

2024). In parallel, Hsp70 in *P. trituberculatus* functions as an inducible stress-related molecule linked to innate immune defense, supporting the view that heat stress can shift the animal into a protective but energetically costly stress-response state.

4.2 Risks of bacterial diseases and opportunistic infections

High temperature can increase bacterial disease risk in crab culture not simply by favoring a single pathogen, but by simultaneously weakening host defenses and changing the surrounding microbial environment. In aquaculture systems more broadly, elevated water temperatures reduce immunocompetency and increase disease susceptibility, while also increasing loads of opportunistic *Vibrionaceae* in the water column (Samsing and Barnes, 2024). This pattern is relevant to swimming crab because *Vibrio alginolyticus* is already recognized as a major causative agent of emulsification disease associated with large mortality in *P. trituberculatus*.

The infection hazard is amplified during periods when host barriers or physiological stability are compromised. During molting and immediately after molting, swimming crabs are especially vulnerable because the hard carapace and cuticle, which normally act as the first physical barrier against pathogen invasion, are temporarily weakened (Liu et al., 2022). More generally, opportunistic bacterial disease in aquaculture is increasingly understood as a multicausal process driven by environmental stress, host damage, and microbial shifts rather than a simple one-pathogen-one-disease model, which makes high-temperature episodes particularly dangerous under intensive farming conditions (Samsing and Barnes, 2024) (Figure 1).

Mechanisms by Which Elevated Temperature Increases Bacterial Disease Risk in Swimming Crabs

A Multi-factorial Pathway Involving Environment, Host and Microbiome

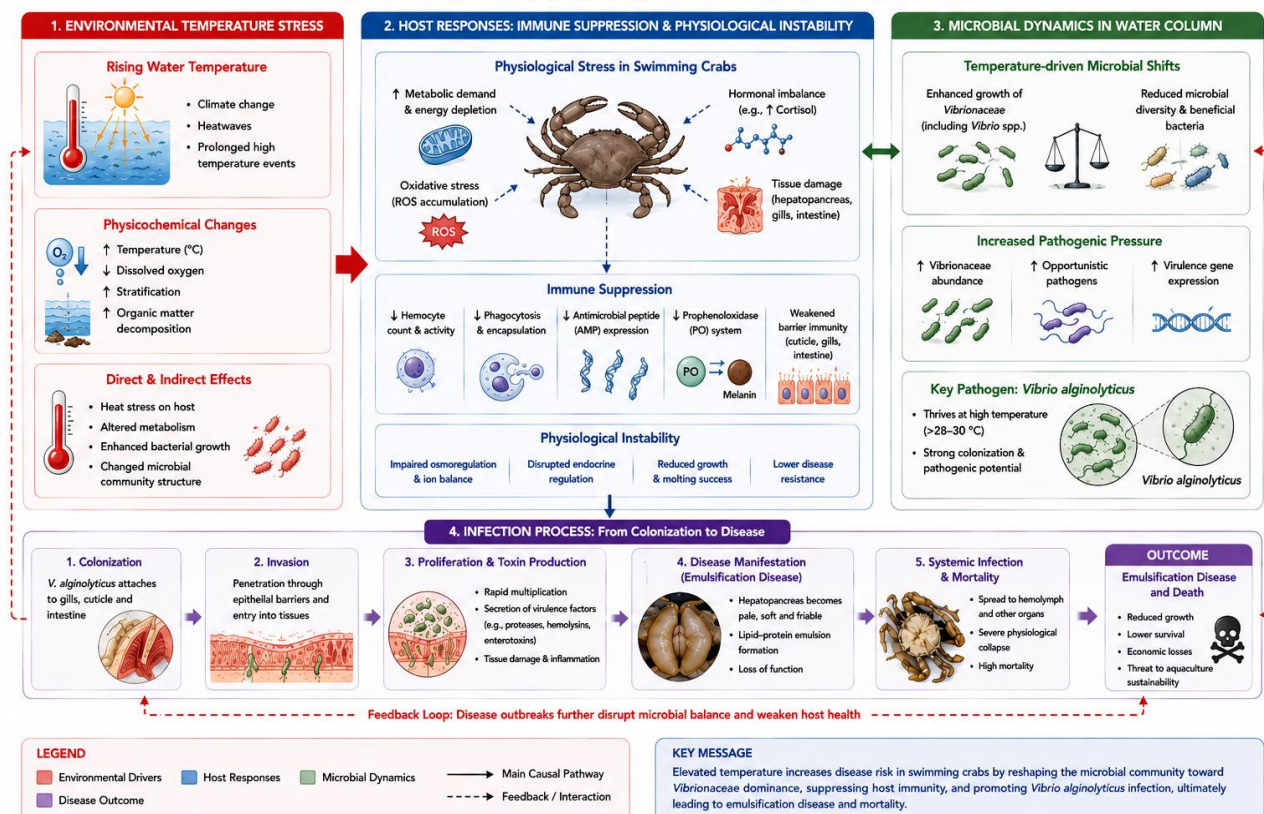


Figure 1 Mechanistic pathway linking high temperature to increased bacterial disease risk in swimming crab (*Portunus trituberculatus*) through host-microbiome interactions

4.3 Molting abnormalities and growth retardation

High temperature can disrupt molting rhythm in swimming crab, and the effect appears to depend on whether temperature remains within a favorable physiological window or exceeds it. Moderate warming often shortens