

aquaculture systems for large yellow croaker should minimize sharp temperature gradients and provide access to thermally suitable layers, especially during peak summer surface warming. Reviews on extreme temperature events in aquaculture suggest that structural modifications such as increased water depth or coverings, and the use of recirculating systems, can buffer fish from temperature spikes (Islam et al., 2021).

Experimental work on recirculating ponds shows that optimizing the layout, perforation rate, and angles of water supply pipelines can markedly improve thermal uniformity and weaken stratification (Zhang et al., 2024). In larger water bodies, selective withdrawal strategies that adjust intake depth can raise downstream water temperatures during critical spawning and growth periods while weakening reservoir stratification, offering a model for managing inflow and outflow depths in large pond or reservoir-based aquaculture (Wang et al., 2024).

5.2 Dissolved oxygen optimization and water circulation system design

In feed-based ponds, major oxygen sources are phytoplankton photosynthesis and mechanical aeration, while fish and microbial respiration constitute dominant sinks, leading to high daytime oxygen but dangerously low nighttime levels under warm, eutrophic conditions. Reviews of aeration technologies emphasize that selecting efficient aerators and correctly sizing and positioning them is crucial to maintain optimal dissolved oxygen in intensive systems.

Empirical studies in brackish ponds demonstrate that paddle-wheel aerator placement, as well as seasonal variation in total dissolved and suspended solids, strongly influence mixing intensity, water velocities, and oxygen transfer rates, and that data-driven models can forecast dissolved oxygen with high accuracy to guide aeration scheduling (Ramesh et al., 2024). In RAS, simple pipeline diffused aeration systems using pure oxygen have been shown to substantially increase outlet dissolved oxygen with predictable performance based on pipe length, inlet oxygen, and contact time, allowing controllable DO regulation during periods of high temperature and metabolic demand (Ji et al., 2024).

5.3 Water quality regulation and pollutant control strategies

Dynamic modeling of RAS highlights that ammonia, nitrite, nitrate, dissolved oxygen, and pH are tightly linked to fish metabolism, feeding intensity, biofilter performance, and water exchange, and that strengthening biological filtration and oxygenation is key to preventing toxic accumulations (Udayakumar et al., 2025). Reviews of recirculating systems detail that particulate matter, nitrogen pollutants, phosphate, carbon dioxide, antibiotics, steroids, and heavy metals can build up and compromise fish health, so integrated treatment units must filter or degrade these substances and recycle purified water (Li et al., 2023).

Biological approaches have been particularly effective for nitrogen control. Bacteria-microalgae associations in recirculating ponds significantly reduced total nitrogen, ammonia, and nitrite while improving fish production, supported by shifts in microbial communities toward nitrification and denitrification pathways. Similarly, assembled bacterial consortia of *Bacillus* and *Pseudomonas* species have efficiently converted ammonia to nitrite and further to less toxic nitrate in aquaculture wastewater, greatly improving fish survival compared with untreated controls. Reviews focused on *Bacillus* species confirm their broad capacity to modulate physical and chemical water quality parameters, including nitrogenous species, heavy metals, and microbial balance, offering a cost-effective tool for maintaining stable environments during stressful warm periods (Figure 2).

6 Nutritional and Feeding Management Strategies

6.1 Adjustments of energy and protein requirements under high temperature

High summer temperatures increase metabolic costs, so diets must supply sufficient digestible energy while avoiding excessive metabolic and oxidative burden. Recent reassessment of large yellow croaker nutrition in net pens indicates that crude protein levels of about 490-520 g/kg combined with 90 g/kg lipid support fast growth, high nitrogen retention, and appropriate body lipid with normal antioxidant capacity, suggesting this range as a baseline for high-demand periods (Chen et al., 2023). For thermal stress conditions, evidence from spotted seabass shows that protein requirements can shift with temperature, with slightly lower optimal protein at 33 °C than at 27 °C, indicating that heat alters nutrient metabolism and the efficiency of protein use.