Marine and Naval Technological Advancements for Robotic Autonomy (MANTA RAY)

SWaT: Safe Whale Tag

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MANTA RAY Mission Statement

Team MANTA RAY is an interdisciplinary marine robotics project focused on seafloor mapping and underwater perception. As shown in Figure 1, the project emphasizes inter-vehicle communication, autonomous behavior, and mechanical system improvements to increase precision and performance.

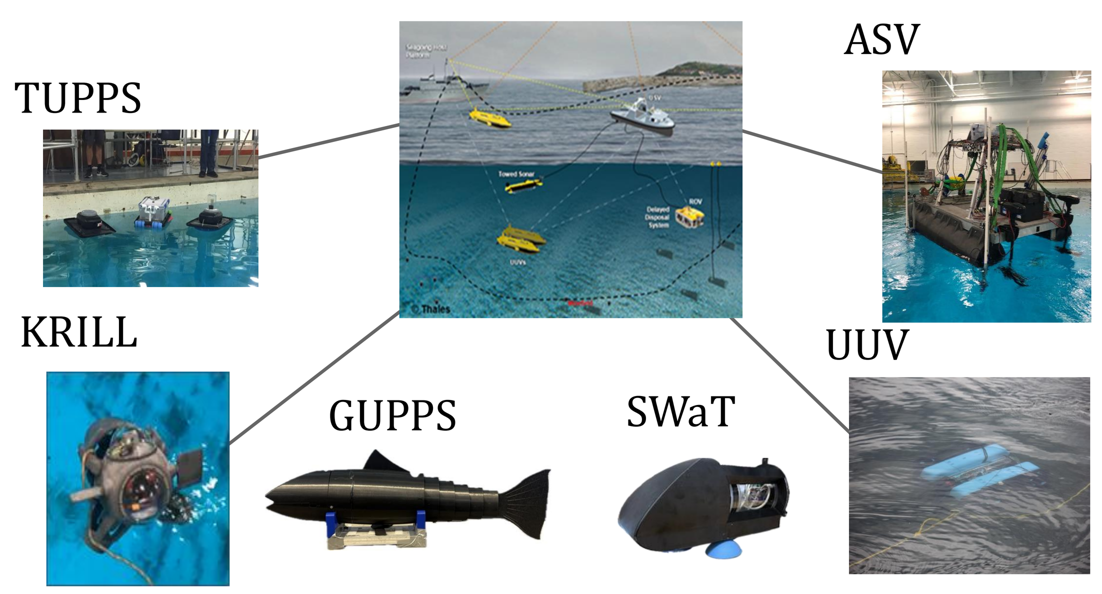

Figure 1: Overview of team MANTA RAY mission.

SWAT Mission Statement

In traditional whale tagging practices, the tag is deployed and attached to the skin of the whale using a dart-like design. These darts have a barbed design, and as the tag is pierced into the blubber of the whale, the barbs anchor the tag in place (McPherson, 2023).

While there is no extensive research into the long-term effects of Type A tagging practices, there is research that suggests that these tagging methods can cause infections, pain to the animal, and scar tissue on the cetacean (Gulland et al., 2024).

The goal of the Safe Whale Tag (SWaT) is to create a tag that utilizes suction, rather than using skin-piercing methods. While current suction-based tags are available on the market now, the hope for SWaT is to create a tag that will outlast the current estimated deployment time of up to 24 hours (McPherson, 2023) and continue to log data over the course of the tag deployment.

