



Technological Aids: Sensors, Automation and Monitoring

Ethan Wright*

Department of Aquatic Engineering, Massachusetts Institute of Technology, Cambridge, United States of America

DESCRIPTION

In recent years, there has been a noticeable increase in the adoption of sensor arrays and automation technologies within aquaculture research. These advancements are gradually transforming traditional fish and shellfish farming by enabling more precise, real-time management of critical water quality parameters. Although studies focusing on nutrition and water chemistry remain dominant, a growing body of work now highlights the use of various sensors and automated control systems to monitor and regulate culture environments, particularly in tanks and earthen ponds. One of the primary applications of sensor technology in aquaculture is real-time monitoring of essential water parameters such as dissolved oxygen, temperature, pH and conductivity. Maintaining these variables within optimal ranges is crucial for ensuring the health, growth and survival of cultured species. In conventional aquaculture setups, water quality is typically assessed through manual sampling and laboratory analysis, which is time-consuming and may miss rapid fluctuations. The integration of sensor arrays provides continuous, automated data collection that enables timely detection of changes or potential problems before they escalate. These sensors can be deployed individually or in combination, forming comprehensive monitoring systems that deliver a detailed snapshot of the aquatic environment at any moment.

Several studies have analyzed the deployment of sensor networks connected to actuators devices that can automatically adjust environmental conditions based on sensor feedback. For example, dissolved oxygen sensors linked to aeration systems can trigger air or oxygen injection when oxygen levels fall below a set threshold. Similarly, pumps can be activated to circulate or exchange water in response to detected changes in temperature or water chemistry. Feed delivery systems may also be automated to release precise amounts of feed at scheduled intervals or in response to fish activity patterns monitored by sensors. These closed-loop control systems reduce the need for constant human intervention, improve consistency in water quality management and help optimize feeding efficiency, which can reduce waste

and enhance growth performance. A particularly interesting area of development involves the use of low-cost sensors paired with open-source microcontrollers, such as Arduino or Raspberry Pi platforms. These affordable technologies have gained attention for their potential to democratize aquaculture monitoring, making advanced control systems accessible to small-scale or resource-limited farms. Researchers have compared the performance of these cost-effective sensor setups against commercial-grade units, often finding comparable accuracy and reliability when properly calibrated. This approach encourages innovation and customization, as farmers or technicians can modify hardware and software to suit specific operational needs. Moreover, open-source communities provide extensive resources and support, facilitating rapid development and dissemination of sensor solutions tailored to aquaculture.

Data management plays a vital role in these sensor-based systems. Continuous monitoring generates vast amounts of time-series data, which require careful logging, processing and analysis to extract meaningful insights. Many studies employ data logging techniques combined with statistical tools to identify anomalies such as sudden drops in dissolved oxygen or spikes in ammonia levels. Trend analysis enables the detection of gradual changes that might indicate deteriorating water quality or emerging health risks to cultured organisms. This information supports proactive decision-making and preventive management strategies, rather than reactive responses after problems become visible. Some pilot studies have implemented advanced feedback control algorithms that automatically maintain water parameters within predefined target ranges. These strategies rely on real-time sensor input to fine-tune aeration rates, water exchange volumes, or feeding schedules, thereby stabilizing the culture environment even under fluctuating external conditions. Feedback control enhances system resilience by dynamically adapting to changes such as temperature shifts, oxygen consumption by fish, or organic load buildup. Such automation can improve productivity and animal welfare by minimizing stress associated with water quality instability.

Remote monitoring and alert systems represent another promising application. By linking sensor arrays to mobile

Correspondence to: Ethan Wright, Department of Aquatic Engineering, Massachusetts Institute of Technology, Cambridge, United States of America, E-mail: ewright@mit.edu

Received: 29-Jul-2025, Manuscript No. JARD-25-30159; **Editor assigned:** 31-Jul-2025, PreQC No. JARD-25-30159 (PQ); **Reviewed:** 14-Aug-2025, QC No. JARD-25-30159; **Revised:** 21-Aug-2025, Manuscript No. JARD-25-30159 (R); **Published:** 28-Aug-2025, DOI: 10.35248/2155-9546.25.16.1023

Citation: Wright E (2025). Technological Aids: Sensors, Automation and Monitoring. J Aquac Res Dev. 16:1023.

Copyright: © 2025 Wright E. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

communication networks, data and alerts can be transmitted *via* SMS, email or smartphone applications. This connectivity allows farmers to monitor their operations remotely, receiving timely notifications if any parameter strays outside safe limits. Remote access reduces the need for constant on-site presence and enables quicker intervention in emergencies, potentially preventing mass mortalities or severe production losses. The integration of IoT (Internet of Things) technologies in aquaculture is thus poised to enhance farm management through increased accessibility, transparency and responsiveness. While sensor and automation research in aquaculture is still

emerging compared to more established fields such as nutrition and water quality, it is rapidly gaining traction. The steady decrease in sensor costs coupled with improvements in user-friendly software and hardware platforms is driving broader adoption. The ability to continuously monitor and adjust culture conditions in real time presents opportunities to improve operational efficiency, reduce labor demands and increase sustainability. As these technologies mature, they are likely to become standard components in both small-scale and commercial aquaculture operations.