Jurnal Sains Akuakultur Tropis
Departemen Akuakultur
Fakultas Perikanan dan Ilmu Kelautan – Universitas Diponegoro
Jl. Prof. Soedarto, SH, Tembalang,Semarang 50275
Telp. (024) 7474698, Fax.: (024) 7474698
Email: sainsakuakulturtropis@gmail.com, sainsakuakulturtropis@undip.ac.id

# THE EFFECT OF WATER QUALITY DYNAMICS ON THE GROWTH PERFORMANCE OF VANNAMEI SHRIMP *Litopenaeus vannamei* IN INTENSIVE PONDS AT CV. DAUN PRIMA, EAST JAVA

**Rifqah Pratiwi[1], Dimas Rizky Hariyadi[1*)], M. Akhyar Defa'I Zahwa[1], Dian Eka Ramadhani[2]**

[1]*Study Program of Aquaculture Engineering, Kupang Marine and Fisheries Polytechnic, Kupang, East Nusa Tenggara, 85351, Indonesia*
[2]*Study Program of Technology and Management of Applied Aquaculture, Vocational School of IPB University, Bogor, West Java, 16680, Indonesia*

*Corresponding Author: diimashariyadi@gmail.com

## ABSTRACT

*Litopenaeus vannamei* shrimp is a leading fisheries commodity in Indonesia. It's quite popular for cultivation related to strong attributes that include; fast growth, disease resistance, and high economic value. One of the successes of shrimp cultivation is greatly influenced by water quality. Water quality dynamics describes the occurrence of fluctuations in water quality in the media, which is an important factor that influences shrimp growth performance. This study aimed to evaluate the effect of water quality dynamics on the growth performance of vannamei shrimp in intensive ponds in CV. Daun Prima, East Java. The research method used is a case study which includes interviews, observation, and following all stages of the shrimp production process at CV. Daun Prima. The results showed optimal water quality, including temperatures of 27 – 31°C, brightness of 20 – 45 cm, pH of 7.5 – 8.1, dissolved oxygen of 4.50 – 5.33 mg/L, and salinity of 30 – 33 g/L. Growth performance of the shrimp produced, such as ABW of 3.55 – 15.33 grams/ind, ADG of 0.21 – 0.35 grams/day, and survival rate of 80%. Water quality dynamics in intensive ponds are stable during maintenance. Water quality parameters are within the optimal range to support the growth performance of shrimp. This study benefits shrimp farmers, industry stakeholders, and policymakers by identifying optimal water quality conditions that enhance growth performance and survival rates in vannamei shrimp farming.

**Keywords:** Dynamics, Growth Performance, *Litopenaeus vannamei*, Shrimp, Water Quality

## INTRODUCTION

*Litopenaeus vannamei* shrimp is one of the aquaculture commodities that can potentially improve the national economy. Indonesian shrimp exports amounted to US$2.16 billion with a volume of 241,200 tons in 2022. In value terms, Indonesian shrimp exports decreased by 3.22% compared to the previous year, reaching US$2.23 billion. The volume of shrimp exports in 2022 will be 3.80% lower than the previous year. In 2021, Indonesia's shrimp export volume was recorded at 250,715 tons. Looking at the trend, Indonesian shrimp exports tend to increase in the last decade. However, shrimp exports decreased last year. The decrease in vannamei shrimp exports is attributed to factors such as market price fluctuations, intense global competition, shifts in consumer demand, as well as issues related to international trade regulations or logistical constraints affecting shrimp distribution to overseas markets. Other factors contributing to this decline include challenges in aquaculture practices, seed quality, feed, and water quality. Despite the decline, this commodity contributed the most to Indonesia's total fisheries exports, which reached US$6.24 billion in 2022. Its share reached 34.56% over the past year (KKP, 2023). The vannamei shrimp offers numerous benefits for cultivation, including fast growth, resistance to diseases, the ability to thrive in high stocking densities, high survival rates, and a relatively low feed conversion ratio (Rahim *et al.,* 2021).



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Water as a cultivation medium is very influential on shrimp growth performance. Water quality dynamics are changes and variations in water quality from time to time during the cultivation process (Sabilu *et al*., 2022). Maintaining ideal water quality throughout the cultivation process can influence shrimp feeding behavior, leading to improved growth and resilience, ultimately enhancing overall harvest productivity (Ariadi *et al.,* 2020; Pratiwi *et al*., 2023b). Conversely, water quality conditions that are not optimal will impact decreasing productivity. Optimal water quality and tends to be stable can improve shrimp growth and survival performance (Emilyasari, 2013; Pratiwi *et al*., 2023c). Therefore, monitoring of pond water quality needs to be done to determine the changes that occur to minimize crop failure. This study aimed to evaluate the effect of water quality dynamics on the growth performance of vannamei shrimp in intensive ponds in CV. Daun Prima, East Java.

