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Robust Autonomous pH Monitoring from Marine Vehicles Using the AQ² pH Sensor

INTRODUCTION

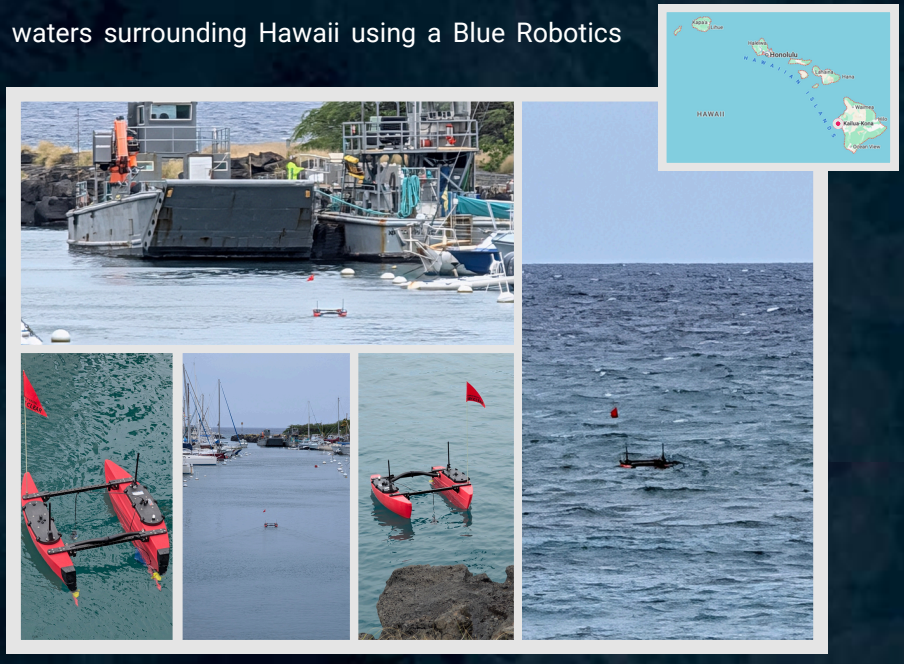
Reliable pH monitoring is becoming increasingly important for understanding coastal processes, ocean acidification, environmental compliance, and ecosystem health. While pH is routinely measured from fixed stations and research vessels, autonomous platforms such as remotely operated vehicles (ROVs), autonomous surface vessels (ASVs), and uncrewed marine systems offer the opportunity to collect high-resolution spatial datasets that would otherwise be difficult or expensive to obtain.

Deploying pH sensors on mobile platforms presents several practical challenges. Conventional glass electrode pH probes are inherently fragile, require frequent calibration, and are sensitive to storage conditions and changes in sample salinity. These limitations increase operational complexity and reduce confidence in long-duration or field deployments. The AQ² pH sensor addresses these challenges through a robust solid-state sensing technology that requires no routine calibration, no wet storage, and can operate across a wide range of salinities without changing sensor configuration. These characteristics make it particularly well suited for autonomous marine vehicles where simplicity, reliability, and low maintenance are essential.

This white paper presents the deployment of the AQ² pH sensor on a Blue Robotics BlueBoat during coastal operations in Hawaii. The mission demonstrates the sensor's ability to collect stable, high-quality pH and temperature data while transitioning from sheltered harbour waters into the open ocean.

DEPLOYMENT SITE & METHODOLOGY

The field trial was conducted in coastal waters surrounding Hawaii using a Blue Robotics BlueBoat equipped with an AQ² sensor.



The vehicle was launched from a sheltered harbour before travelling into open coastal waters. Throughout the mission, the vehicle continuously recorded pH, temperature and GPS position

The AQ² sensor was integrated directly into the vehicle architecture using its digital communications interface, requiring no specialist conditioning electronics or preparation before entering the water.

