Growth of oysters (*Crassostrea Sp.*) at different stocking densities in Alue Naga Ponds, Banda Aceh

Ichsan Rusydi[1*], *Muhammadar* Abdullah Abbas[1], *Dhia* Riska[1], and *Karla* Amelia[2]

[1]Department of Aquaculture, Faculty of Marine and Fisheries, Syiah Kuala University, Indonesia;
[2]Marine Science and Fisheries Faculty, Raja Ali Haji Maritime University, Tanjungpinang, Riau Islands Province, Indonesia

Abstract. Oysters are a coastal natural resource utilized by communities as a source of livelihood. This study aims to assess the growth in length and weight of oysters (Crassostrea sp.) under different stocking densities in ponds located in Alue Naga. The experimental method used was a Completely Randomized Design (CRD) with three treatments, each repeated three times, consisting of densities of 30, 35, and 40 individuals per 1500 cm². Data were analyzed using Analysis of Variance (ANOVA), followed by Duncan's test. The results showed that different stocking densities significantly affected ($P<0.05$) the absolute length growth, absolute weight growth, and weekly length growth rate. The average results indicated that treatment A with a stocking density of 30 individuals per 1500 cm² achieved an absolute length of 45.51 mm, absolute weight growth of 35.23 grams, and a weekly length growth rate of 3.87 mm/week. Treatment B with a density of 35 individuals per 1500 cm² achieved an absolute length of 39.07 mm, absolute weight growth of 32.91 grams, and a weekly length growth rate of 3.25 mm/week. In contrast, treatment C with a density of 40 individuals per 1500 cm² resulted in an absolute length of 31.35 mm, absolute weight growth of 31.53 grams, and a weekly length growth rate of 2.61 mm/week. The highest growth rates were observed in treatment A with a density of 30 individuals per 1500 cm².

* Corresponding author: ichsanrusydi@usk.ac.id

1. Introduction

The coastal areas of Banda Aceh harbor diverse natural resources that serve as essential sources of food and livelihood for local communities. Oysters, specifically from the genus Crassostrea and Ostre, are among the coastal commodities utilized by residents. In Aceh, six species of edible oysters have been identified: *Crassostrea virginica, Crassostrea gigas, Crassostrea iridescens, Crassostrea angulata, Crassostrea cucullata,* and *Ostrea edulis* [1]; [2].

Oysters, belonging to the phylum Mollusca, class Bivalvia, and order Ostreoidea, typically attach to hard substrates [3]. Their distribution is influenced by currents, which transport larvae to suitable attachment sites. As filter feeders, oysters can act as bioindicators of water quality by filtering plankton and other particulates from the water [4].

The village of Alue Naga, located in Syiah Kuala District, is a tidal area where oyster harvesting forms a significant livelihood, particularly for women. However, overharvesting has led to a decline in oyster populations, with smaller sizes being harvested due to premature harvesting. Environmental pollution further exacerbates the issue, highlighting the need for sustainable, environmentally friendly oyster aquaculture.

Ponds offer a controlled environment for oyster farming, minimizing contamination from external pollutants while maintaining optimal salinity, temperature, and dissolved oxygen levels. According to data from the Marine and Fisheries Office, Aceh has approximately 31,995.9 hectares of ponds, of which many remain underutilized. Previous studies have shown better growth rates at lower stocking densities using submerged raft methods. However, no research has yet explored floating raft methods in pond systems. This study aims to address this gap and provide insights for sustainable oyster farming practices in Alue Naga.

2. Method

2.1 Study Area

This research was conducted in February-April 2021 and took place in the Alue Naga pond, Syiah Kuala District, Banda Aceh (Figure 1)

Fig. 1. Research Map

2.2 Tools and Materials

The tools and materials used in this research are as follows:

