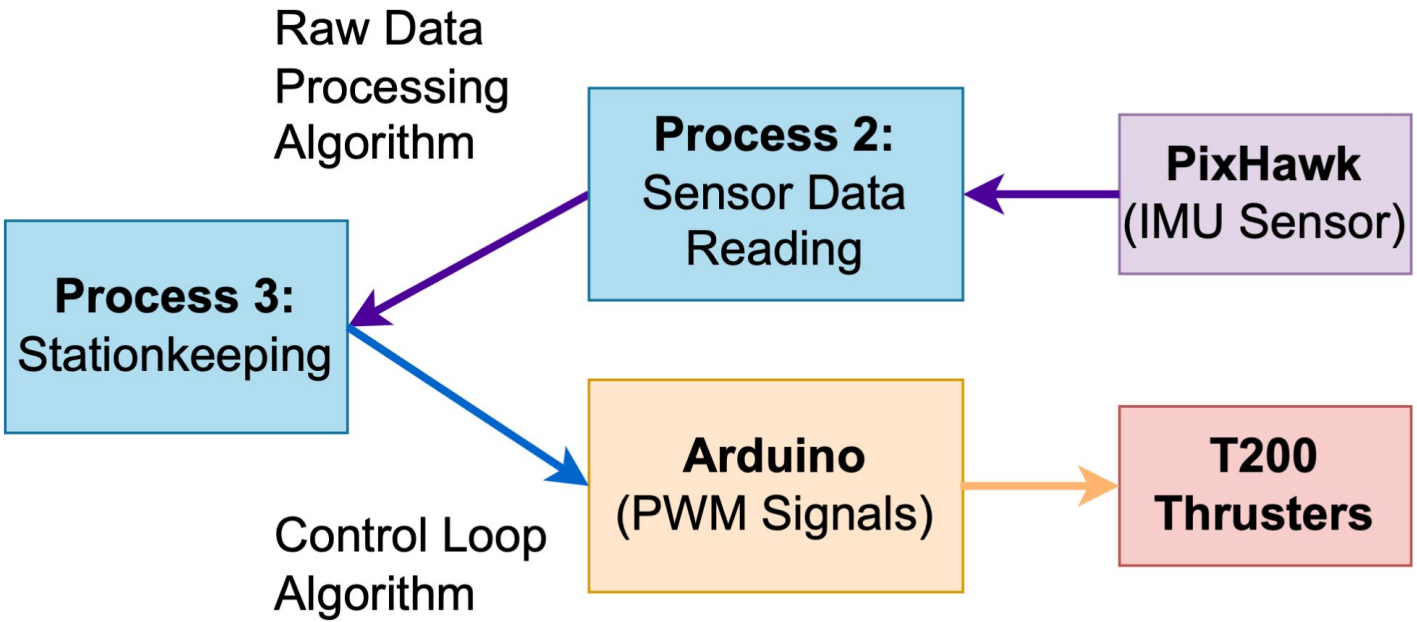
Main System Processes (on Raspberry Pi)



