

show broad natural variation in protein, fat, ash, and carbohydrate among clam species and habitats, meaning that any density effect in Manila clam culture will likely interact with locality-specific environmental conditions (Erniati et al., 2023). Thus, density management should be viewed as a nutritional-quality control lever, even though species-specific proximate composition trials for market-size Manila clams are still needed.

5.3 Sensory quality and market value

Evidence directly linking stocking density to the sensory quality of Manila clams is sparse, but the available literature supports a plausible pathway from density to market value through tissue fullness, nutritional condition, and freshness-related attributes. Consumer research on shellfish shows that perceived quality is positively associated with freshness, while attitudes are positively associated with sensory attributes and familiarity. This means that any density regime that weakens flesh development or condition index is likely to reduce commercial appeal even if survival remains acceptable. Since edibility percentage and condition index are commonly used to characterize harvest quality in bivalves, reduced soft-tissue yield under crowding would also be expected to lower unit value in live and processed markets (Parvathy et al., 2023).

Broader aquaculture quality studies suggest that the highest production density is not necessarily the most profitable once eating quality is considered. In fish, medium density can produce superior texture and more balanced flavor profiles, whereas density-related stress at low or high extremes impairs flavor harmony (Jia et al., 2025). A wider welfare review similarly concludes that both excessively low and excessively high stocking densities can damage production outcomes, supporting the idea of an intermediate “golden” density rather than simple maximization of biomass. For clam fisheries and farming systems, stock and biomass levels also shape market supply stability, which is itself an economic dimension of quality; surf clam assessments show that density and biomass vary markedly across habitats and directly affect the capacity to meet market demand. Overall, the literature supports the conclusion that moderate stocking density is most likely to optimize Manila clam sensory quality proxies and market value, although direct taste-panel and postharvest studies in this species remain a clear research gap. In sum, stocking density affects Manila clam quality most clearly through condition index and soft-tissue development, and the broader literature indicates parallel effects on nutritional and sensory quality. The best-supported practical conclusion is that moderate density preserves flesh development and quality better than overcrowding, while the exact optimum remains system- and environment-specific.

6 Effects of Stocking Density on Culture Environment and Health Status

6.1 Impacts of high stocking density on sediment quality

High stocking density can alter sediment conditions by increasing biodeposition and changing benthic biogeochemical processes. In bivalve systems, suspension feeding accelerates the transfer of particulate material from the water column to the bottom, which can increase sedimentation and favor the accumulation of fine organic-rich deposits, especially in shallow or low-energy culture areas (Song et al., 2024). Long-term shellfish farming has also been associated with higher sediment moisture, elevated acid volatile sulfide, and greater concentrations of some heavy metals where hydrodynamic exchange is reduced, indicating that density effects on sediment quality depend strongly on local flushing and farm structure (Ping et al., 2023).

At the same time, sediment effects are not uniformly negative and appear to follow a density threshold. In IMTA mesocosms, benthic clams reduced inorganic nitrogen and phosphate in the water column while modifying sediment microbial communities and increasing the abundance of nitrogen-cycling genes, showing that clam presence can stimulate sediment functions linked to nutrient transformation. For Manila-clam enhancement, benthic fauna and sediment properties were similar to controls and total organic carbon was even lowest in the enhancement area, suggesting that moderate stocking or stock enhancement can have limited sediment impacts compared with more intensive long-term shellfish installations.

6.2 Effects of density variation on water quality and environmental carrying capacity

Density variation has a clear but nonlinear influence on water quality, because moderate clam biomass can improve some indicators whereas excessive biomass can push systems beyond ecological carrying capacity. In integrated