

Review Article

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Evaluation of Sea Cucumber Growth Under Different Stocking Densities

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Abstract Sea cucumber aquaculture has become an important sector of the marine farming industry due to the high nutritional and economic value of sea cucumbers. Among the various management practices, stocking density is recognized as one of the most critical factors affecting growth performance, survival, resource utilization, and production efficiency. This paper evaluates the effects of different stocking densities on sea cucumber growth by reviewing the biological characteristics of sea cucumbers, key factors influencing density determination, growth assessment indicators, and the physiological and ecological mechanisms associated with density-dependent responses. Particular attention is given to the interactions among stocking density, feeding behavior, environmental quality, and competitive pressure. The analysis indicates that moderate stocking densities generally promote optimal growth, higher survival rates, and efficient utilization of available resources, whereas excessively high densities may result in increased competition, environmental deterioration, physiological stress, and reduced growth performance. Conversely, excessively low densities may lead to underutilization of culture facilities and decreased production efficiency. A case study of practical sea cucumber farming further demonstrates the importance of density optimization in balancing economic returns and ecological sustainability. The findings highlight the necessity of adopting scientifically determined stocking densities according to culture conditions, developmental stages, and management objectives. This study provides a theoretical basis and practical guidance for improving sea cucumber culture productivity and supporting the sustainable development of the sea cucumber aquaculture industry.

Keywords Sea cucumber; Stocking density; Growth performance; Aquaculture management; Culture sustainability

1 Introduction

Sea cucumbers are high-value invertebrates increasingly farmed to meet growing demand and to reduce pressure on overexploited wild stocks. Aquaculture has become an established industry in parts of Asia, especially China, where large-scale production of *Apostichopus japonicus* and other species now supplies most domestic consumption and supports stock enhancement and ocean ranching initiatives. At the same time, serial overexploitation of global fisheries and sharp declines in wild populations have prompted interest in aquaculture, ranching, and restocking as tools for both production and conservation. In emerging regions such as the Mediterranean and North-East Atlantic, aquaculture is still developing, but is viewed as essential for relieving harvesting pressure and restoring depleted stocks. Stocking density is a central variable in sea cucumber culture because it directly affects growth, survival, physiology, and welfare. Many studies report that growth performance generally declines as density increases, with low to moderate biomasses yielding higher individual growth and high densities often causing growth depression or even negative growth (Ciriminna et al., 2024). Experiments with *Holothuria scabra* and *Holothuria atra* show that low stocking densities in pens or cages produce greater weight gain per individual than higher densities, while survival may remain acceptable across a range of densities (Hartati et al., 2020).

Beyond effects on growth, high densities can act as a chronic stressor, altering behavior, digestion, and stress physiology, and may reduce disease resistance and tolerance to additional stressors in *A. japonicus* (Tian et al., 2024; Tian et al., 2025). Optimal stocking density has implications not only for animal performance but also for ecosystem processes and the environmental footprint of farms. As deposit-feeders and ecosystem engineers, sea cucumbers ingest large amounts of sediment, enhancing nutrient cycling, modulating dissolved oxygen and nutrient levels, and influencing organic matter dynamics in benthic systems. In integrated multitrophic aquaculture, increasing sea cucumber biomass can improve bioremediation of particulate waste and, at moderate densities, reduce sediment