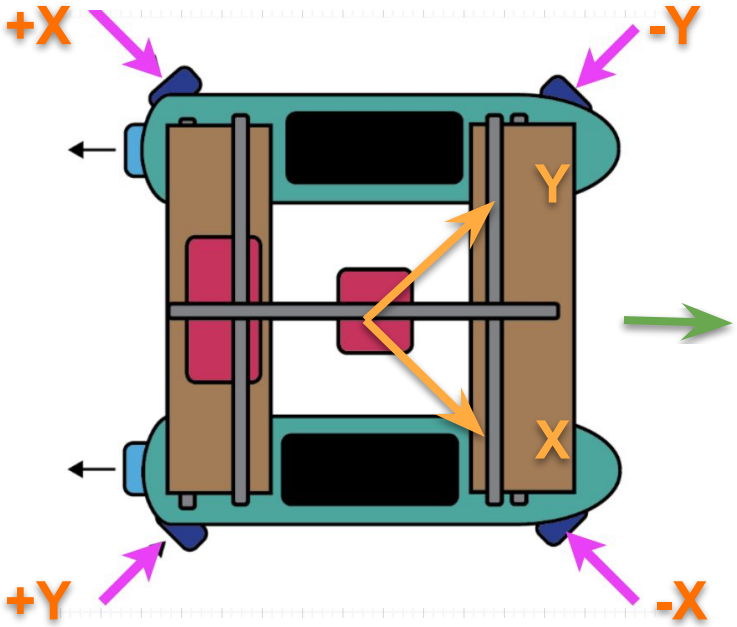
System State Control Diagram



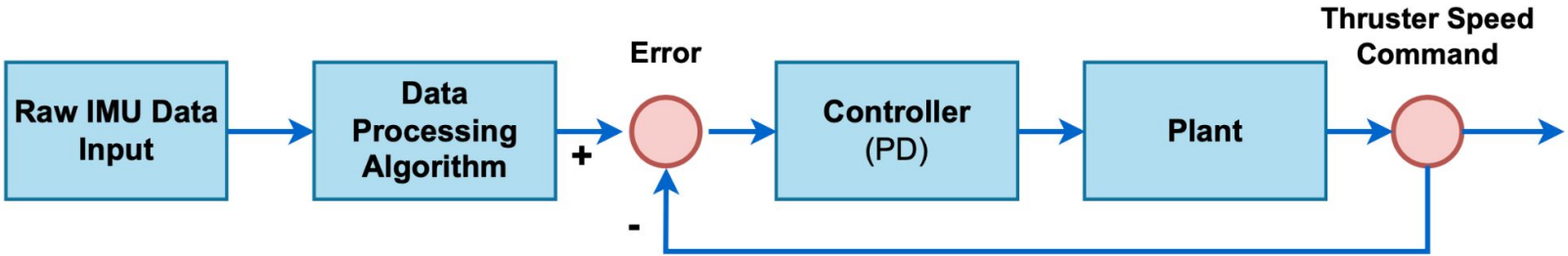
System Stationkeeping State Diagram



Stationkeeping Thruster Configuration

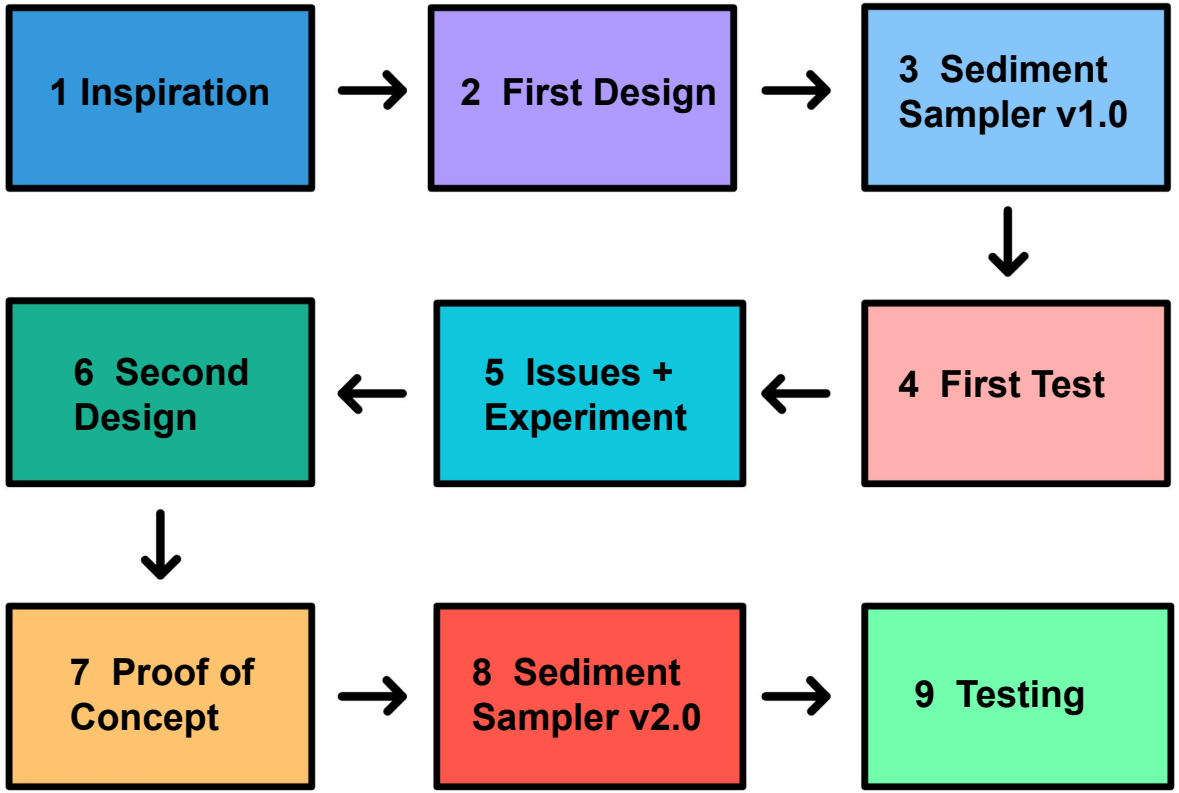


Stationkeeping Control Loop



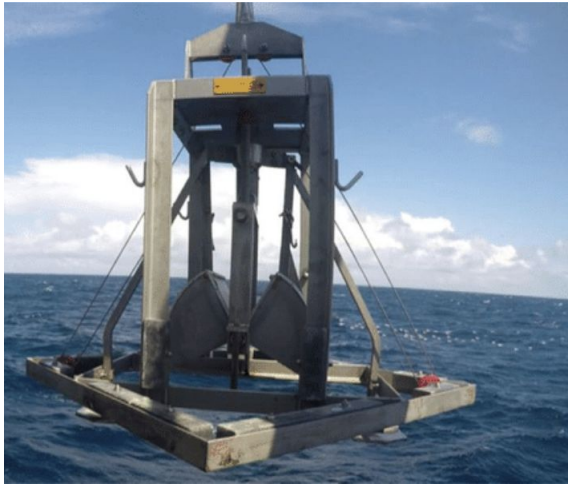
Sediment Sampling

Sampler Design Process