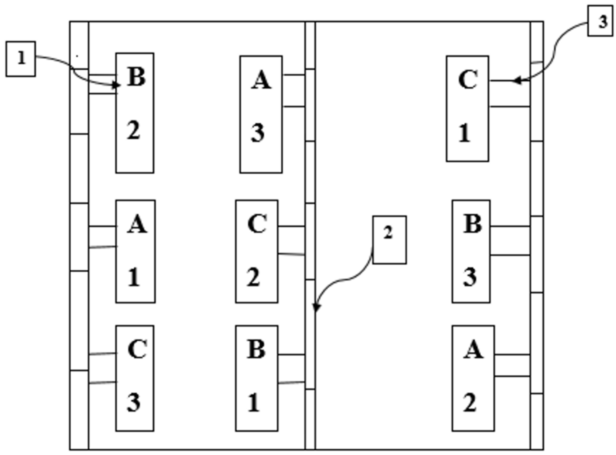
Table 1 Research tools and materials

No.	Tools and materials	Amount	Function
1.	Refractometer	1 Unit	Measuring Salinity
2.	Digital thermometer	1 Unit	Measuring Temperature
3.	pH Meter	1 Unit	Measuring pH
4.	DO Meter	1 Unit	Measuring Dissolved Oxygen Content
5.	Basket (30 X 50 cm ^{2})	9 Unit	Treatment Container
6.	Meat Oyster Seeds	315 Individuals	Research Sample
7.	Digital Vernier Caliper	1 Unit	Measuring Oysters
8.	Digital scales	1 Unit	Weighing Oysters
9.	support pipe	2.5 Meters	Placing the enlargement container
10.	Nylon rope	15 Meter	Basket Binder
11.	GPS	-	To view the location
12.	Stationery	1 Set	Recording Data

2.3 Design test

The research method used was the Complete Random Design (CRD) model with 3 treatments (Figure 2), each treatment repeated 3 times with different stocking densities using the floating method with a container of 30 x 50 cm. Previous research used the sinking raft method consisting of 3 treatments and 3 repetitions with a container measuring 30 x 50 cm and different densities, namely 25, 30 and 35 ind / 1500. Good growth data was obtained in treatment A with a density of 25 ind / 1500 [5]. The study implemented treatments that included:

Treatment A: Method of placing oyster seeds with a density of 25 ind/1500
Treatment B: Method of placing oyster seeds with a density of 30 ind/1500
Treatment C: Method of placing oyster seeds with a density of 35 ind/1500



Description: 1). Repeated treatment 2). Support (bamboo) 3). Binder

Fig. 2. 1of the Enlargement Container

2.4 Data analysis

2.4.1 Weekly Length Growth Rate (WGR)

The weekly growth rate in length can be calculated using the formula according to Effendie [6]:

$$LPPM = \frac{L_t - L_o}{t}$$

$LPPM$ = Weekly length growth rate (cm)
L_t = Final average length of the study (cm)
L_o = Initial average length of the study (cm)
t = Sampling time (1 week)

2.4.2 Growth in Absolute Length (PM)

The growth of oyster length was calculated at the beginning and end of the study using the formula according to Effendi [6]:

$$PM = p_t - p_o$$

PM = Absolute length growth (cm)
p_t = Length at the end of the study (cm)
p_o = Initial length of research (cm)

2.4.3 Absolute Weight Gain (BM)

The absolute weight growth of oysters was calculated using the Effendi formula [6]:

$$BM = W_t - W_O$$

BM = Absolute Weight (g/day)
W_t = Average Final Weight of Research (g)
W_O = Initial Average Weight of Research (g)

3. Results and Discussion

3.1 Test results

For 12-week study, it was shown that the growth in absolute length (PM), absolute weight (BM) and weekly length growth rate (LPPM) in oysters given different stocking densities showed varying values. The results of the study of growth in absolute length in treatment A at a stocking density of 30 oyster seeds were 46.51 mm, in treatment B with a stocking density of 35 was 39.07 mm, and a stocking density of 40 seeds was 31.35 mm. Absolute weight in stiffness A with a stocking density of 30 had an average increase of 35.23 grams, in treatment B with a stocking density of 35 was 32.91 grams, while the stocking density of 40 increased by 31.53 grams. The daily growth rate with treatment A increased by 3.87 mm/week, in treatment B 3.25 mm/week, and in treatment C increased by 2.61 mm/week.

The test results using ANOVA showed that the stocking density had a significant effect ($P < 0.05$) between treatments , namely in absolute length growth (PM), weight (BM), weekly length growth rate (LPPM) . The highest growth was obtained in treatment A with an average value of 46.51 ± 0.91^c , where the lowest stocking density treatment (35 ind / 1500 cm²). While for absolute weight growth (BM) the results obtained were an average of 35.23 ± 0.14^c. And for weekly length growth with a value of 3.87 ± 0.76^c.

Table 1 Results of treatment on absolute length growth (PM), absolute weight growth (BM), weekly length growth (LPPM).

Stocking Density Treatment	(PM) (mm)	(BM) (grams)	(LPPM) (mm/week)
A (Treatment 30)	46.51 ± 0.91^c	35.23 ± 0.14^c	3.87 ± 0.76^c
B (Treatment 35)	39.07 ± 0.27^b	32.91 ± 0.29^b	3.25 ± 0.02^b
C (Treatment 40)	31.35 ± 0.49^a	31.53 ± 0.22^a	2.61 ± 0.04^a

Description: Different *superscript letters in the same column indicate significant differences (P<0.05) and the* same *superscript letters in the same column indicate no significant differences (P>0.05).*

The absolute length and weight of oysters showed consistent growth each week, with weekly increases ranging from 2.61 to 3.87 mm for absolute length and 2.62 to 2.93 grams for absolute weight across all treatments. Based on the findings, the highest growth in length, weight, and overall development was observed in Treatment A with a stocking density of 30 individuals per 1500 cm², while the lowest growth occurred in Treatment C with a stocking density of 40 individuals/1500 cm².