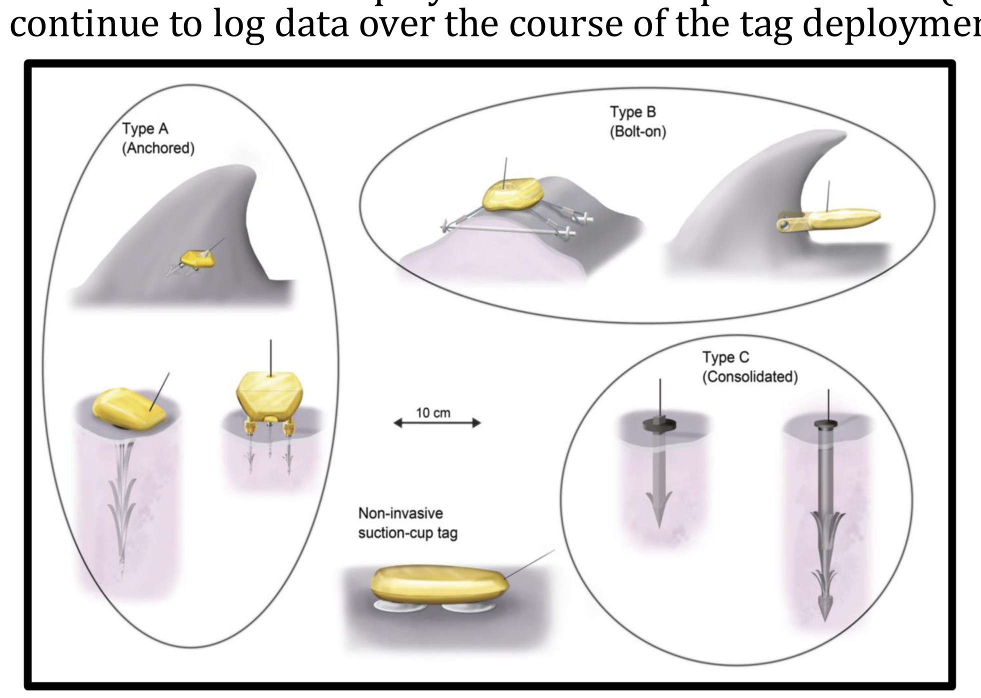

Figure 2: Illustration of both invasive and non-invasive tags (Russel et al. 2019)

Acknowledgements

This work was funded in part by New Hampshire Sea Grant's Workforce Development Project E/WFD-3, pursuant to National Oceanic and Atmospheric Administration Award No. NA24OARX417C0037. This work was also funded by NUWC Keyport NEEC (Grant N00174-20-1-0006) and NURP Sponsors (Grant N0014-23-1-2451).

Special thanks to Dr. Martin Renton, Eric Seeley, and Sam De Lano from NUWC Keyport. Dr. Chris Hixenbaugh, Jack Groeneveld-Meijer, Dr. Kaelyn Gamel and Dr. Elizabeth Magliuli from NUWC Newport. Dr. Tom Lippmann, Karin Whiting, and Maddie Dwyer for their support at the Chase Ocean Engineering building.

Our team would like to thank the CEPS Makerspace for their help in manufacturing our designs.

Design Components

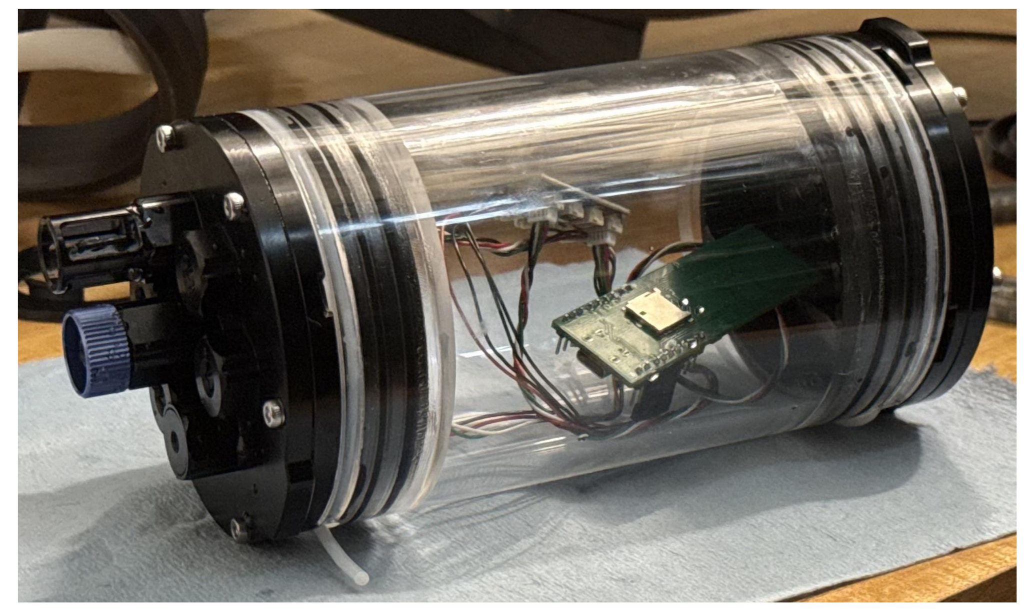

Figure 3: A Blue Robotics Watertight Enclosure Tube containing sensors integrated with the SWaT chip to collect and analyze temperature and pressure data.

