Microplastic Research in Fish
Supernova & Co.

Abstract

Our ROV, initially for coral restoration, can offer broader subsea solutions, minimizing environmental harm in the ocean. Inspired by the Purdue Biomimicry Project, its adaptability allows for bio-inspired attachments for tasks like selectively "catching" invasive fish species with soft fishing lures and quantifying microplastics using a modular filtration system. This refined modularity extends its value beyond initial constraints, enabling efficient and sustainable interventions for both ecological conservation and challenges in underwater ecosystems.

Background & Rationale

Living in Hawaii, the ocean is an essential part of our lives—it surrounds us, sustains us, and defines our environment. It shapes our culture, drives our economy, and provides the resources we depend on. However, pollution—especially microplastics—is becoming an increasingly urgent issue. These tiny plastic particles break down into microscopic fragments that persist for years, accumulating in marine ecosystems and potentially harming wildlife.

Figure 1: Sand Island, Honolulu, HI
Photo Credit: To-Hawaii.com

Understanding the extent of this contamination is crucial, so we use an ROV to catch fish and test them for microplastics. By studying these pollutants in marine life, we gain insight into ocean health and pollution levels. Our testing site at Sand Island, a historically and ecologically significant area in Honolulu Harbor, offers a unique setting for this research. Once known as Quarantine Island and later repurposed as a WWII internment camp, Sand Island now serves as an industrial port and is home to invasive fish species like ta'ape and roi, likely introduced via ballast water. Examining these fish helps us assess pollution's effects on marine ecosystems, particularly in urban waters.

Through this work, we contribute to a larger effort to protect Hawaii's fragile marine environment. The ocean sustains us—now, we must do our part to maintain it.

Approach

To implement our project, we will first finalize the design and construction of the ROV using durable lightweight PVC frame equipped with three thrusters for precise maneuverability. Incorporate bio-inspired shrimp mimic baits to attract the invasive ta'ape and install a modular filtration system for collecting microplastics. Testing at Sand Island is where we'll deploy the ROV to evaluate its performance in capturing fish and gathering data on microplastic concentrations in water and sediment.

Community engagement is crucial; we will organize workshops to raise awareness about invasive species and sustainable fishing practices such as reduce, reuse, recycle. While we also collaborate with local fishermen and environmental organizations such as the U.S. Environmental Protection Agency.

After analyzing microplastic data, we will refine the ROV's capabilities and develop advanced filtration systems targeting specific microplastics: microbeads, synthetic fibers, plastic fragments, thin films, and nurdles. The system uses a multi-stage process, starting with a coarse filter for larger particles, followed by intermediate and fine filters for medium and tiny particles. This high-efficiency system can filter out microplastics as small as 1 micron, ensuring effective removal and contributing to cleaner marine environments.

Researchers at the University of Hawaii study coral reef health, focused on water quality, as well as the impact of marine debris, particularly microplastics, on marine life. Addressing microplastic pollution helps ensure the long-term health of these environments.

Overall Design

Our ROV features a sturdy 18-inch rectangular PVC frame that is lightweight and durable. Equipped with three thrusters, it can maneuver in any direction, ensuring precise control underwater. Our ROV has strategic pool noodles placement at the top and back to achieve neutral buoyancy with a evenly distributed weight. This design allows the ROV to access hard-to-reach areas, making it ideal for inspections, testing, and microplastic removal, establishing it as a vital tool for marine conservation.

Camera

The ROV's camera system is designed for high-resolution underwater imaging, capturing detailed footage for marine research and environmental monitoring. A wide-angle lens provides an extended field of view, while low-light enhancement ensures clarity in dim conditions. Motion compensation and image stabilization reduce distortion in turbulent waters, maintaining steady visuals. Depth-rated housing protects internal components, enabling operation at various depths. Real-time data transmission allows direct video feed for remote analysis.

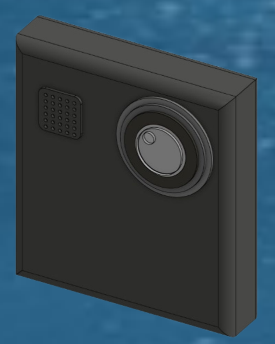


Figure 2: Camera (Credit: R. Tsuha on Onshape)

Buoyancy

To achieve optimal neutral buoyancy, pool noodles are strategically planned in the ROV's design. These buoyant elements counteract the weight of the frame and any payload, ensuring stability and maneuverability during operations. The brainstorming and design process regarding buoyancy are critical for the ROV's effectiveness in underwater environments. By achieving neutral buoyancy, the ROV can maintain its stability, maneuverability, and operational efficiency, making it a reliable tool for a wide range of underwater applications, such as collecting marine samples and conducting monitoring tasks.