## METHODOLOGY

### Time and Place

This research was conducted from March 27 to May 25, 2023, in commercial ponds at CV. Daun Prima, Bancar Village, Tuban Regency, East Java Province.

### Research Materials

This study utilized a variety of tools, including ponds, paddle wheels, thermometers, secchi disks, pH meters, dissolved oxygen meters, refractometers, water pumps, beaker glass, digital scales, mesh nets, rope mines, plastic bottles, and anco. Additionally, the materials used were vannamei shrimp seeds (with a size of 0.001 gram/ind), feed, hydrochloride, quicklime, hydroperoxide, pH buffer, aquades, and seawater.

### Research Design

The research method used is a case study which includes interviews, observation, and following all stages of the shrimp production process at CV. Daun Prima, East Java.

### Work Procedure

The production stages of vannamei shrimp in this study are carried out according to standard operational procedure (SOP) CV. Daun Prima with intensive system cultivation in pond volume 4,200 $m^3$ using a high stocking density of 141 ind/$m^3$. This study focuses on taking data on the actual condition of water quality. Several water quality parameters were observed, including temperature, brightness, pH, dissolved oxygen, and salinity. Water quality monitoring is carried out 2 times a day, namely in the morning (at 6 a.m.) and afternoon (at 4 p.m.). In addition, growth is also carried out by sampling 1 time in the first 40 days, then every 10 days until 87 days of maintenance or shrimp reaches the sales target size.

### Data Analysis

Water quality parameters controlled in this study include temperature, brightness, pH, dissolved oxygen, and salinity. Growth performance data, including average body weight (ABW), average daily growth (ADG), survival rate (SR), and harvest biomass. Water quality parameters refer to the method of Pratiwi (2016) and growth performance refers to the method of Witoko *et al.* (2018). The information gathered is organized in Microsoft Excel and examined descriptively.

## RESULTS AND DISCUSSION

### Water Quality Dynamics

Water quality dynamics refers to changes and variations that occur in water quality over time (Sabilu *et al*., 2022). This includes factors such as pollution levels, water quality (temperature, acidity, dissolved oxygen), nutrients in the waters, and more. Water quality dynamics can be affected by various factors, including human activities, weather, the natural environment, and climate change. Optimal water quality is one of the requirements in aquaculture activities (Pratiwi *et al*., 2022). Water quality in maintenance media shows conditions of fluctuations in temperature, brightness, pH, dissolved oxygen, and salinity that tend to be homogeneous and stable (Figure 1). The results of this study, temperature conditions in the morning ranged from 27 – 29°C and afternoon ranged from 28 – 31°C (Figure 1a). The optimal temperature for vannamei shrimp rearing ranges from 25 – 32°C (Ariadi *et al*., 2021). Daily temperature fluctuation during maintenance is still stable with a fluctuation value of 1°C. According to Mangampa *et al.* (2011), good daily temperature fluctuations for vannamei shrimp rearing are at least below 3°C.

Outdoor shrimp rearing allows for weather-induced temperature changes. When the weather is rainy, the air temperature becomes lower, causing the water temperature to decrease, and vice versa. According to Pratiwi *et al.* (2022), low temperatures will make shrimp appetite decrease so that it can inhibit the shrimp



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growth process. Conversely, high temperatures can speed up shrimp metabolism, so shrimp appetite increases. This correlates with increased dissolved oxygen consumption and can cause the stock of dissolved oxygen content in the waters to decrease and can stress shrimp if their availability decreases. Also, climate change can affect water temperature, and environmental conditions can trigger the emergence of diseases. Some pathogens become more active or spread more quickly under certain conditions (Ramadhani *et al*., 2023), which can cause stunted growth and has the potential to cause mass death.

Brightness is a parameter that describes the ability of sunlight or light to enter a body of water. Brightness is the penetration of light to penetrate the depth of water, if the waters are turbid, the penetration of sunlight decreases, resulting in low water brightness (Patty *et al*., 2020). Based on the results of the study, the condition of water brightness during maintenance ranges from 20 – 45 cm (Figure 1b). The high brightness at the beginning of maintenance is due to the low organic matter content and plankton density. This means that the water's turbidity level is still minimal or the condition of the media still tends to be clear. Conversely, the end of the brightness value is due to the high content of organic matter and plankton density in the waters. The brightness value is influenced by the density of plankton, zooplankton, and particles dissolved in water (Supriatna *et al*., 2020). Overall, the brightness value is still within the optimal range and fluctuations tend to be stable. The brightness optimal for intensive shrimp cultivation ranges from 20 – 50 cm (KKP, 2016).