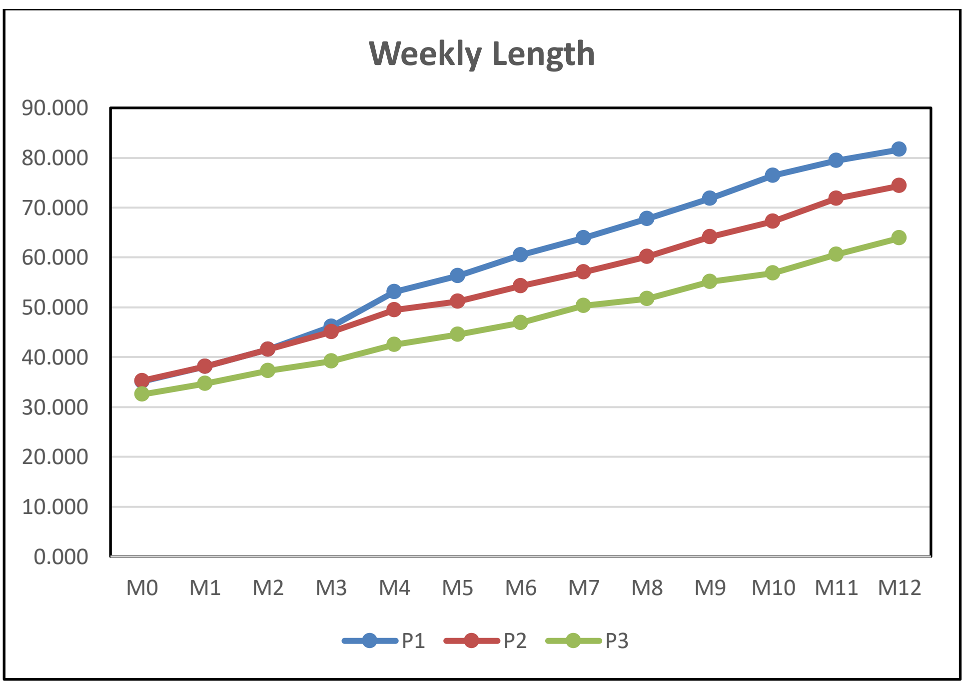


Fig. 1 Growth graph of meat oyster length for 12 weeks

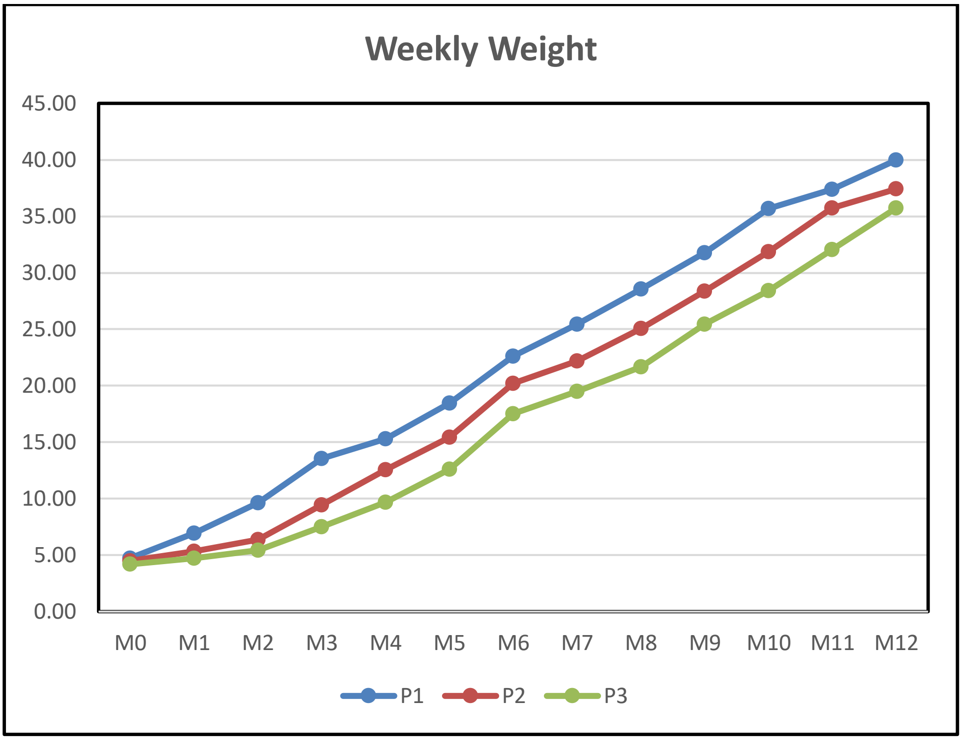


Fig. 4.2Growth graph of meat oyster weight for 12 weeks

The growth in length and weight based on the results obtained in Figures 3 and 4 shows an increase every week, in the first week it can be seen that there is an increase in the growth of length and weight in oysters. In the growth of absolute length in the 4th week there is an increase in growth in treatment A with a stocking density of 35 ind/1500 cm². In the growth of absolute weight with treatment A also experienced a stable increase every week, while in treatments B and C experienced an increase in week 6, then the growth of length and weight experienced a stable increase every week.

