Red tide: a new approach to monitor using a RWC system

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Abstract

This poster highlights how Deep Sea Apollo develop a system to monitor red tides in Florida West Coast. The approach consists in a tracking system using data from satellites and scientific instruments to monitor red tide at macro levels, and a RWC system integrated by a Remote Operated Vehicle (ROV) with a water sample collector device. Through the device attached to the robot, and the help of a crane, humans will not need to enter or touch the water to get the sample. ROV Aqua Rocket 4.0 was designed for serviceability, specifically to maneuver with great balance and stability, with a repositionable water collector device, and a reinforced waterproof method to protect the motors when is used in saltwater. Analysis of experimental results in-site included in the poster will demonstrate how testing results were used to decide on our final design. This presentation describes the development process and design details that make the Florida Red Tide Monitor System (FRTMS) and ROV Aqua Rocket 4.0 the best system for ensuring public safety, maintaining healthy waterways, and collecting water samples.

ROV Aqua Rocket 4.0 unique features includes:

- commercial off-the-shelf (COTS) components –made of readily available materials.
- box shape for good stability
- repositionable water sample collector device – easily attach/detach tool
- eco-friendly - ROV is powered from an external source in the form of electrical power through a tether cable, so it adds no pollution to the sea
- brightly colored: to clearly identify the ROV orientation from distance or depth
- reinforced waterproof motors
- crane included

Background & Motivation

In 2018, red tide hit Florida West Coast causing the death of marine life and affecting tourism and local business (Hendricks, 2018). It was not safe enter or get in contact with the water, so scientists had a hard time monitoring, sampling, predicting when the red tide will be over. After a team discussion, the crew members decided to address the problem creating a system to monitor red tide in Florida. For that purpose, the team will develop a tracking system using data from satellites and scientific instruments to monitor red tide at macro levels, and will design, build, and test an underwater robot with a water sample collector device. Through the device attached to the robot, and the help of a crane humans will not need to enter or touch the water to get the sample and the data need it to monitor at micro levels the *Karenia brevis,* the phytoplankton that caused the red tide. Collecting a water sample will help NOAA and NASA and our community with information to monitor the concentrations of *Karenia brevis* in Florida waters..

Images from: Anna Maria Island Sun

Methodology

Deep Sea Apollo developed the Florida Red Tide Monitor System (FRTMS) to monitor the red tide in our community minimizing human contact with water. This system consists in monitor data from NASA satellites and scientific instruments from NOAA and Florida Fish and Wildlife Conservation, and an ROV with a water collector device with a crane to place the ROV in the water in a safe way.

A. Tracking system – A Google Spreadsheet bi-weekly updated with data from My NASA Data Earth System Data Explorer Monthly Chlorophyll Concentration for phytoplankton, Red Tide Current Status from NOAA and Florida Fish and Wildlife Conservation on selected points on Florida West Coast, and data collected from team's water sample collector device.
B. RWC System – The RWC is a system integrated by the ROV, the Water sample collector device, and a Crane to place the ROV in the water.

Engineering Design Process for ROV Aqua Rocket 4.0 development

ASK- The first step of the EDP was to state the real-world problem that the team will be addressing, monitor red tides through water samples. Do research about the ROV designs used for work class in the industry. Review the previous design to decide which elements of it to keep and which to improve upon. This makes us to ask how we get ROV stability (**Capocci, R., *et. al*, 2017**), collect and transport water samples, and pour the water sample without losing it.

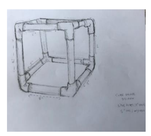
IMAGINE- Team members brainstormed ways we could work with our questions from the first step of the EDP. This process generated a lot of ideas, but we focus on make a stable frame (**MATE, 2019**), and create a water collector device capable of secure, transport and pour the water sample without leaks.

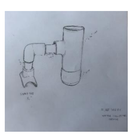
PLAN- Sketches showing the improvements and innovations brainstormed were designed to plan the course of action. The plans included materials, how to build, and testing in fresh and saltwater.

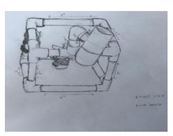
CREATE- After planning, building and testing phase begun for fresh and saltwater. Box shape was built for stability, and water collector device was attached to the top/front of the ROV looking for hydrodynamics (**Moore, S., *et. al.*, 2010**), and to secure and transport the sample. Test in the real-world scenario was a priority to take informed decisions regarding ROV design, water collector device, buoyancy system, and motors.

IMPROVE- After analyzed test results, team members decided to reposition the water collector device from top to bottom, eliminate the elbow and PVC pipe that connect with the Tee, reduce pool noodle to get neutral buoyancy, and reinforced the motor with liquid tape around it, and marine epoxy in the exterior of the film canister.

