

Genome-wide analyses have identified 17 hsp70 genes organized into distinct evolutionary groups, with several showing significant upregulation under heat stress, indicating diversified but coordinated HSP-mediated defenses against temperature challenges. Liver transcriptome studies under heat and cold stress further reveal thousands of differentially expressed genes, with strong enrichment of energy metabolism and related pathways, confirming that temperature stress reshapes metabolic and stress-response networks at the transcriptional level. Signal-transduction cascades such as p38 MAPK also participate in croaker thermal responses.

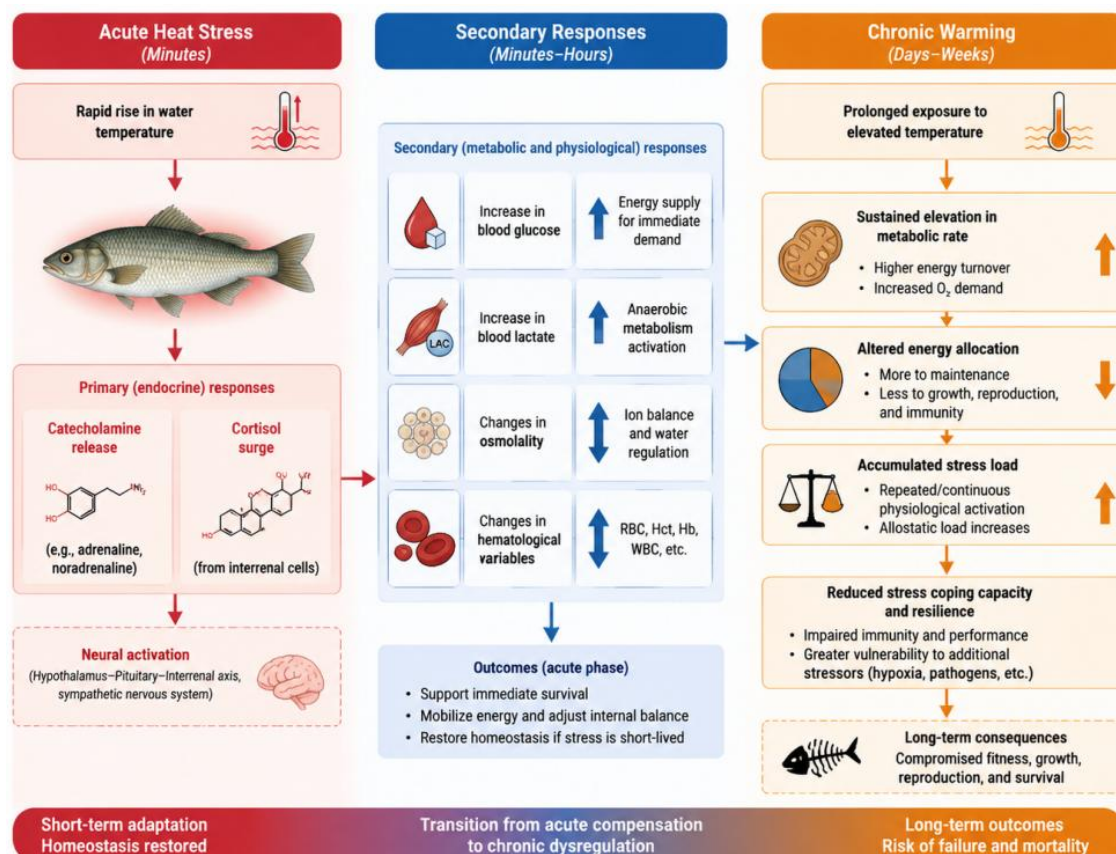


Figure 1 Organismal stress response pathways in fish under acute and chronic thermal stress

Note: Acute warming triggers endocrine activation (catecholamines and cortisol), followed by secondary metabolic responses, while chronic exposure leads to sustained metabolic elevation and reduced stress coping capacity

In a croaker kidney cell line, both cold (10 °C) and heat (35 °C) significantly upregulate p38 MAPK transcripts, and thermal exposure increases p38 phosphorylation together with transcription of HSP27 and caspase-3. Pharmacological inhibition of p38 MAPK suppresses HSP27 and caspase-3 induction, indicating that p38 mediates key branches of the heat shock and apoptotic response in this species. Genetic studies also show that acute heat tolerance (AHT) in large yellow croaker is polygenic, with genome-wide association identifying several significant SNPs and ~30 candidate genes, including heat shock factor 1, DnaJ homologs, Hikeshi and protein disulfide-isomerase A3 (Wu et al., 2021). Comparative analyses highlight the roles of blood-vessel regulation, heat shock response and endoplasmic reticulum stress response in inter-individual variation in AHT, providing a mechanistic basis for breeding heat-tolerant strains.

High-temperature seasons now unfold against a background of intensified marine heatwaves and chronic warming, exposing large yellow croaker to more frequent and severe thermal stress. At the organismal, cellular and molecular levels, heat challenges induce complex stress, oxidative, apoptotic and heat shock pathways that reshape metabolism and compromise growth and health. In large yellow croaker, detailed characterization of thermal limits, transcriptomes, proteomes, signaling cascades and genetic determinants of heat tolerance provides a solid mechanistic foundation for targeted health-management and selective-breeding strategies under a warming ocean.