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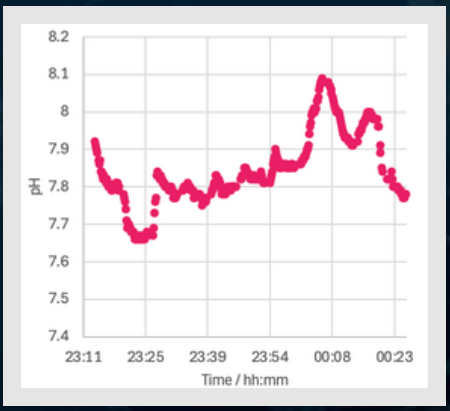
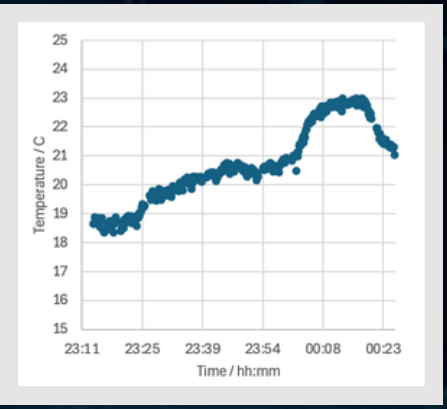
RESULTS & OBSERVATIONS





The recorded trajectory illustrates the movement from enclosed harbour waters into the adjacent coastal environment. As expected, clear environmental gradients were observed. The AQ^2 sensor recorded a gradual increase in pH as the vehicle progressed from harbour waters toward the open ocean. Water temperature also increased progressively during the mission, consistent with the movement away from sheltered harbour waters into warmer coastal waters. The simultaneous measurement of pH and temperature provides valuable environmental context and demonstrates the suitability of the sensor for multiparameter marine surveys.

Many autonomous marine missions involve movement between environments with markedly different salinity, including harbours, estuaries, river mouths, coastal waters, and the open ocean. These transitions present a significant challenge for conventional glass electrode pH sensors, whose performance may be affected by changes in ionic strength and which often require careful calibration under the expected operating conditions.

The AQ^2 pH sensor has been specifically evaluated under both controlled laboratory conditions and real-world deployments to demonstrate reliable performance across these changing environments.

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WHY THIS DEPLOYMENT MATTERS

This deployment demonstrates several practical advantages of the AQ^2 pH sensor for autonomous marine operations. Its rugged, solid-state sensing element provides greater robustness than traditional glass probes, making it well-suited to vehicle-based deployment where sensors may be exposed to impact during launch, operation and recovery.

The AQ^2 also eliminates the need for routine calibration and specialised wet storage, simplifying field preparation, handling and deployment. Its ability to operate across changing salinity conditions without recalibration or changes in sensor configuration is particularly valuable for coastal and autonomous surveys, where vehicles may transition between harbour, estuarine and open-ocean environments during a single mission. Combined with its straightforward integration into existing vehicle architectures and low maintenance, the AQ^2 provides a practical and reliable solution for autonomous marine pH monitoring.

CONCLUSIONS

The Hawaii field deployment demonstrates the suitability of the AQ^2 pH sensor for autonomous marine operations. Throughout the mission, the sensor delivered stable pH and temperature measurements while the vehicle transitioned from harbour waters into the open ocean, capturing the expected environmental gradients without interruption.

Unlike conventional glass electrode systems, the AQ^2 sensor required no calibration immediately before deployment, no specialised storage, and no adjustment as water chemistry changed throughout the mission. These characteristics significantly simplify field operations while improving reliability and reducing maintenance requirements.

As autonomous marine platforms continue to expand their role in environmental monitoring, offshore inspection, aquaculture, and scientific research, robust sensors that minimise operator intervention become increasingly important. The AQ^2 pH sensor provides a practical alternative to traditional glass electrode technology, enabling reliable pH monitoring across diverse marine environments with the simplicity required for modern autonomous vehicle deployments.