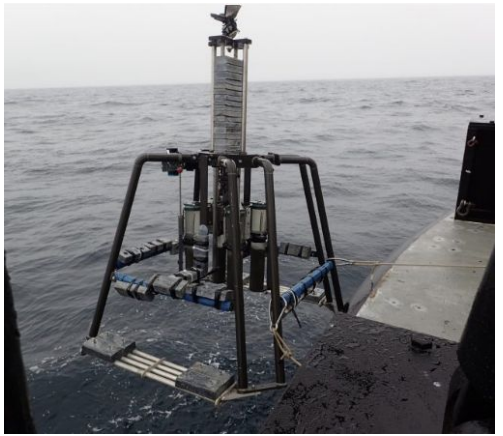
Current Methods of Sediment Collection

1 Inspiration →



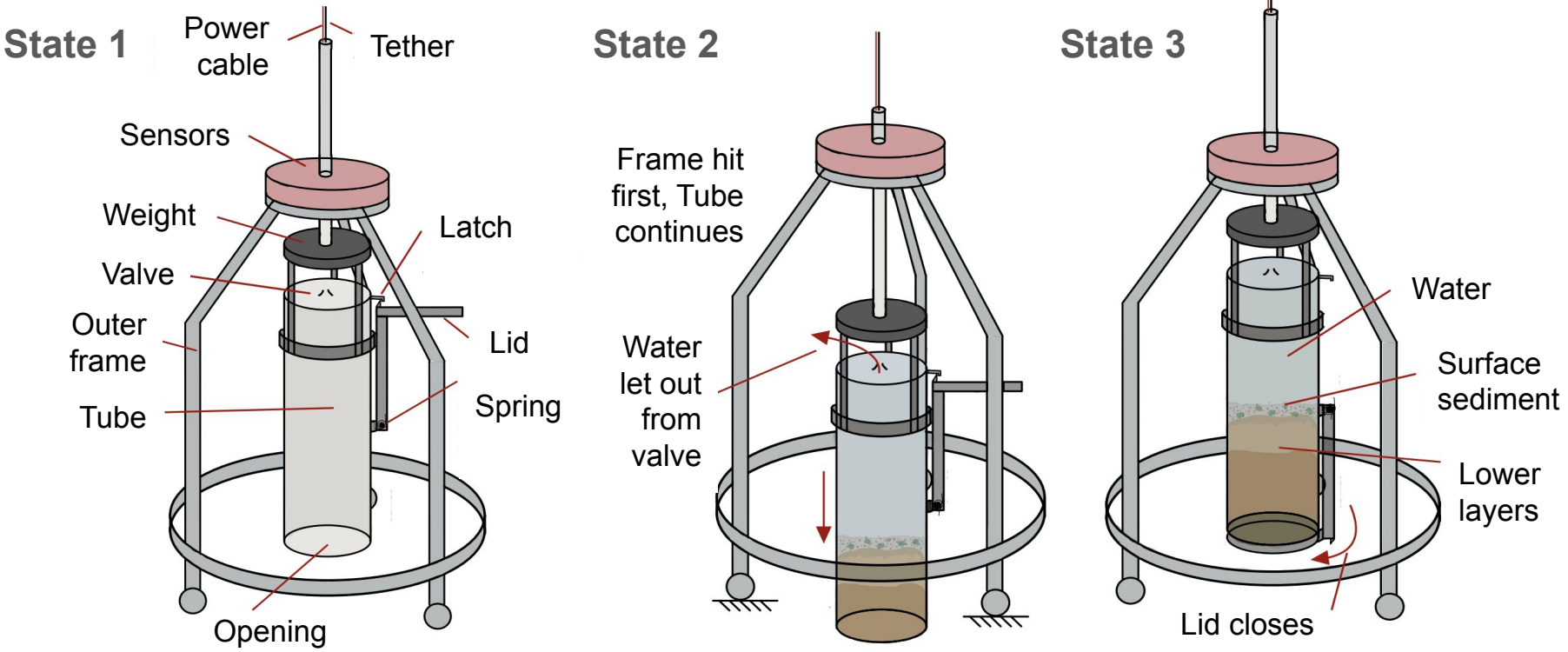
Smith McIntyre Grab

Van Veen Grab



Multicore

System Design Process: Version 1



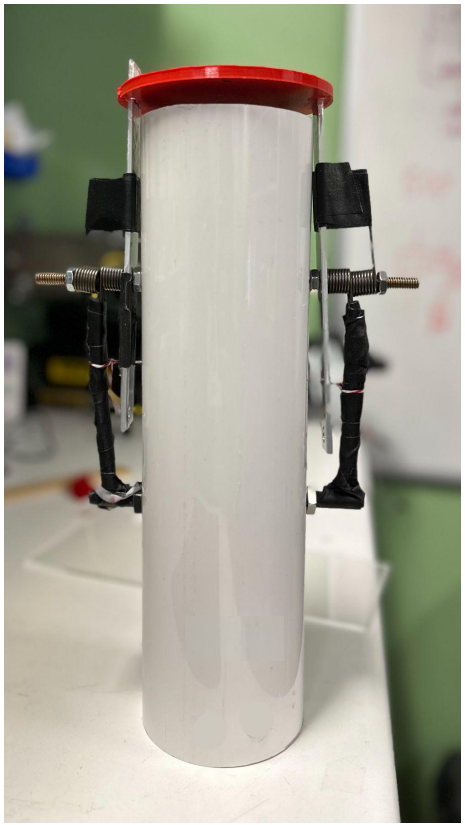
Sediment Sampler V1 Testing

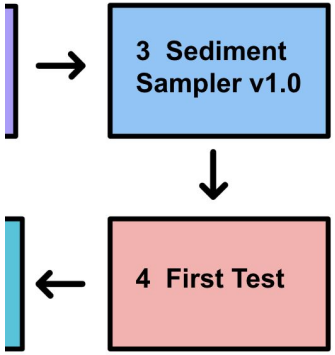
Features

- PVC
- Aluminum arms