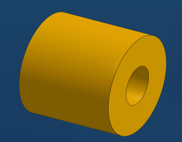
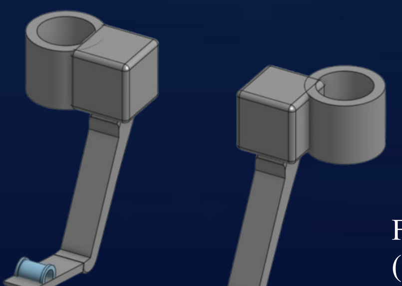


Figure 3: Pool Noodle (Credit: R. Tsuha on Onshape)

Attachment

We designed all attachments using Onshape and initially printed with 15% infill, which made them positively buoyant and affected the ROV's trim. To maintain stability, we adjusted the infill so each attachment is neutrally buoyant, preventing changes to overall buoyancy when swapping parts. Key modifications include wrapping electrical tape around motors and CPVC pipe fittings for water resistance and tighter connections. Placing the left and right thrusters inside the frame reduces the ROV's width, improving maneuverability through obstacles. The final Extended "DuoHook" features a longer, split hook design to meet class rules requiring PVC/CPVC/PEX frames without 3D printed parts. This attachment is tailored for success in our new mission.



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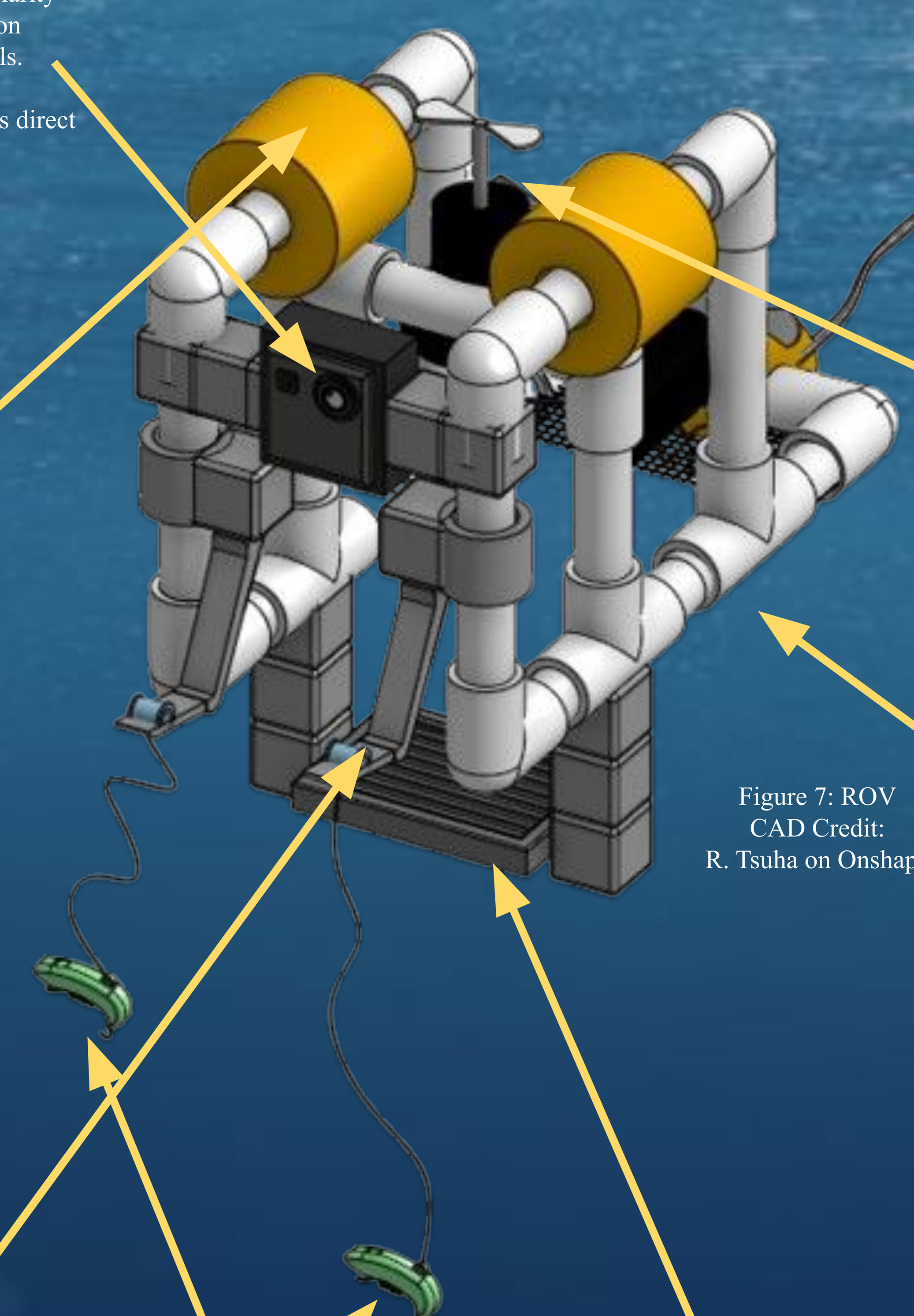

