

Integrated multi-omics studies indicate that these diets enhance energy pathways while down-modulating excessive stress and inflammatory responses. In parallel, emerging breeding work on heat-tolerant and stress-resistant lines, along with gradually adopted intelligent monitoring and AI-supported decision tools, suggests that biological, nutritional, and technological approaches can be combined into a coherent health management framework for hot seasons.

Despite rapid progress, most experimental studies on large yellow croaker thermal stress are short-term, carried out under controlled or semi-controlled conditions, and focus on single factors such as temperature, diet, or transport. This limits understanding of how chronic multi-stressors—heat combined with hypoxia, pollutants, high density, and pathogens—interact over full production cycles. In addition, many multi-omics investigations are done at juvenile stages and in specific seasons, creating uncertainty about how findings scale to different life stages, strains, and farming regions. Methodologically, current work is often fragmented between physiology, nutrition, genetics, and engineering. Large, integrative field trials that compare different culture systems, diets, and management packages under realistic summer conditions remain scarce. Meanwhile, smart aquaculture and AI/AIoT research is dominated by generic models and laboratory or pilot demonstrations, with relatively few tools tailored to the behaviour, color, schooling patterns, and disease spectrum of large yellow croaker. Barriers such as high initial costs, requirement for technical expertise, and lack of standardized data pipelines also slow real-world deployment.

Future research should prioritize long-term, system-level studies that couple environmental regulation (temperature, oxygen, water quality) with precision nutrition, stocking-density control, and disease prevention for entire summer grow-out cycles. Combining multi-omics with continuous environmental and behaviour monitoring can clarify how specific management packages influence resilience, growth, and product quality. Parallel breeding and genomic selection programs targeting acute and chronic heat tolerance, hypoxia resistance, and disease robustness will be critical to create strains adapted to future warming. On the technological side, intelligent fish-farm concepts and AIoT platforms offer powerful prospects for high-temperature health management. Networked sensors, computer vision, and machine-learning models can underpin real-time control of feeding, aeration, and environmental alarms, while advanced diagnostic tools and AI-based disease recognition can support earlier, more targeted interventions. To make these solutions practical for croaker farmers, future work should emphasize species-specific model training, cost-effective modular hardware, explainable interfaces, and capacity building. Ultimately, integrating heat-tolerant germplasm, functional feeds, optimized offshore or recirculating systems, and intelligent management tools will be the key pathway to resilient, sustainable large yellow croaker aquaculture under a warming climate.

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Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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