- Red lid
- 2 Torsional springs

Problems

- Lid did not seal
- Springs not strong enough





Suction by Vacuum

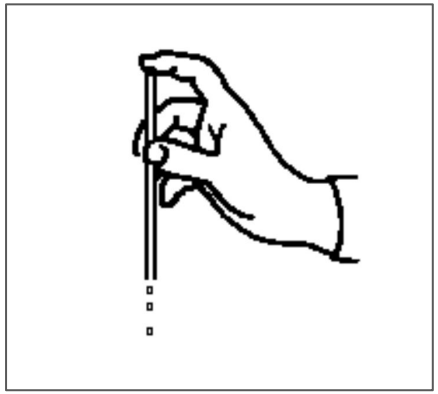
Testing showed mud drained out

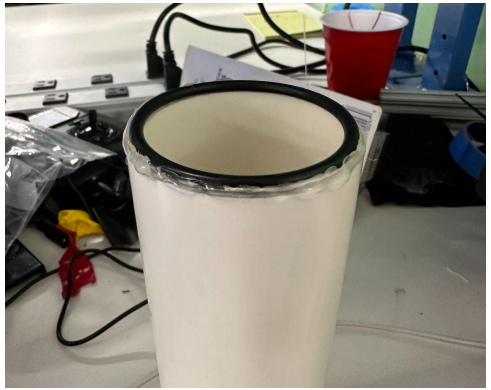
Can suction hold water + mud?

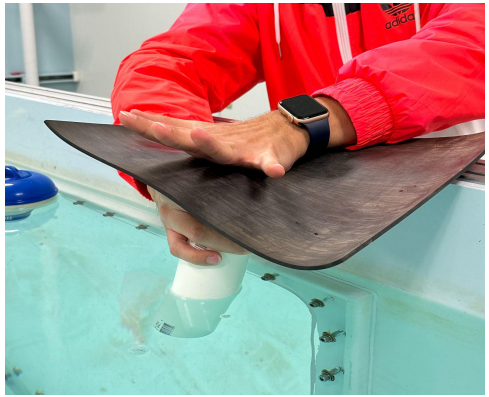
Used O ring + Rubber.

Did not work, but helped.

Decided to use.