Figure 7: ROV CAD Credit: R. Tsuha on Onshape

Lure

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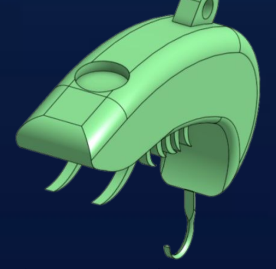


Figure 5: Bait (Credit: R. Tsuha on Onshape)

Fig 6: Ta'ape Fish (Credit to manoa.hawaii.edu)

Tether

The tether is essential for the ROV's operation, providing power and control signals to the motors for movement. Its durable design, helps protect the wires connected to the motors. It is made from abrasion-resistant materials like nylon, ensures reliability under high pressure and harsh underwater conditions. Without it, the ROV would lose functionality, making the tether a critical component for success.

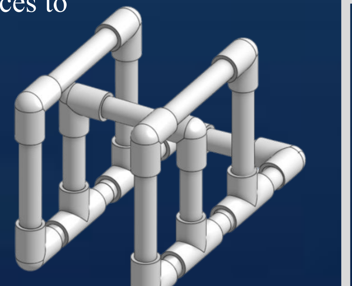
Propulsion System

Our ROV's propulsion system utilizes three brushless thrusters—two rear-mounted horizontal thrusters for forward/backward thrust and steering, and one vertical thruster for precise depth control. This configuration enables omnidirectional movement, including surge, heave, and yaw. The thrusters are strategically positioned to maximize torque and responsiveness while maintaining precise movement. Each thruster features a ducted propeller design for enhanced thrust and protection. This system delivers exceptional maneuverability, allowing for station-keeping in currents and precise navigation in confined spaces.

Figure 10: Motor (Credit: R. Tsuha on Onshape)

Frame

Our ROV's structural framework utilizes PVC piping, selected for its optimal combination of lightweight durability, corrosion resistance, and cost-effectiveness in marine applications. While the hollow pipes naturally provide negative buoyancy, our integrated flotation system ensures proper submersion control. The rectangular geometry - complemented by strategic buoyancy adjustments - delivers exceptional stability and precision for operational tasks. This modular architecture facilitates easy maintenance and system upgrades, resulting in a robust, economical ROV platform capable of reliable performance across varying underwater environments, from confined spaces to open-water exploration.



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Bait Box

The Bait Box, integrated into the ROV, functions as a targeted attraction system designed to lure invasive fish species for study and sampling. Its perforated design allows the controlled release of fresh shrimp scent, drawing fish toward designated capture zones. The bait mechanism can be adjusted to dispense different attractants based on different water conditions and fish behaviors, optimizing effectiveness. By facilitating species collection while minimizing environmental disruption, this system enhances marine research efforts and supports sustainable monitoring practices in Hawaii's waters.

