7.2 Actual impacts of high/low-temperature events on growth and survival

Short-term high-temperature events superimposed on seasonal warming can trigger sharp increases in mortality and physiological stress. In suspended-cage culture adjacent to a tidal-mixing front, *Pacific abalone* exposed to stable high summer temperatures showed elevated metabolic rates and experienced summer mortality, whereas cages experiencing semidiurnal fluctuations between 20 °C-26 °C had no summer mortality, suggesting that intermittent low-temperature periods can buffer lethal impacts. (Kang et al., 2019) In controlled trials with greenlip abalone, survival remained >95% at 18 °C-22 °C but fell by up to 50% at 26 °C when animals were fed a commercial diet, revealing that modest additional warming above 22 °C can halve survival in larger, market-sized stock over several weeks.

Epidemiological analysis of commercial farms confirms that summer mortality risk is tightly linked to thermal extremes. A case-control study of greenlip and hybrid abalone in Australia showed that the risk of summer mortality doubled for every 2 °C increase in maximum weekly water temperature, with interactions involving age, previous mortality history, feed rate and post-grading mortality further modulating outcomes (Figure 2) (Bansemer et al., 2023). Continuous laboratory exposures of *Haliotis discus hannai* to temperatures above 26 °C likewise reduced survival, increased falling rates and caused abnormal foot structures, indicating compromised attachment and heightened mortality risk when summer peaks exceed species-specific thresholds.

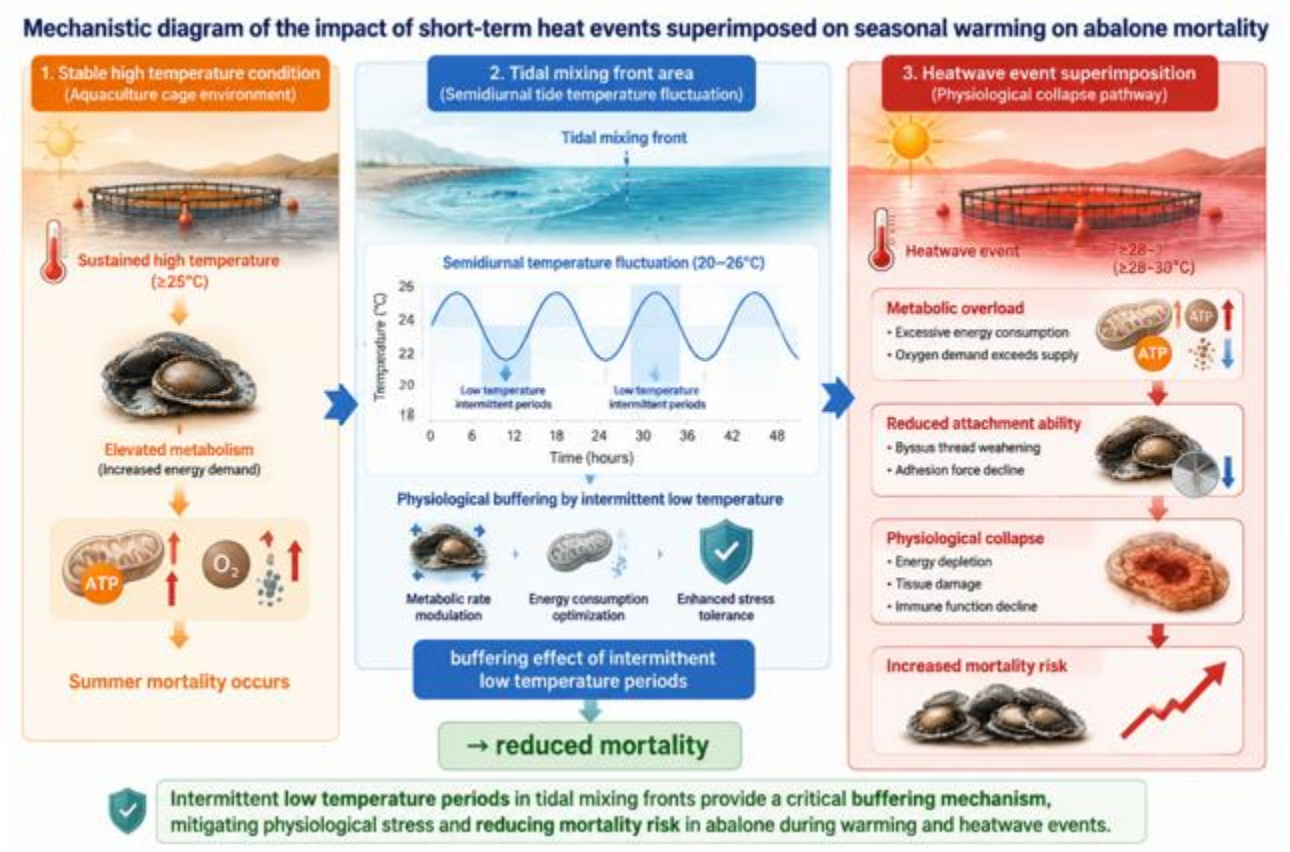

Figure 2 Buffering effects of short-term temperature fluctuations on summer mortality in *Haliotis* spp.

7.3 Evaluation of temperature control measures and farming profitability

Because open coastal farms often cannot economically control temperature, management has focused on nutritional and system-design strategies to mitigate seasonal stress. In hybrid abalone reared at 12, 17 and 22 °C, higher dietary protein (up to 410 g /kg) improved weight gain, specific growth rate and feed conversion, particularly at 22 °C, and did so without compromising flesh quality, indicating that diet optimization at higher temperatures can shorten culture duration and “profit maximisation” despite seasonal warming (Hassan et al., 2023). Similarly, summer-mortality experiments show that providing live macroalgae (Ulva lactuca) at 26 °C maintained survival above 97%,