Factors causing fluctuations in water pH are carbon dioxide from aquatic organism respiration, dissolved carbon dioxide from diffusion of air, mineral acids from pollution carried by rainwater, organic acids that occur naturally from humus deposits, or hydrolysis of salts from mineral deposits leached into water supplies. Shrimps as an exoskeleton organism (shelled/carapace) will absorb more mineral ions to support molting activity as part of its growth process. This makes it vulnerable to fluctuations in water pH during the maintenance period. Adding the lime can be used to increase the pH to remain optimal and to maintain water productivity. This is safe to do because it is following the principles of biosecurity (Pratiwi *et al*., 2020). Based on the study's results, the water's pH in the morning ranged from 7.5 – 7.6, and in the afternoon ranged from 7.9 – 8.2 (Figure 1c). The condition pH of water that is optimal is in the range of 7.5 – 8.5 (Setiyawan *et al*., 2020). Overall, the pH of the water was in the optimal range and fluctuations tend to be stable. Water pH conditions in the morning and afternoon will be stable and optimum if there are no fluctuations of more than 0.5 (Ariadi *et al.,* 2020).

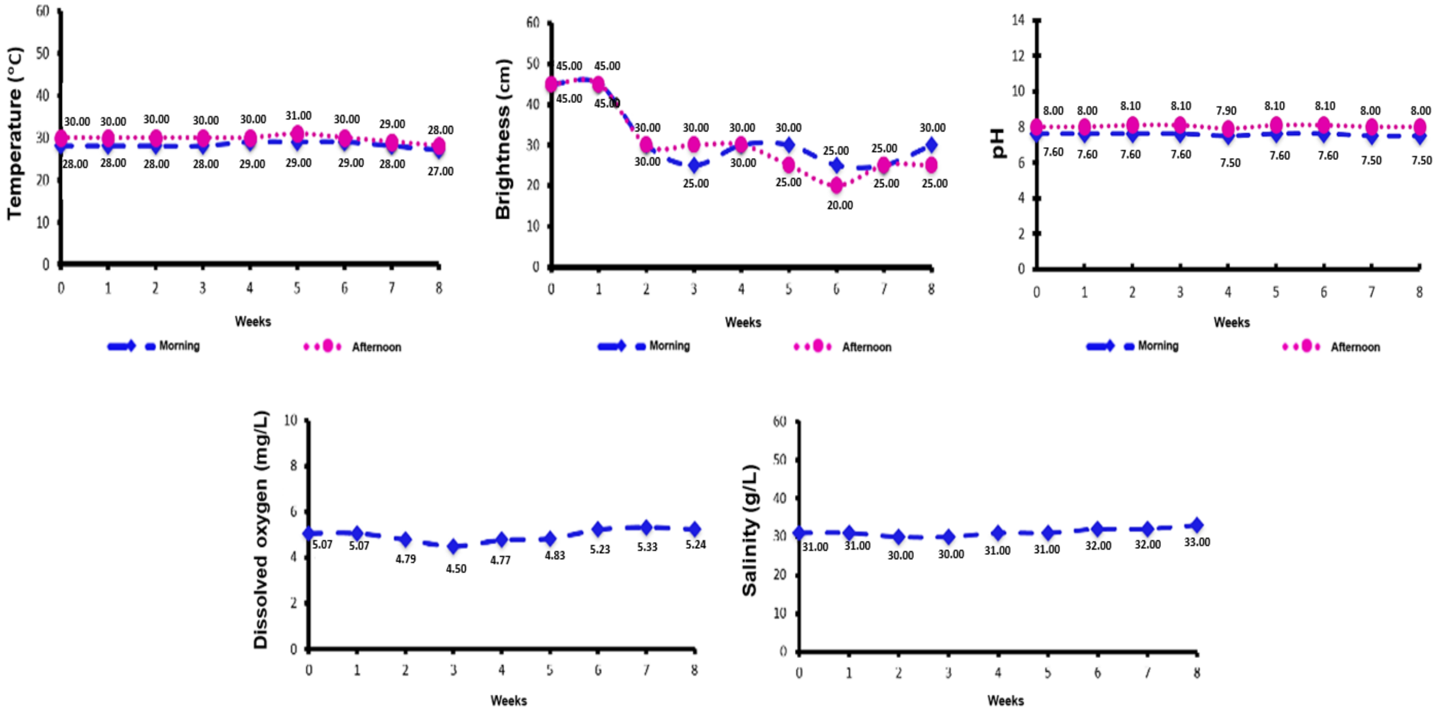


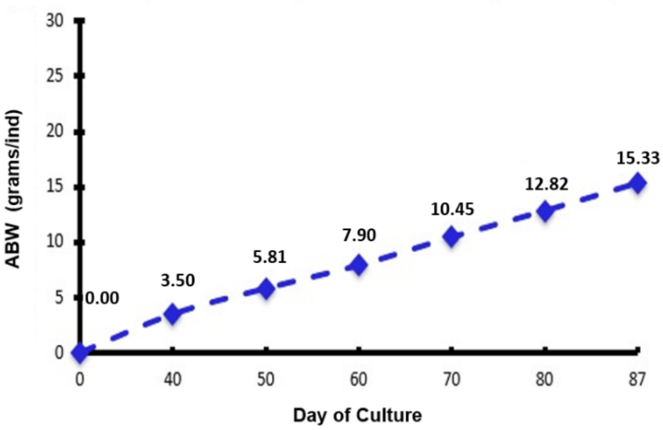

**Figure 1.** Dynamics of water quality in intensive ponds of vannamei shrimp production: (a) temperature, (b) brightness, (c) pH, (d) dissolved oxygen, and (e) salinity

*Dissolved oxygen* is the content of dissolved oxygen in water. The condition of dissolved oxygen is one of the factors that affect the success of cultivation. This is following the opinion of Makmur *et al.* (2018), that dissolved oxygen concentration is a critical factor in the health and success of vannamei shrimp rearing. Based on the results of this study, the condition of dissolved oxygen during the maintenance period ranged from 4.50 – 5.33 mg/L (Figure 1d). The optimal range of dissolved oxygen in vannamei shrimp enlargement is > 4 mg/L (Ariadi *et al.