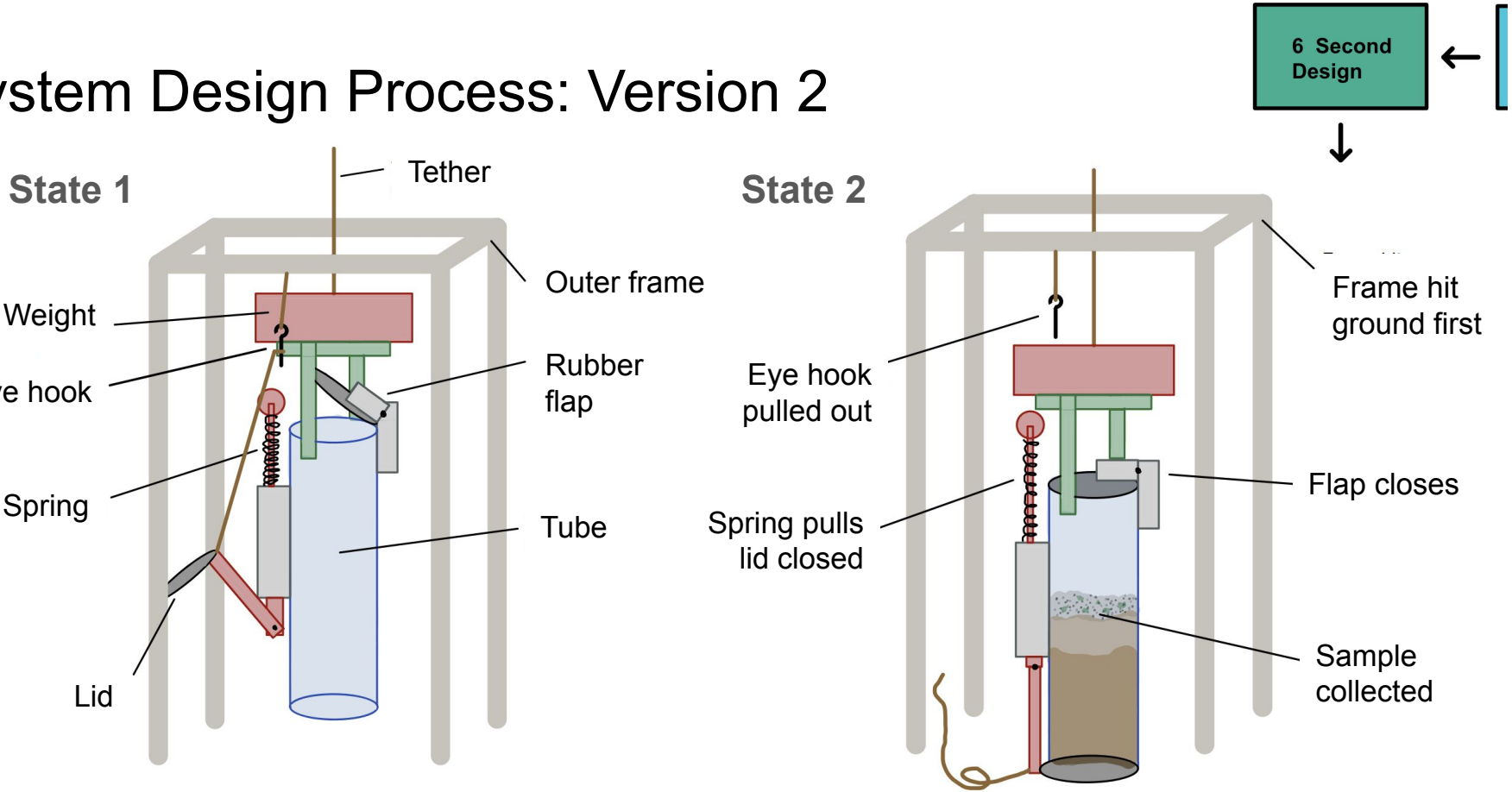




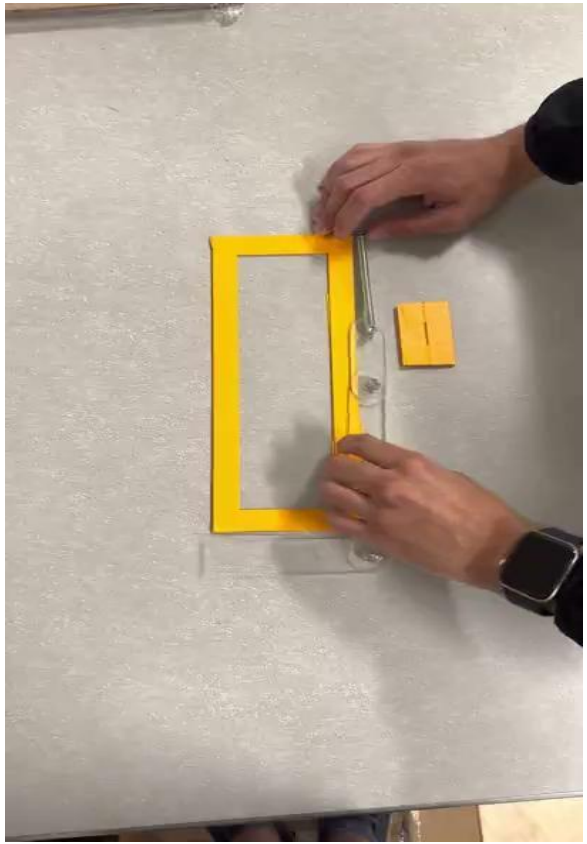


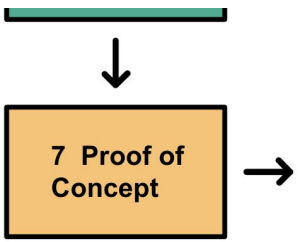
Sediment Sampler Version 2: Inspiration

System Design Process: Version 2

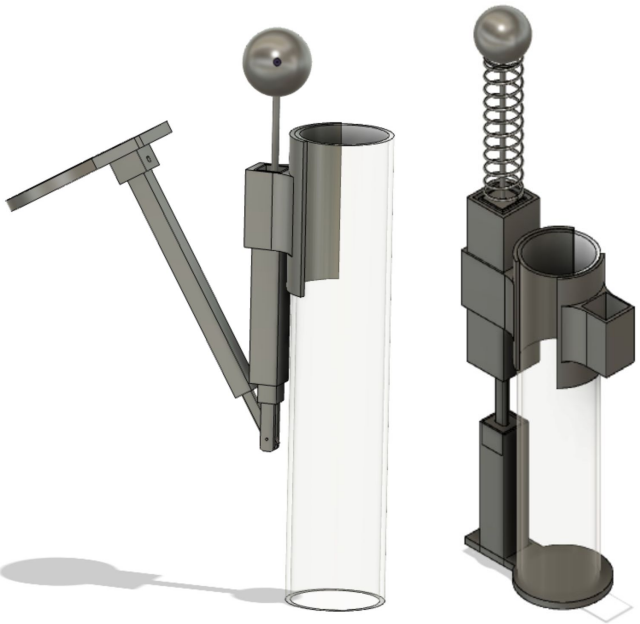


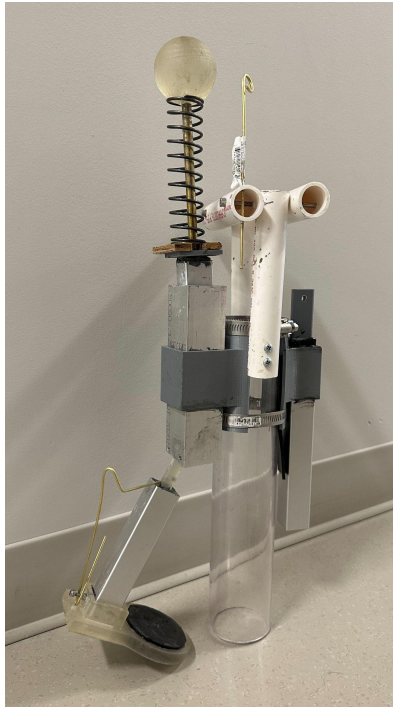
New Mechanism: Proof of Concept





Sediment Sampler Version 2:





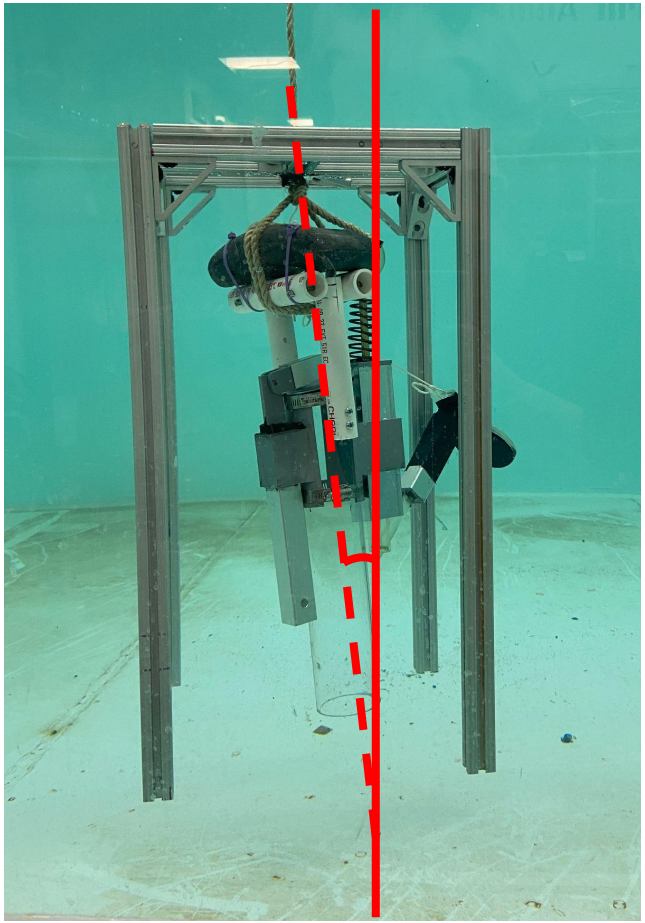
Sediment Sampler Results

Problems

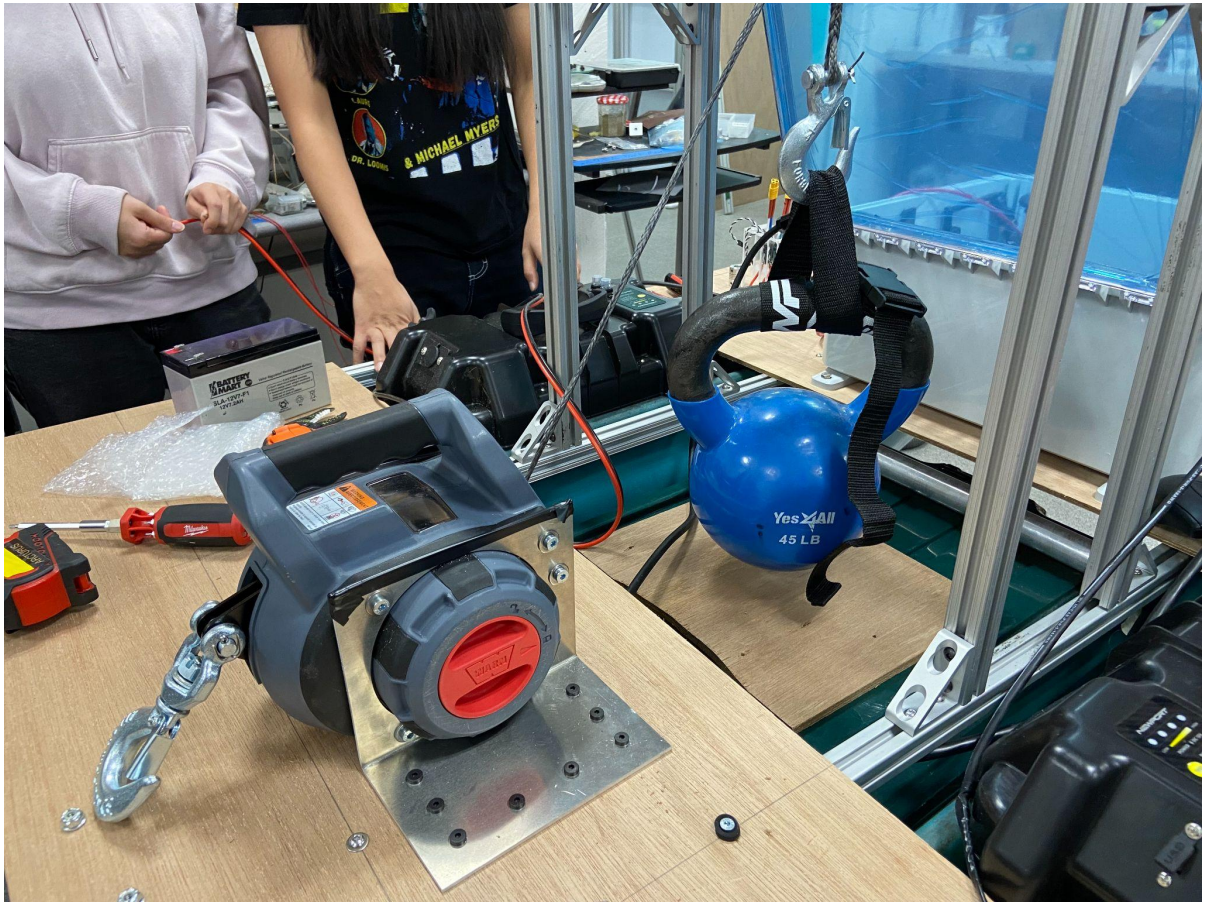
- When sampler sinks at an angle unable to collect mud
- Components are too brittle

