

3 Effects of High Temperature on Physiological Functions of Large Yellow Croaker

3.1 Changes in metabolic rate and energy allocation

High temperature reshapes liver metabolism of large yellow croaker, shifting how energy is produced and allocated. Proteomic analysis under high-temperature stress shows reduced protein synthesis and a transition from oxidative phosphorylation to glycolysis, alongside increased fatty acid biosynthesis and reduced fatty acid catabolism in the liver of thermally stressed fish (Zhang et al., 2023). Transcriptomic work further confirms that temperature stress in large yellow croaker broadly alters energy-metabolism pathways, with genes encoding key metabolic enzymes markedly up- or down-regulated in the liver.

Long-term exposure to high rearing temperatures redistributes energy away from somatic growth toward defense and maintenance. In large yellow croaker acclimated to 30 °C, body weight declines while oxidative stress markers such as gill superoxide dismutase activity increase, indicating a trade-off between growth and heat tolerance. Multi-omics analysis under summer heat shows that dietary inulin can partially rebalance this allocation by upregulating hepatic glycolysis and fatty-acid biosynthesis and enriching beneficial gut bacteria, thereby supporting energy production and growth under chronic thermal stress (Yin et al., 2026).

3.2 Disruption of respiration and osmoregulatory functions

High water temperature challenges gill function in teleosts, combining respiratory strain with osmoregulatory disturbance. In Atlantic salmon smolts, rapid warming to 24 °C in seawater causes complete mortality and severe ion-regulatory failure, with poor plasma ion control and depressed gill Na^+/K^+ -ATPase activity, highlighting a temperature threshold beyond which osmoregulation collapses. Similar enzyme suppression occurs in juvenile goldfish, where elevated temperatures reduce gill Na^+/K^+ -ATPase expression while inducing structural lesions such as lamellar fusion and epithelial detachment, implying impaired gas exchange and ionic balance under heat stress (Ngozichukwu and Rahman, 2025).

Transcriptomic analysis in Siberian sturgeon gills illustrates the mechanistic basis of these osmoregulatory disturbances. Heat stress elevates reactive oxygen species and tissue damage, while downregulating Na^+/K^+ -ATPase α and upregulating multiple ion-transport genes involved in active ion absorption and passive efflux, indicating increased gill permeability and compensatory ion-transport adjustments (Yang et al., 2023). In other species, high-temperature exposure elevates antioxidant enzymes and heat-shock proteins in gills, yet oxidative and nitrative damage still develops, underscoring that respiratory and osmotic homeostasis remain vulnerable when temperatures exceed adaptive limits (Schleger et al., 2024).

3.3 Decline in growth performance and feed utilization efficiency

Long-term high temperatures generally depress growth performance once the thermal optimum is exceeded. In hybrid catfish, growth and feed utilization follow a quadratic response to temperature: performance peaks around 32 °C but falls sharply at 37 °C, where growth, feed efficiency, and tissue condition all deteriorate (Khieokhajokhet et al., 2022). Studies on cherry salmon show a similar pattern: body weight, growth rate, feed intake, and feed efficiency are significantly higher at cooler 10 °C-14 °C than at 18 °C-22 °C, with 22 °C associated with poor feeding and impaired growth and health (Lee and Balasubramanian, 2023). These performance declines are tightly linked to metabolic costs and feed conversion. In cherry salmon, reduced feed efficiency at elevated temperatures is attributed to increased standard metabolic rate, which leaves less dietary energy available for growth under fixed ration sizes. Across other cultured species, higher rearing temperatures can require more feed per unit biomass gain and worsen nutrient deposition, as seen in growth-hormone transgenic Atlantic salmon reared at 16.5 °C, which show poorer feed conversion and less efficient omega-3 deposition than fish at cooler temperatures.

High temperatures in large yellow croaker culture shift liver metabolism toward glycolysis and altered lipid use, while long-term warming forces an energy trade-off away from growth and toward stress defense. Gill respiration and osmoregulation become fragile under heat, with Na^+/K^+ -ATPase suppression, structural damage, and oxidative stress compromising gas exchange and ion balance. Across species, exceeding optimal temperatures consistently reduces growth performance and feed efficiency by raising metabolic costs and impairing nutrient utilization, highlighting the need to manage summer temperatures carefully in large yellow croaker aquaculture.