*, 2021). Based on the graph above, in the 2nd week and 3rd week, the dissolved oxygen value decreases. This is because the higher the day of culture (DOC) of shrimp, the higher the concentration of dissolved oxygen needed by shrimp (Supriatna *et al.,* 2020). Conversely, in 4th week the condition of dissolved oxygen tends to increase. This is because, in the 4th week, a partial harvest is carried out, thus making the population and burden of using dissolved oxygen by shrimp decrease. According to Wafi *et al.* (2021) and Sumitro *et al.* (2020), dissolved oxygen levels in pond water will increase along with the decrease in the load of environmental carrying capacity.

Salinity is the salt content contained in water. Based on the results of this study, salinity conditions during the maintenance period ranged from 30 – 32 g/L (Figure 1e). Salinity in 2nd week and 3rd week was known to have decreased from 31 g/L to 30 g/L. This happened because that week the intensity of rain was quite high, so rainwater would suppress the salt content in the pond. However, salinity fluctuations are quite stable and are still optimally ranged, to support shrimp growth. If compared with the research of Arsad *et al.* (2017), shrimp have a salinity preference that is not too high, which is optimal at a salinity of 10 – 30 g/L, but can grow well at a salinity of 5 – 45 g/L.

## Growth Performance

Growth is a change in form in terms of length, weight, and content following changes in time (Pratiwi, 2014). Growth in crustaceans is characterized by periodic changes in body length and weight gain that occur after molting. Molting occurs in exoskeleton animals, including shrimp where the old skin is removed and then replaced with a new skin (Pratiwi *et al.*, 2016). Growth monitoring can be done by sampling shrimp at each scheduled unit of time. Sampling is a way to determine shrimp growth and suspect feed conversion ratio (FCR) during the rearing period (Pratiwi *et al*., 2023b). The growth performance of vannamei shrimp is calculated by sampling, namely the first sampling in the first 40 days, then carried out every 10 days. Sampling was carried out to obtain data on average body weight (ABW), average daily growth (ADG), and harvest biomass.



