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UNDERWATER WORKFORCE IN SUSTAINABLE AQUACULTURE: HUMAN EXPERTISE AND FUTURE PATHWAYS FOR THE BLUE ECONOMY

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Abstract

Aquaculture plays a strategic role in sustainable food production and the blue economy. Among its unseen yet indispensable elements are professional divers, who carry out essential underwater operations. In aquaculture facilities, divers perform a wide range of tasks including installation, inspection, and maintenance of floating cage systems (HDPE), monitoring fish behavior and health, supporting harvesting operations, conducting environmental assessments beneath cages, and performing emergency repairs. These responsibilities encompass net and buoy maintenance, underwater infrastructure control, and observation of organic accumulation and sediment quality—functions that remain highly dependent on human expertise. As global aquaculture production continues to grow, the demand for skilled divers is rising rapidly. However, challenges persist regarding safety, environmental conditions, and technical competency. In this context, technological integration is reshaping the field: Remotely Operated Vehicles (ROVs), artificial intelligence (AI)-based image analysis, and Internet of Things (IoT) systems are transforming underwater work processes. Hybrid ROV-diver operations, deep learning-assisted damage detection, and IoT-based sensor networks are becoming standard in modern aquaculture systems. Nevertheless, in areas such as emergency response, adaptability, and direct observation, the human element remains irreplaceable. In conclusion, while technology is redefining underwater operations, the role of divers is evolving rather than disappearing. The future of aquaculture will rely on a model where human expertise and advanced technology coexist, ensuring safer, smarter, and more efficient underwater ecosystems.

Keywords: Aquaculture diving, ROV, IoT, Blue economy