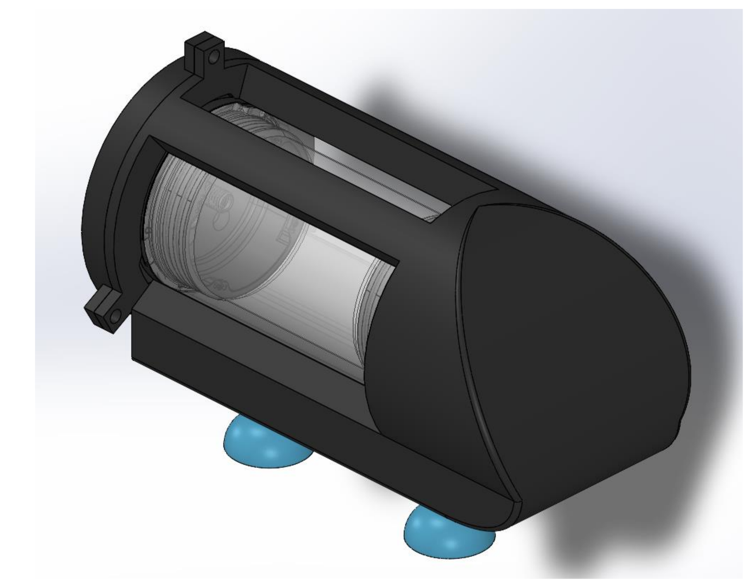

Figure 4: An isometric view of a SolidWorks assembly of the design for the housing unit, consisting of the main shell and rear lid.

Figure 5: Pictured, is the synthetic whale skin created from rubber, as the base, and epoxy resin layered on top, to allow for realistic testing scenarios.

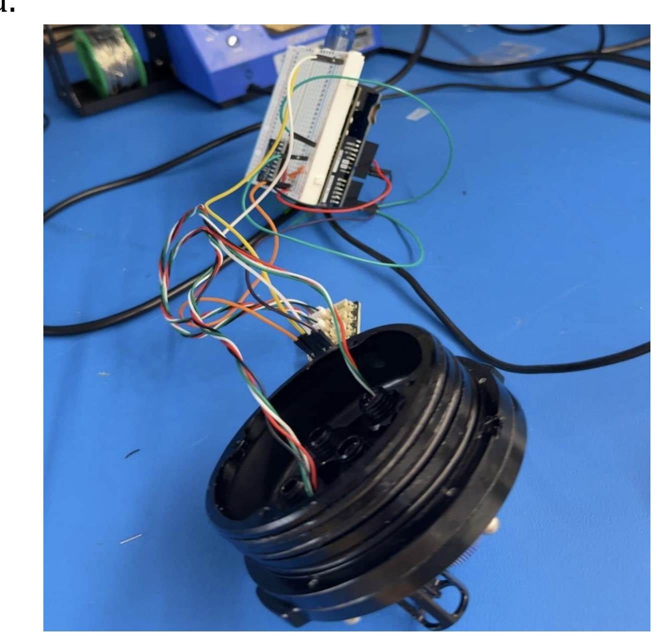

Figure 6: The tag is equipped with an inertial Measurement Unit, temperature, and pressure sensors to collect data from the whale's environment. These sensors operate on an Arduino Uno, with a data logging shield that would store all collected data on an SD card until the tag is physically retrieved.

Design Progression

Design in September	Design in January	Final Design

Figure 7: Pictured above are the 3 different designs the team has created this year, with the most recent being the prototype on the right

Initial design from last year: This design came from the team prior, and the design had no ports for sensors, and was not waterproof.	Final version of second design: Inside the model, there was plenty of space for electronics, but limited ports for sensors, and it was not waterproof. After many attempts at making it waterproof the team decided it was best to move on.	Final design: Waterproof with sensor ports and plenty of inside space for electronics and 7 ports for sensors.

Future Work

Future work would include developing more refined and purpose-built circuitry for SWaT. As of now, the tag consists of a simple Arduino Uno microcontroller and a USB power bank, which, while functional for initial prototyping, are not optimized for long-term or open-water deployments. Transitioning to a custom PCB design would allow for a more compact, power-efficient, and waterproof electronics package. This would also open the door to integrating additional sensors, such as a hydrophone for acoustic recording or a GPS module for surface position logging, as well as adopting more application-specific components such as a low-power microcontroller and a dedicated lithium battery with charging circuitry.