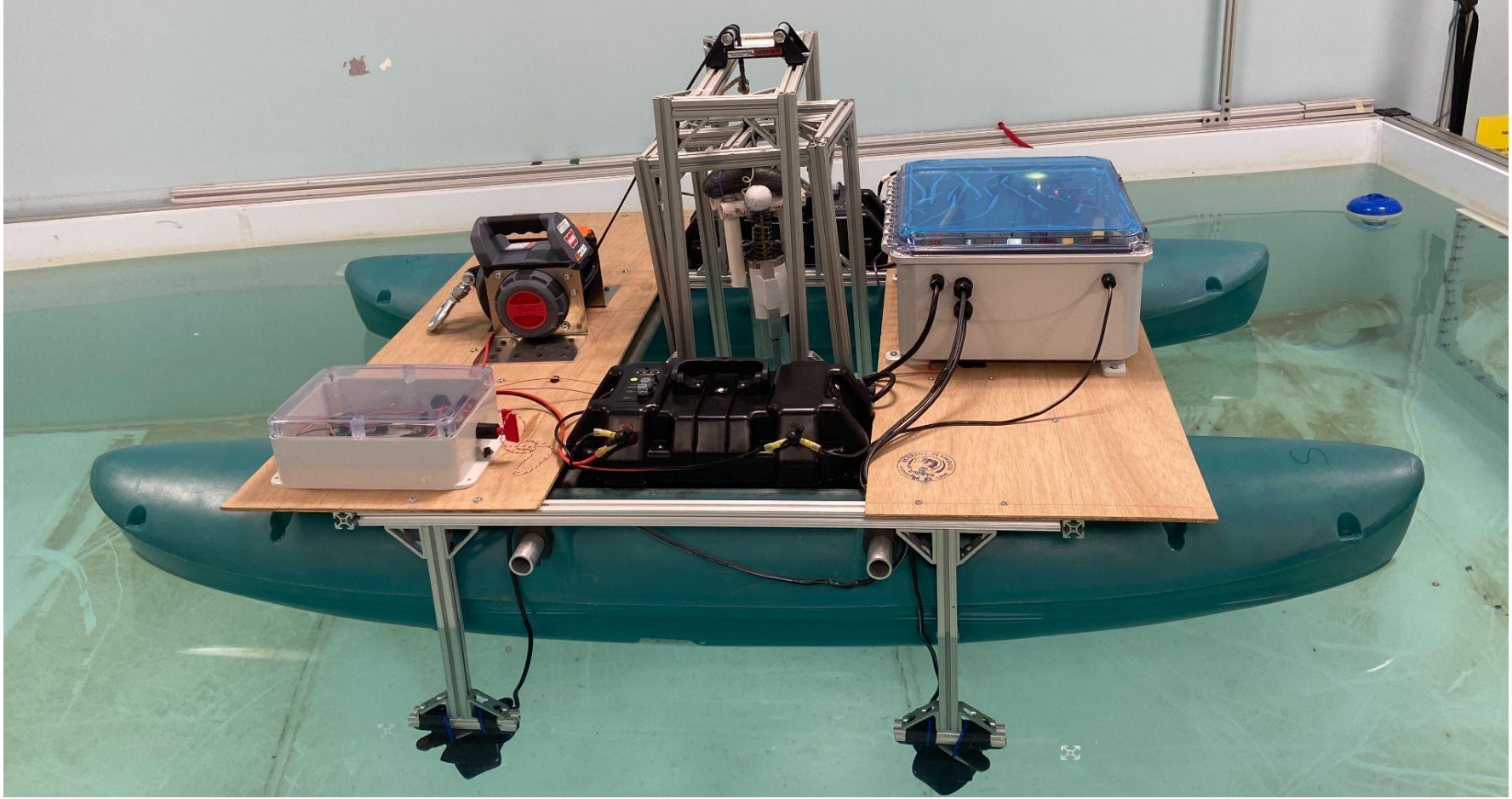
Next Steps

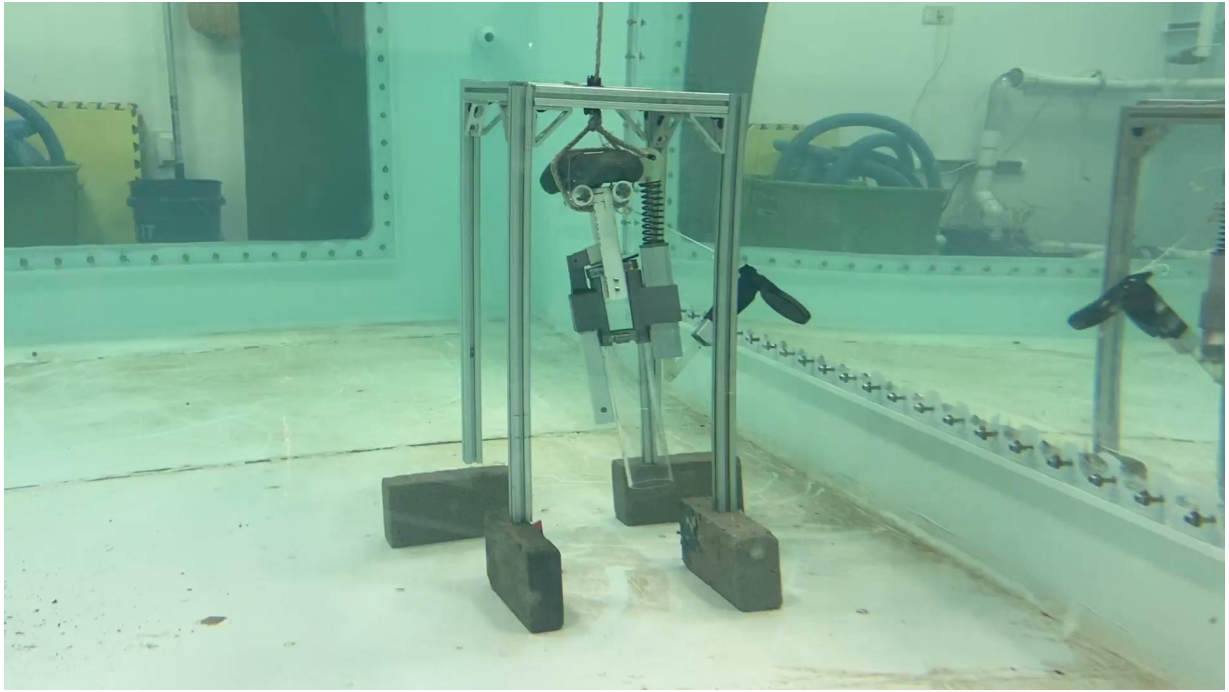
- Sinking vertically
  - Redesign sampler to be rigidly attached to frame
  - Even weighting so system sinks vertically
- Components machined from aluminum



In Lab Testing


& MICHAEL MYERS
DR. LOOMIS
YesYAll
45 LB



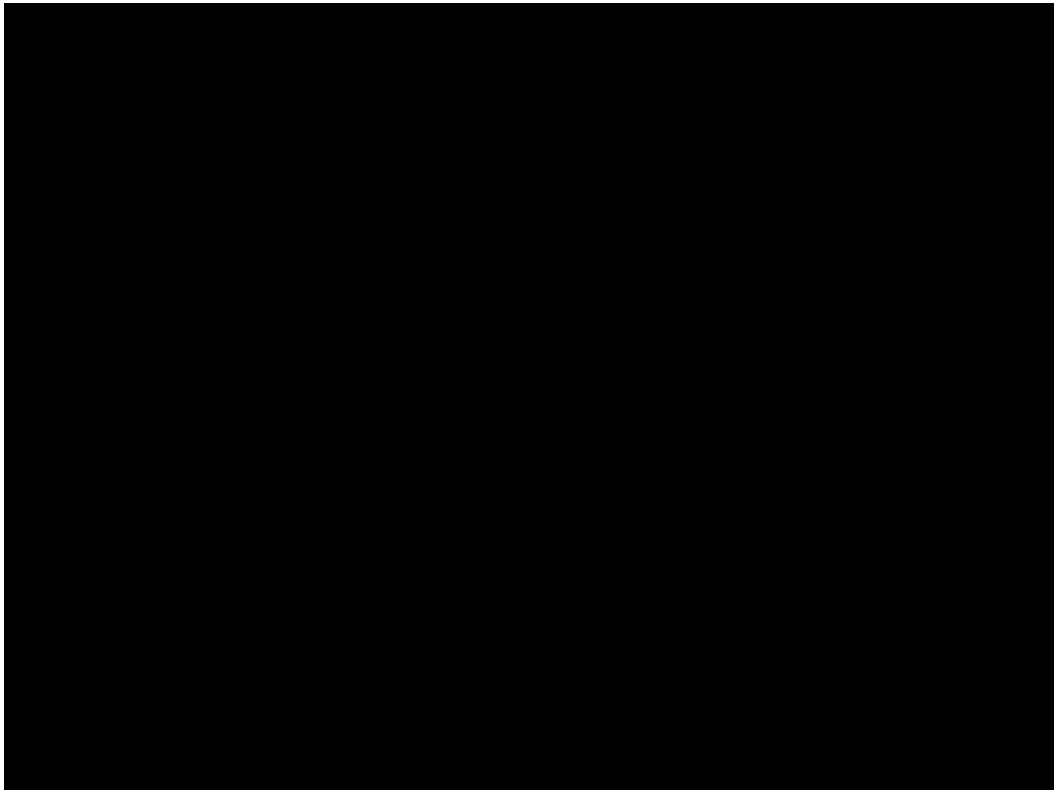



9 Testing

Field Testing


Hobie
FLOAT CAT


9 Testing



Part 3:
What we learned & looking ahead

Conclusion

- Sample *A. catenella* cysts in sediment during winter to predict bloom levels in spring
- Protect ecosystem, seafood industry, and consumers
  - Informed and effective regulation
- Empower researchers and lower barriers for data collection
  - Address worsening HABs

Next Steps and Future Work

- Evaluate stationkeeping capabilities
- Collaborate with labs to select sampling sites
- Validate collected samples with lab
  - Sample storage
- Scale up sample collection
- Improve system robustness
- Utilize data for predictive model

Other applications of autonomous sediment sampler

- Other research!
  - Marine geology
  - Ecosystem health
- Monitor pollutants in bodies of water
  - Heavy metal toxins
  - Pesticides
  - Vibrio
- Deep ocean sediment sampling

Questions?