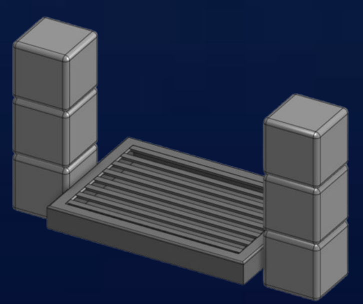

Figure 8: Bait Box (Credit: R. Tsuha on Onshape)

Project Overview

Our ROV is a significant advancement in marine conservation. Inspired by the Purdue Biomimicry Project, it features an adaptable, modular design that supports coral restoration, manages invasive species, and quantifies microplastics. With innovative bio-inspired attachments, our ROV demonstrates the potential of technology to foster ecological balance. As we enhance its capabilities, we aim to promote healthier oceans and protect marine biodiversity for future generations.

Applications

One application for detecting microplastics in fish ensure health and food safety. Researchers can assess seafood contamination to guarantee safe human consumption by monitoring microplastic levels in fish. Furthermore, they can develop safety guidelines in edible fish.

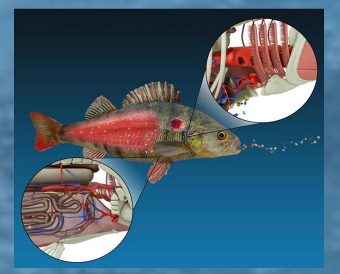

Figure 11: Artist illustration on microplastic in fish gills
Photo Credit: ScienceDirect

Another application is assisting in ecological conservation. Marine ecologists can study the impact of microplastic ingestion in marine food webs. This can help them evaluate long-term effects on fish survival, health, and reproduction. Fishermen also benefit from microplastic research by identifying high-risk fishing areas and improving sustainable catching practices.

Future Improvements

In addition to incorporating systems for removing microplastics and debris from the ocean, we envision several meaningful enhancements for our ROV project. These include developing advanced filtration systems to capture microplastics of various sizes, implementing real-time data transmission for quicker monitoring, and using AI to improve navigation and object identification. We plan to integrate solar power to extend operational time, design modular attachments for specialized tasks (extracting marine life), and develop student-led community programs to inspire locals in ROV missions. We plan to receive feedback from mentors to get answers to critical questions and be adaptable to our tasks. By establishing collaborative research partnerships with universities and environmental organizations, we aim to improve our research capabilities and share our findings, helping contribute to a healthier ocean ecosystem. We also plan to assess microplastics in Hawaii's marine environments to understand their prevalence and impacts on local ecosystems by measuring the amount of microplastics in the fish.

Community Engagement

Supernova & Co. is dedicated to addressing the issue of microplastics in our oceans and their impact on marine life and human health. By engaging the community, we aim to raise awareness about the importance of monitoring microplastic levels in fish to ensure seafood safety and ecological conservation. Through workshops, educational partnerships with local communities, and community clean-up events, we encourage active participation in reducing plastic pollution. We invite fishermen, students, educators, and community members to collaborate with us in adopting sustainable practices, such as reducing, reusing, and recycling. By working together, we can effectively combat microplastic pollution in our oceans and promote healthier marine ecosystems.

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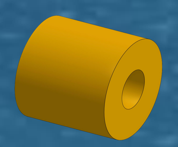

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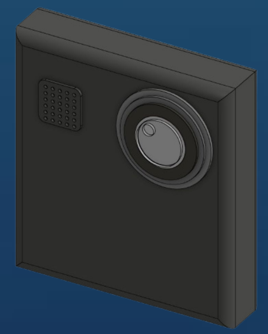

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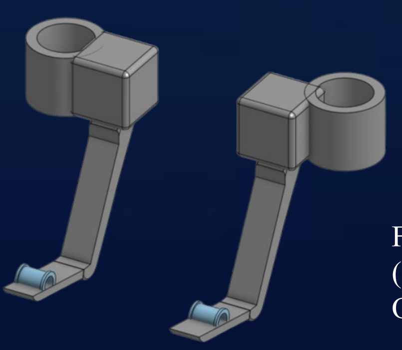