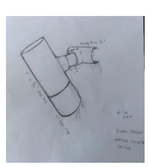
Sketches and images - First design ROV Aqua Rocket 4.0

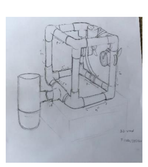


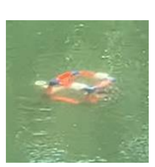




Sketches and images - Final design ROV Aqua Rocket 4.0 and crane







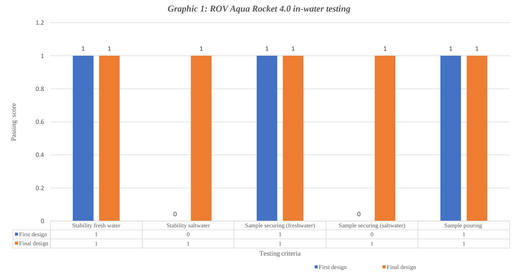
Results & Discussion

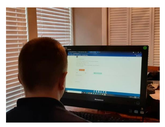
Density is not the same in saltwater; salt in seawater makes it denser than freshwater (**Bohm, H., et. al., 1997**). This affect the behavior of Aqua Rocket when was tested in saltwater. Deep Sea Apollo decide to innovate with a repositionable water sample collector device. The snap tee allows the pilot to easily attach/detach and reposition in any part of the ROV. The main component of the device, the 1" x ½" PVC Tee, is attach not glue to a PVC pipe, allowing the pilot to turn the Tee right or left to easily pour out the water sample without detaching the device from the ROV. This feature diminishes the probability of losing part of the sample when transfer to petri dishes, slides, or another scientific tools for analysis.

In-site saltwater was conducted after a successful freshwater test. ROV Aqua Rocket was capable of dive in a straight line stable, the top part remains in the correct position, and the sample was collected, secured, and transport to shore without losing it. Pouring test was conducted and the sample was verted without detaching the device from the ROV. ROV Aqua Rocket pass all the test and the team determines that it will be the final design.

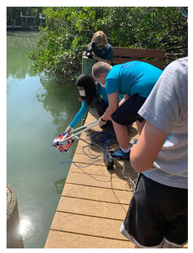
Results from the in-site monitoring validated a functional RWC with a stable ROV navigating the waters, collecting, securing, transporting, and pouring the sample for further analysis, and a crane capable of deploy and retrieve the ROV and the sample in a secure way for humans. No presence of *karenia brevis* was found during the analysis of the water sample. Water quality shows nominal parameters for pH (7), dissolved oxygen (4 ppm), and turbidity (0 JTU).

Graphic 1: ROV Aqua Rocket 4.0 in-water testing

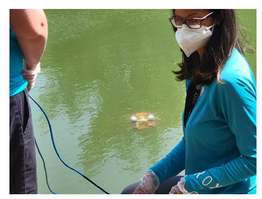


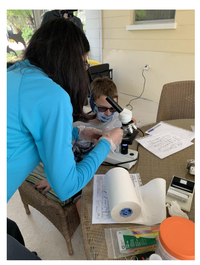


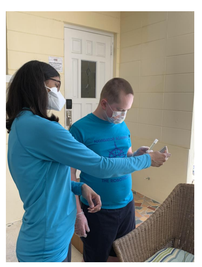
Tracking System

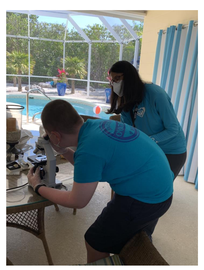


RWC System
ROV Aqua Rocket 4.0, Water sample collector device and crane









Analyzing data: no presence of *karenia brevis* was found. Water quality parameter (pH, Dissolved oxygen, and turbidity) nominal.

Conclusion

Our objective was developing a system to monitor the red tide. Accessibility to information about the blooming of the *Karenia brevis* will keep the community alert and ready to act in case of a red tide. The development of the RWC system composed by the ROV, the water collector device, and the crane will facilitate the scientists and community members that minimize the risk of get in contact with water when a water sample to monitor the phytoplankton or water quality parameters are needed it.

With the development of the Florida Red Tide Monitor System (FRTMS) to monitor the red tide in our community, Deep Sea Apollo contributes to minimize human contact with water, independently if the waters are impacted or not by the red tide. This project empowers our community not only letting the people know when the waters are safe but providing a monitor system that is made with readily available and low-cost materials easy to replicate.

Next Steps

Deep Sea Apollo would like to continue monitoring Florida waters and contribute to prevent red tides. The team would like to create an alert system when red tide is approaching warning the community through a text message or an App with the locations. In addition, the team would like to add a navigation system and sensors to the ROV to collect data in a more accurate and instant way.

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References:

Bohm, H., Jensen, V., & Johnston, N. (1997). *Build your own underwater robot and other wet projects*. Vancouver: Westcoast Words.

Capocci, R., Dooly, G., Omerdić, E., Coleman, J., Newe, T., & Toal, D. (2017). Inspection-Class Remotely Operated Vehicles—A Review. *Journal of Marine Science and Engineering*, *5*(1), 13. MDPI AG. Retrieved from http://dx.doi.org/10.3390/jmse5010013

Farndon, J. (2003). *Buoyancy*. Tarrytown, NY: Benchmark Books.

Hendricks, J. (2018). Red tide reaches Anna Maria Island. Retrieve from https://www.amisun.com/2018/08/07/red-tide-reaches-anna-maria-island/

Marine Advanced Technology Education Center (2019). General Buoyancy Concepts. Retrieved from https://docs.google.com/presentation/d/e/2PACX-1vTE66pPwUH4714_kF4lDv9b0P_NaxPxRqEdMkNE2dMF3quCHhr4vkbZ9MP3YmturuTPtaBDZ1ncSRly/pub?start=false&loop=false&delayms=3000&slide=id.g15d0c88b0c_2_0

Moore, S. Bohm, H., & Jensen, V. (2010). *Underwater Robotics: Science, Design and Fabrication*. Monterey, CA: Marine Advanced Technology Education (MATE) Center

Wickman, K. (2017). *Light is a wave! Conceptual Physical Science Reference Manual*. Polk County, Florida: CK-12.org