Staten Island ROV Beach Rescue: Leveraging Robotics for Plastic Pollution Cleanup

SITHS Special Operations Team

Staten Island Technical High School, Staten Island, NY, USA

Project Overview

Our SeaPerch project was designed to address plastic pollution in Staten Island's beaches and waterways. As plastic waste increasingly accumulates due to human negligence, we aimed to create a solution to actively remove it. Using the SeaPerch underwater ROV as a base, we customized the design with 3D-printed hooks to grab various types of plastic debris. We tested different designs and refined their shapes for better grip and control underwater. We also adjusted motor positions and buoyancy to improve maneuverability and navigate different water conditions. Our hypothesis was that a simple, low-cost ROV could effectively collect plastic waste. Through testing and iteration, the project proved that student-built technology can have a real environmental impact, combining engineering and environmental awareness to solve community problems.

Background & Motivation

Plastic waste is a serious threat to Staten Island's coastline, where pollution from human activity results in large amounts of debris accumulating on beaches and in shallow waters (Dennis, 2025). When exposed to sunlight and physical stress, plastics break down into microplastics, which can be ingested by marine animals, causing health complications or death. These microplastics can enter the food chain, eventually affecting humans (Wang et al., 2024). Birds, fish, and marine mammals often mistake plastic for food, leading to organ damage, starvation, or digestive blockages (Lowe, 2021). Additionally, the wind and ocean currents can carry this waste further into the ocean, increasing the scope of the problem. Recognizing the importance of addressing this issue, we set out to design an ROV that could collect and remove plastic waste before it breaks down. Our motivation was to reduce ecological damage, protect wildlife, and raise awareness about local pollution. This project allowed us to turn concern into action through design and innovation.

Figure 1. Debris found on Oakwood Beach in Staten Island (Rush, 2017).

Figure 2. Debris found on Oakwood Beach in Staten Island (Simas, 2024).

Real-World Connections

The design of our SeaPerch ROV hooks draws inspiration from real-world applications, demonstrating how engineering solutions can be adapted for different environments. The Y-hook is influenced by cradle grabhooks, which are used in material handling to secure heavy loads. These hooks are designed to distribute force evenly, reducing stress and increasing load capacity - principles we applied to ensure that our hook could securely carry marine life without objects falling off during transport. Similarly, the J-hook's curved shape is inspired by its use in commercial fishing, where it's commonly used to hook fish in the mouth or throat. Its deep curvature offers a secure hold, preventing slippage, which is particularly important in the underwater environment of SeaPerch. These real-world designs ensure that our hooks are both functional and efficient in handling underwater objects.

Figure 3. ROV cleaning underwater infrastructure (LateralL, 2025).

Methodology

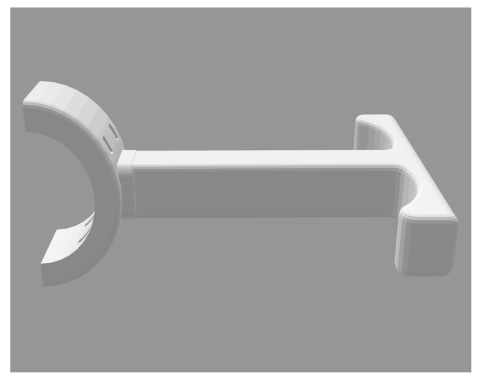
For our SeaPerch project, we began by refining hook designs for tasks such as transporting marine life and sensors. Initially, we tested a T-shaped hook, which was versatile but lacked stability for some tasks. We then experimented with a cross-shaped hook that provided more surface area but had issues with objects slipping off due to its gradual curvature. This led to the development of J-hooks and Y-hooks, inspired by real-world cradle grabhooks, designed to provide better contact points and reduce slippage. We also faced challenges with the flexibility of the materials, which impacted consistency. To address this, we switched to using rigid PLA filament for 3D printing, allowing for precise, durable hooks and improved visibility with bright red filament. Additionally, we designed C-shaped connectors to attach the hooks securely to the ROV's frame. By utilizing CAD software like Fusion 360 and TinkerCAD, we were able to model and test multiple iterations to ensure functionality and efficiency.

Refining Hooks

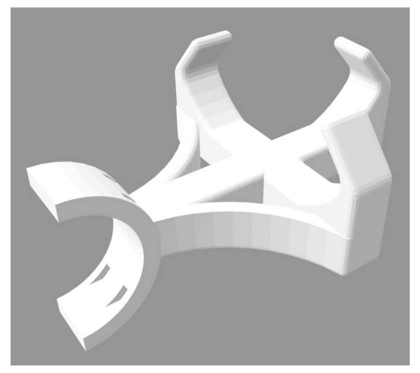
(a) (b)

Figure 4. (a) shows measurements taken for our ROV, (b) shows a team member adjusting elements on our ROV.

