

Research Insight

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Statistical Analysis of Environmental Effects on Shrimp Growth and Survival Rate

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Abstract Shrimp aquaculture is highly dependent on environmental stability, and fluctuations in water quality parameters can significantly affect growth performance, physiological health, and survival rates. This review aims to summarize the application of statistical approaches for evaluating environmental effects on shrimp production and to establish a quantitative framework for understanding environmental-growth-survival relationships. Key environmental factors, including temperature, dissolved oxygen, salinity, pH, ammonia, and nitrite, are discussed in relation to their impacts on shrimp metabolism, immune responses, feeding behavior, and mortality risk. Statistical methods such as correlation analysis, regression models, mixed-effects models, survival analysis, and machine learning algorithms are evaluated for their effectiveness in identifying critical environmental drivers and predicting shrimp performance. A case study based on Pacific white shrimp (*Litopenaeus vannamei*) production demonstrates how environmental monitoring data can be integrated with predictive models to determine optimal culture conditions and develop early-warning systems. Furthermore, the integration of statistical modeling with sensor-based monitoring and precision aquaculture technologies provides new opportunities for improving production efficiency and environmental management. Overall, statistical analysis serves as an essential tool for transforming environmental data into actionable strategies, supporting sustainable shrimp farming under increasing environmental variability and climate-related challenges.

Keywords Shrimp aquaculture; Environmental factors; Statistical modeling; Growth performance; Survival analysis

1 Introduction

Shrimp aquaculture has become one of the most economically significant segments of global aquaculture, driven by strong international demand, high market value, and sustained production growth over recent decades. Farmed shrimp reached 6 million tonnes in 2018, and production growth from 1998 to 2018 exceeded that of global aquaculture overall, underscoring the sector's importance to export earnings, rural livelihoods, and broader aquatic food systems. At the same time, shrimp farming remains vulnerable to major sustainability constraints, especially disease, climate variability, and the resource intensity of intensive production systems. These pressures make productivity improvement not simply a matter of increasing inputs, but of understanding how culture conditions shape biological performance under commercial farming conditions. For this reason, research on shrimp growth and survival has become central to aquaculture development, because these two outcomes directly affect yield, profitability, and farm resilience in a sector expected to continue expanding despite environmental uncertainty.

Among the many determinants of shrimp production, environmental conditions are consistently identified as major influences on growth, survival, and final yield. Temperature is especially important because it regulates feeding activity, metabolism, and growth rate, while excessive or prolonged exposure to unfavorable temperature ranges can impair production and increase mortality risk. Experimental work on juvenile *Penaeus vannamei* further showed that the best survival occurred between 20°C and 30°C at salinities above 20‰, whereas the best growth was observed between 25°C and 35°C, with overall production optimized near 28°C-30°C and salinities of 33‰-40‰. In pond systems, dissolved oxygen, pH, alkalinity, calcium hardness, and nitrogen-related variables also affect physiological stress and performance, even when measured values are not immediately lethal. This means that shrimp response to the culture environment depends not only on single variables in isolation, but on how multiple water-quality factors fluctuate through time and interact with stocking and management conditions.