

severity (King et al., 2018; Destoumieux-Garzón et al., 2024). Abiotic stressors such as low salinity or high temperature further disrupt digestive microbiota, increase pathogenic taxa (e.g. *Vibrio*), and are linked with inflammatory dysregulation and higher mortality during *Vibrio* infections (Li et al., 2022; Li et al., 2023). Oyster disease in farming systems emerges from the interplay of innate immune capacity, tissue-level damage, metabolic reprogramming and microbiome stability. Viral and bacterial pathogens exploit immune weaknesses and energy constraints, while environmental stressors destabilize microbial communities and inflammatory control, tipping oysters from resistance toward dysbiosis, systemic infection and mortality.

7 Case Study: Disease Outbreak Characteristics in Intensive Oyster Farming Systems

7.1 Analysis of typical disease outbreak processes in high-density farming areas

In intensive Pacific oyster farming areas, mass mortality episodes typically begin within farming zones and then spread rapidly across leases and into surrounding waters, highlighting the amplifying effect of high host density and farm clustering on infection pressure. Outbreaks often show strong spatial and temporal dependence, with disease fronts progressing from intensively used farming sectors toward less stocked or peripheral sites, consistent with local transmission driven by waterborne dispersal and farm connectivity (Figure 2) (Richard et al., 2021). Outbreak timing is tightly linked to seasonal windows when temperature favours pathogen replication, and juvenile cohorts in dense nursery structures are usually affected first, often experiencing very high losses within short periods. Husbandry operations such as handling and high stocking densities can further intensify outbreaks, with evidence that recent manipulation and dense basket systems increase mortality relative to lower-density rope culture or standard stocking levels (De Kantzow et al., 2017).

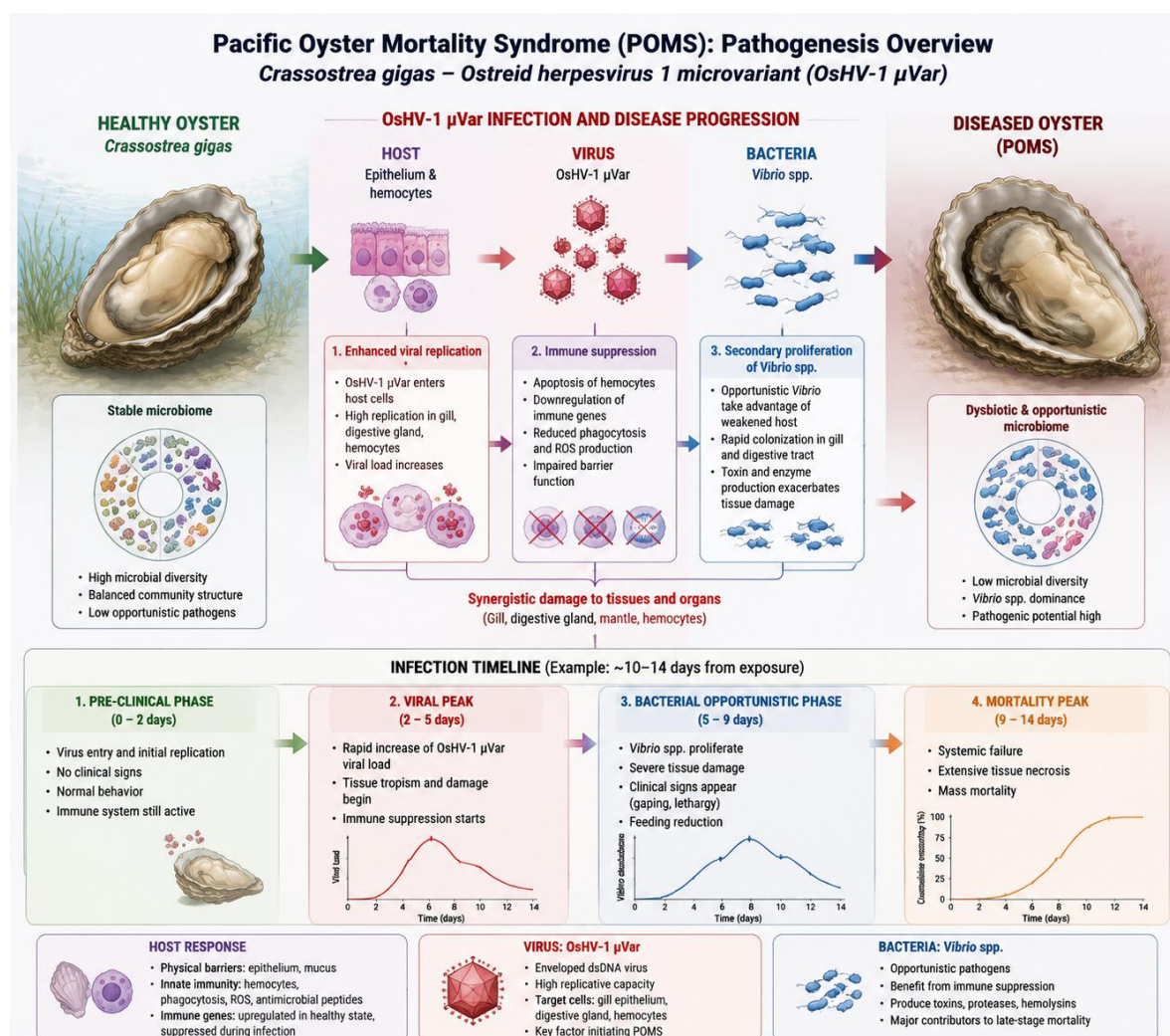


Figure 2 Pathogenesis cascade of Pacific Oyster Mortality Syndrome (POMS) in *Crassostrea gigas*