

MICROCONTROLLER AND INTERNET OF THINGS BASED SYSTEM FOR MONITORING AND CONTROLLING DISSOLVED OXYGEN IN NATIVE MARINE FISH FARMING

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Summary

A modular system based on microcontrollers and IoT was developed for the automatic monitoring and control of dissolved oxygen (DO) in fish farming ponds. The system integrates DO and temperature sensors with oxygenation control via solenoid valves, communicating through AWS IoT Core and displaying data in Grafana. After seven months of operation, it maintained saturation between 80–110%, demonstrating its robustness, scalability, and potential to modernize Chilean aquaculture.

Introduction

Dissolved oxygen (DO) is one of the most critical variables in aquaculture, as it directly influences the metabolism, growth, and well-being of farmed organisms. In native marine fish, such as the Northern Cojinoba (*Seriolaella violacea*), adequate DO availability is essential to ensure productive efficiency and the success of farming systems. However, the lack of accessible technologies adapted to local contexts has limited the implementation of automated monitoring and control solutions in small- and medium-scale operations.

This study presents the development and validation of a prototype system based on microcontrollers and the Internet of Things (IoT), designed for monitoring and regulating DO in a 500 L tank of an open aquaculture system. The architecture integrates two modules: (i) a monitoring module with an ESP32 and DO and temperature sensors from Atlas Scientific, responsible for the continuous capture and transmission of data; and (ii) a control module with an ESP8266 that operates a pneumatic solenoid valve connected to compressed oxygen cylinders, adjusting the injection based on the measured levels.

Both modules communicate via AWS IoT Core, securely sending information to the cloud, where the data is displayed on Grafana's dynamic dashboards. After more than seven months of continuous operation, the system generated an average of 7,000 daily records, maintaining DO saturation in the 80–110% range and ensuring optimal culture conditions.

The results demonstrate that integrating low-cost microcontrollers with IoT services is a robust, scalable, and replicable alternative with the potential to significantly contribute to the modernization of aquaculture in Chile.

Materials and methods

The system was implemented at the Marine Botany Laboratory (UCN) and consisted of two modules: an ESP32 with dissolved oxygen and temperature sensors (Atlas Scientific) for continuous monitoring, and an ESP8266 that controlled a pneumatic solenoid valve connected to compressed oxygen cylinders. Data was transmitted via MQTT to AWS IoT Core, stored in DynamoDB and S3, and visualized in Grafana. In over seven months of testing, the system generated approximately 7,000 daily records at a frequency of 20 seconds (Fig. 2).



Fig 1. Faculty of Marine Sciences, Universidad Católica del Norte, Coquimbo.

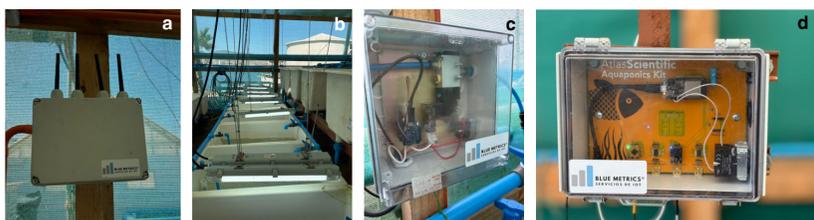


Fig 2. a) 4G Router. b) Cultivation System. c) Oxygen Injection Controller based on ESP8266. d) Water Quality Controller for Dissolved Oxygen and Temperature.

Key	Key	Value	Key	Value	Key	Value
01	1741724277200	15.94	109	1741713477	17.085	03-11-2025 17:17:57
01	1741724297200	16.06	109.8	1741713497	17.057	03-11-2025 17:18:17
01	1741724317251	16.01	109.5	1741713517	17.072	03-11-2025 17:18:37
01	1741724337251	15.87	108.5	1741713537	17.233	03-11-2025 17:18:57
01	1741724357295	15.95	109.1	1741713557	16.978	03-11-2025 17:19:17
01	1741724377320	15.69	107.3	1741713577	17.178	03-11-2025 17:19:37
01	1741724397372	15.59	106.6	1741713597	17.073	03-11-2025 17:19:57
01	1741724417407	15.41	105.4	1741713617	17.09	03-11-2025 17:20:17
01	1741724437439	15.32	104.8	1741713637	17.032	03-11-2025 17:20:37

Fig 3. Preliminary dataset stored in AWS DynamoDB.

Sensors in the pond measure key water quality parameters and send the data to a microcontroller, which transmits it via a router to the AWS cloud. This enables secure storage, real-time monitoring, and remote access through web and mobile applications. The collected data is used by the oxygen injection controller to turn the system on and off only when needed, optimizing the use of pure oxygen in the culture system. The system automates data collection, reduces manual labor, improves response time to changes, and optimizes efficiency through data-driven management, while cloud integration ensures scalability, security, and accessibility (Fig. 4).

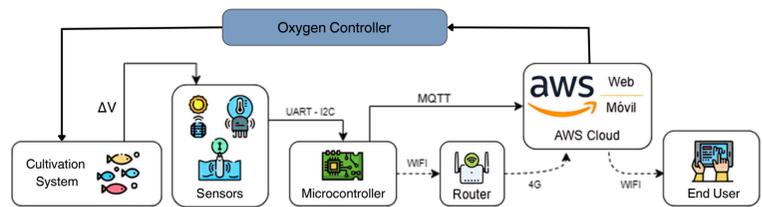


Fig 4. Architecture of the dissolved oxygen data acquisition and control system. Key components required to deliver pond information to the end user.

Results

The result is the real-time transmission of data on O₂ saturation through the AWS cloud, which will allow operators to observe trends and improve decision-making, optimizing management and reducing response time (Fig. 5).

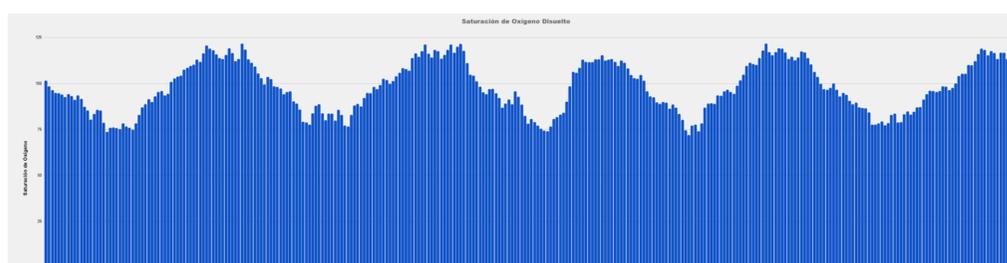


Fig 5. Oxygen saturation (%) recording for 60 minutes with a sampling frequency of 20 seconds.

References

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Acknowledgments

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