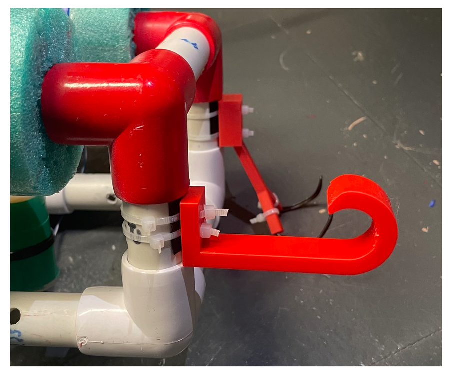
Hook Iterations



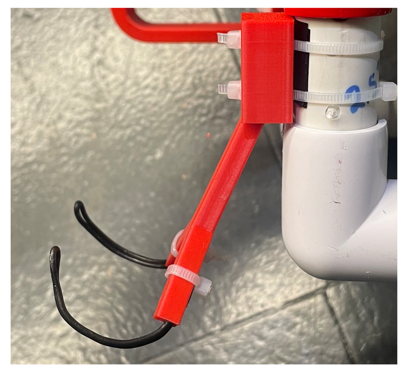
T-HOOK ⇨



CROSS-HOOK ⇨



J-HOOK ⇨



Y-HOOK

Results

Testing showed that the PLA T-hook was the fastest, completing the task in 74 seconds, followed by the stainless-steel T-hook at 111 seconds. The stainless-steel J- and Y-hooks were slower, at 198 and 165 seconds, while their PLA versions performed slightly better at 170 and 167 seconds. This suggests PLA generally outperformed stainless steel, especially in the T-hook design. In frame testing, the smaller rectangular frame completed the obstacle course in 85 seconds, outperforming the larger one at 98 seconds. This confirmed that a smaller, more agile frame improves maneuverability.

Variables Tested

Hook Material
Hook Design ⇨ Speed
Efficiency

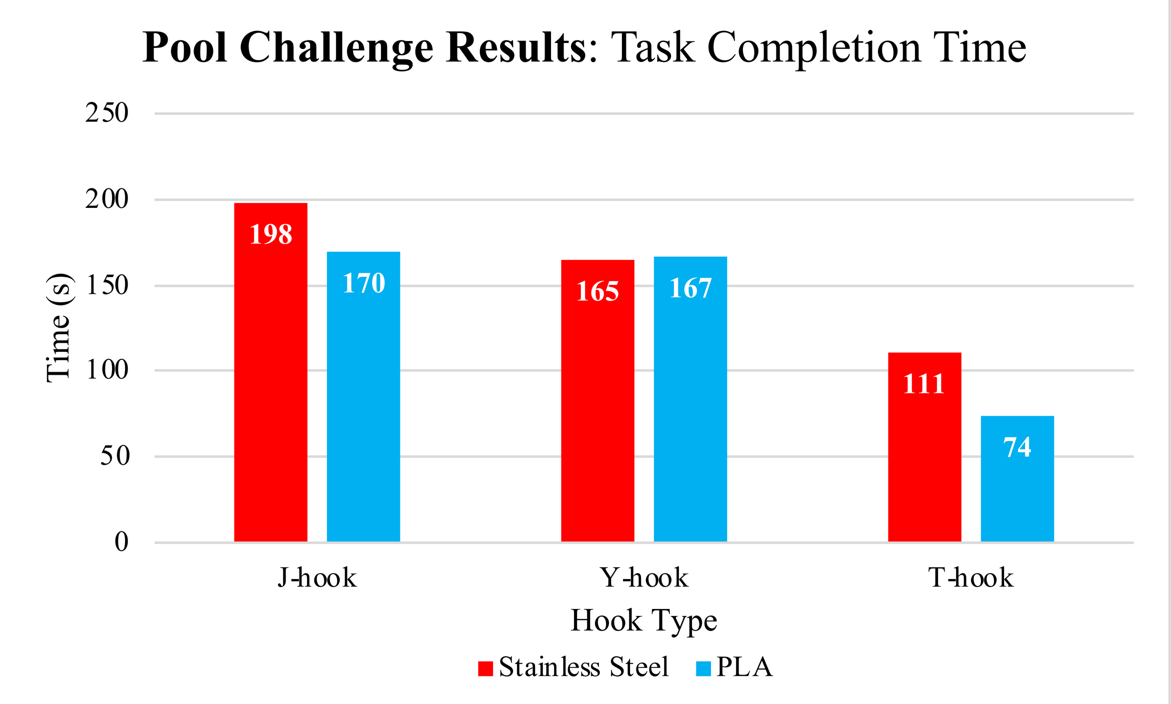


Figure 5. This graph shows the task completion time for three different hook designs, the J, Y, and T hooks. A stainless steel and PLA version of the hooks were tested.

Ideas For How To Improve

- Conduct further research on hook designs
- Refine hook dimensions
- Adjust buoyancy on the robot
- Continue optimizing speed and precision

Conclusion

Our ROV successfully demonstrated that practical, student-driven engineering can support environmental cleanup. With targeted design improvements - like dual 3D-printed hooks, modified motor angles, and improved buoyancy - we created a tool capable of retrieving floating and submerged plastics in controlled settings. Moving forward, we aim to incorporate an underwater camera for enhanced control and deploy the ROV in real conditions off Staten Island's coast. Collaborating with local environmental groups and testing in open water will provide further insight into scaling and improving our design. We also plan to make our build process open-source for replication by other student teams.

Next Steps

Our ROV successfully demonstrated that practical, student-driven engineering can support environmental cleanup. With targeted design improvements - like dual 3D-printed hooks, modified motor angles, and improved buoyancy - we created a tool capable of retrieving floating and submerged plastics in controlled settings. The next question we have to answer about our ROV is how we can improve its control and implement it in the real-world. For this, we aim to incorporate an underwater camera for enhanced visibility and deploy the ROV in real conditions off Staten Island's coast. Collaborating with local environmental groups and testing in open water will provide further insight into scaling and improving our design. We also plan to make our build process open-source for replication by other student teams.

Areas For Growth

How do we improve control and implement our ROV in the real world?

⇨ Underwater visibility
⇨ Further testing with hooks

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Figure 6. Team picture with our coach!

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