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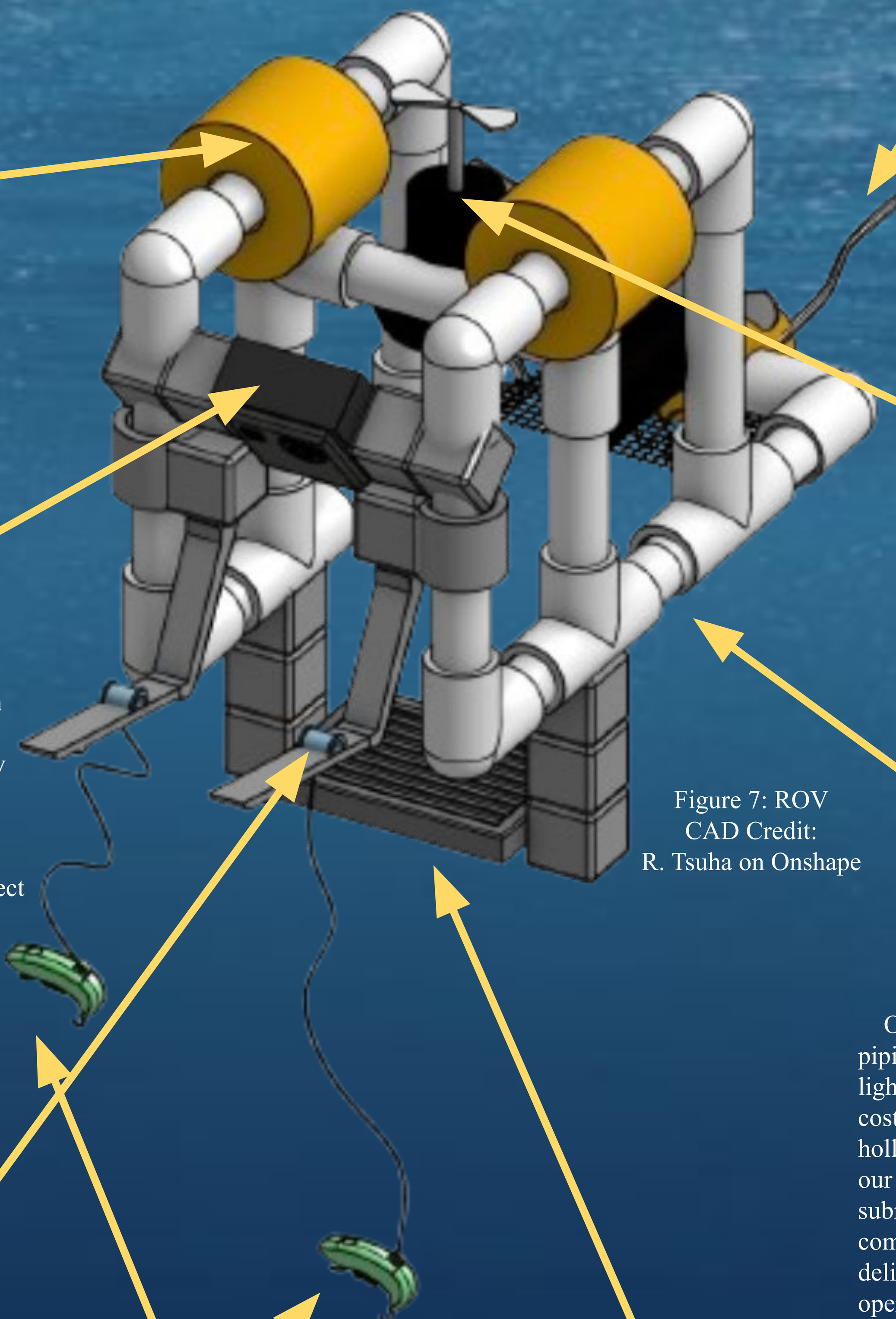

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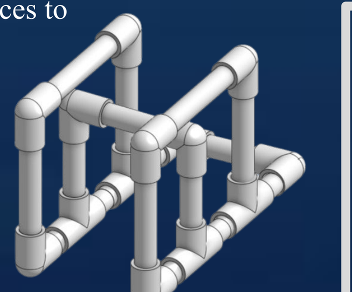

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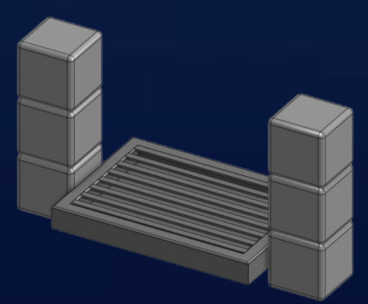

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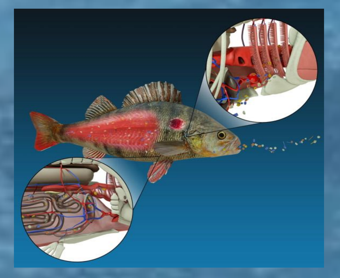

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