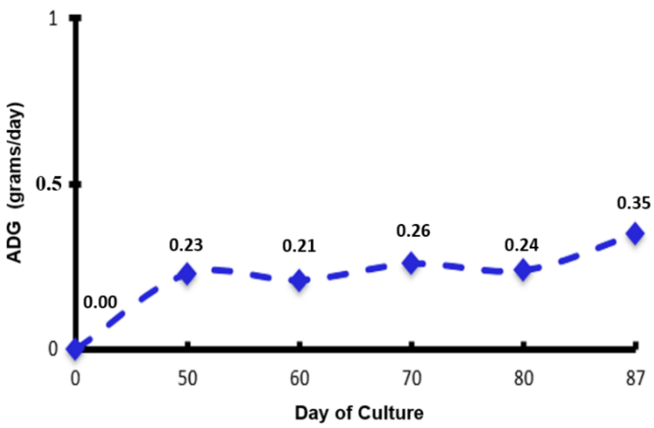




**Figure 2.** Average Body Weight (ABW) and Average Daily Growth (ADG) during maintenance

Based on the results of this study, it is known that the average body weight of shrimp continues to increase along with the increase in maintenance time. The performance of shrimp at ABW harvest reaches 15.33 grams/ind and ADG 0.35 grams/day with a maintenance period of 87 days. The condition of maintenance media remains optimally controlled by paying attention to *carrying capacity* so that 2 partial harvests are carried out by harvesting shrimp as much as 20% based on biomass. Partial harvesting was carried out at the time of DOC 68 and DOC 80. The partial harvest applied greatly supports the optimal average weight gain process of shrimp with a weight gain range of 2.3 – 2.5 grams/sampling. According to Wafi *et al.* (2020), partial harvesting is carried out when the cultivation is 60 – 70 days old which aims to keep the growth rate of shrimp stable, the burden of aquaculture waste can be minimized, and reduce the death rate of shrimp due to lack of oxygen. In addition, according to Supono (2006), vannamei shrimp can grow well with a growth rate



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of 1 – 1.5 grams/week. Optimal growth performance can be seen from the production performance of vannamei shrimp rearing for 77 days with an ABW of 15.15 grams/ind and ADG of 0.23 grams/day (Pratiwi *et al*., 2023b) or for 84 days with an ABW of 17.91 grams/ind and ADG 0.36 grams/day (Pratiwi *et al*., 2023c).

## The Effect of Water Quality Dynamics on Vaname Shrimp Growth Performance

Water quality in temperature, brightness, pH, dissolved oxygen, and salinity parameters were within the optimal range to support the growth performance of vannamei shrimp. In addition, there were no fluctuations so the dynamics of water quality in shrimp ponds are quite stable. Water quality is of great significance in vannamei shrimp cultivation as it has the potential to impact the growth and survival of the shrimp. Therefore, it is crucial to manage water quality optimally (Pratiwi, 2014; Pratiwi *et al.*, 2023c). The dynamics of water quality that is stable will support ABW and ADG values that increase until the end of harvest time. According to Emilyasari (2013), optimal water quality and tends to be stable can improve shrimp growth and survival performance.

The optimal water quality conditions will also affect the productivity of vannamei shrimp (Dewi, 2019). Optimal water quality is a prerequisite for successful aquaculture activities (Pratiwi, 2014; Pratiwi *et al.,* 2023a). Water quality has a close relationship and influences each other on the growth performance of vannamei shrimp. Based on the results of this study, the effect of water quality dynamics is shown by increasing growth performance in each week's sampling, also final harvest is shown with a survival rate reaching 80% with a harvest biomass of 4,275 kg. According to Pratiwi *et al.* (2016), survival rate is an important parameter in a cultivation activity, because it determines the amount of production produced or the survival rate of biota in one production cycle. According to Bahri *et al.* (2020), the value survival rate of vannamei cultivation is categorized as good if the value survival rate of ≥ 70%, for the medium survival rate category it ranges from 50 – 60%, and in the low category if the value survival rate of < 50%. The dynamics of water quality in vannamei shrimp ponds with intensive system at CV. Daun Prima tends to be stable and produces optimal growth and survival rates. This study provides practical benefits for shrimp farmers, industry stakeholders, and policymakers by highlighting the importance of maintaining optimal water quality conditions to achieve better growth performance and higher survival rates in vannamei shrimp farming.

## CONCLUSION

The dynamics of water quality in vannamei shrimp ponds with intensive system at CV. Daun Prima tends to be stable and produces optimal growth performance. The results showed optimal water quality, including temperatures of 27 – 31°C, brightness of 20 – 45 cm, pH of 7.5 – 8.1, dissolved oxygen of 4.50 – 5.33 mg/L, and salinity of 30 – 33 g/L. Growth performance of the shrimp produced, such as ABW of 3.55 – 15.33 grams/ind, ADG of 0.21 – 0.35 grams/day, also survival rate of 80%. The characteristics for dynamics of water quality, such as temperature, brightness, pH, dissolved oxygen, and salinity parameters which are controlled within the optimal range can affect the increased growth performance of ABW and ADG, as well as the optimal survival rate. This study benefits shrimp farmers, industry stakeholders, and policymakers by identifying optimal water quality conditions that enhance growth performance and survival rates in vannamei shrimp farming.

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