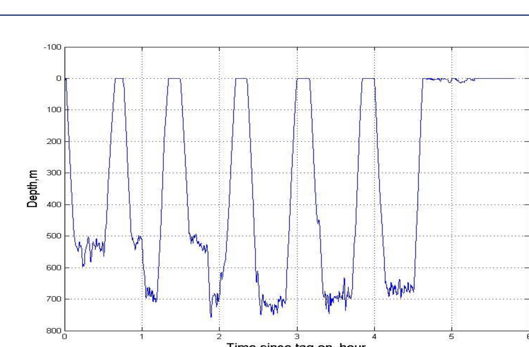

Figure 8: example of real life depth data from a tagged whale. (Sound and Movement Tags, n.d.)

In-field testing would be the logical next step in the development of SWaT. The purpose of open-water deployments would be to evaluate how the tag, housing, and suction cup attachment system perform under harsher and less controlled environmental conditions than those of a tank setting. Variables such as increased water turbulence, biofouling, saltwater corrosion, and the natural movement patterns of live animals would all present new challenges not captured in laboratory testing. Additionally, future iterations could explore improvements to the data logging system, longer deployment durations, and the integration of additional sensors to expand the behavioral and environmental data collected.

Results

The team successfully deployed SWaT suction cupped to a synthetic whale skin attached to an ROV. The ROV was deployed in the Chase Engineering Tank and engaged in jerky movements, breaching behaviors, and changes in depth for 8 minutes, reaching speeds of 2 m/s. The tag remained suctioned to the synthetic skin throughout testing.

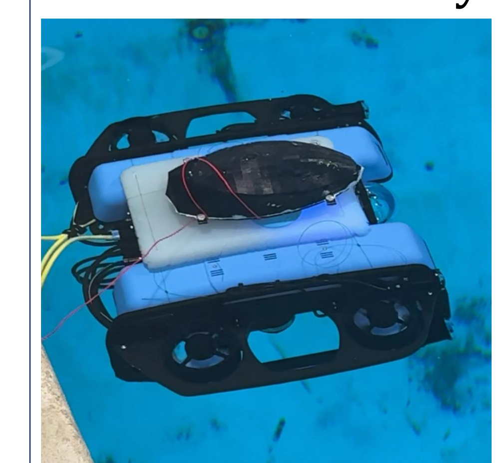

Figure 9: Blue ROV suction cup test

A subsequent test was conducted with the synthetic skin attached to a diver, who swam around the tank for 5 minutes with all onboard sensors actively collecting data.

Unfortunately, the data from this deployment was lost due to an SD card malfunction and could not be recovered.

Conclusions

The SWaT system provides a functional and adaptable housing design with sufficient space for future circuit integration and modifications. The current prototype successfully collects pressure and temperature data and has been tested to depths of 20 feet, with components rated for depths up to 900 feet.

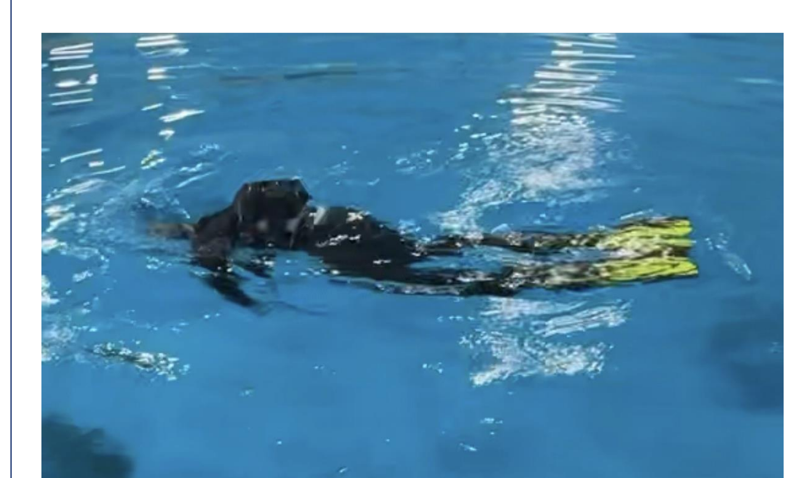

Figure 10: This year's final design of the SWaT, on a diver's back, attached to whaleskin via suction cups.

Future work will focus on biological validation and regulatory approval under the Marine Mammal Protection Act. Testing will continue using synthetic whale skin to simulate real-world conditions while permitting is pursued. Upon approval, the system will be deployed on live cetaceans.

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