Growth with lower stocking densities in treatment A experienced a faster increase than stocking densities in stockings B and C, because low stocking densities did not occur for food competition and also disturbed the growth of oysters in baskets. Growth with high stocking densities can disrupt the growth of oysters and also cause competition for food within the shells so that growth becomes delayed.

Table 3 shows the water quality parameter data obtained from measurements in the Oyster cultivation pond in Alue Naga including: current measurement 0.17 m/s, salinity 30 Ppt, pH 8.7, temperature 30^0 C, and DO 4.8. The measurement results above indicate that the water quality parameters in the pond during the rearing process are still within the tolerance range.

Table 3. Water Quality Parameter Data in Alue Naga Pond

No	Water Quality Parameters	Unit	Measurement results
1	Current	m/s	0.16
2	Salinity	ppt	30
3	pH	-	8.7
4	Temperature	°C	28
5	Dissolved Oxygen	mg/l	4.8

3.2 Discussion

Oyster growth in this study includes measurements based on length and weight. Oyster growth is also supported by environmental factors in the Alue Naga pond, namely due to the availability of food needed for oyster growth and the presence of a water flow entrance into the pond so that food stocks will continue to exist in the pond, not only in the pond. Water quality that is not in accordance with oyster growth will interfere with the metabolism of meat oysters which greatly affects oyster enlargement. According to [6] who stated that the survival of oysters (*Crasstrostrea Sp.*) is very much determined by the availability of good food and good water quality management.

The absolute length growth, absolute weight, and weekly length growth of oysters stocked at densities of 30, 35, and 40 individuals per 1500 cm², with initial sizes ranging from 31 to 37 mm, demonstrated a consistent increase each week. The highest absolute length growth (PM) was recorded in Treatment A, which had the lowest stocking density of 30 individuals per 1500 cm², with an average absolute length of 46.51 mm. In contrast, the lowest absolute length was observed in Treatment C, with a stocking density of 40 individuals per 1500 cm², averaging 31.35 mm. According to [7] stated that if the stocking density is less then there is no competition between individuals. The growth is influenced by two factors, namely, internal factors; genetic traits, physiological conditions and external factors related to the maintenance environment, the lower the stocking density, the lower the level of competition for space and food [8]. The availability of food such as phytoplankton, zooplankton and organic matter greatly affects the growth of meat oysters [9]. This finding aligns conducted in the waters of Alue Naga, which examined different stocking densities (25, 30, and 35 individuals per 1500 cm²) over 12 weeks. The highest growth was observed at a density of 25 individuals per 1500 cm², with an average value of 9.49 mm [5].

The absolute weight growth (BM) exhibited a consistent increase alongside absolute length growth (PM) from week 0 to week 12. The greatest increase in absolute weight was recorded in Treatment A, which had a stocking density of 30 individuals/1500 cm², whereas the smallest increase was observed in Treatment C with a density of 40 individuals/1500 cm². The average absolute weight in Treatment A was 35.23 grams, compared to 32.91 grams in Treatment B (35 individuals/1500 cm²) and 31.53 grams in Treatment C (40 individuals/1500 cm²). Treatment A showed consistent weekly growth, with a significant increase observed in the 3rd week. In contrast, Treatments B and C exhibited significant increases starting in the 6th week, followed by stable weekly growth with only minor increments. This is due to supporting environmental factors and also the ebb and flow of the full moon. According to when oysters are flooded by high tide, oysters can utilize their food at any time because their food is relatively always available [10]. When low tide, oysters do not touch the water and close their shells tightly. If the low tide phase occurs during the day. Oysters close their shells tightly to survive because not getting water during the day reduces the heat of the sun. The results of the One Way ANOVA test had a significant effect on the growth of absolute weight, namely ($P < 0.05$). According to research [11]on optimal oyster growth in the Alue Naga reservoir, namely in the 3rd to 6th week, treatment A with a stocking density of 25 ind/1500 cm² experienced a drastic increase, then growth tended to be stable and only increased by a few grams. The third repetition of plastic fiber media showed that the number of spats attached was longer than the first and second repetitions, this was because there were a lot of barnacles attached to the media so that it could cause a lack of success in attaching the oyster spat because barnacles are one of the nuisance pests. for oyster survival [12].

Different stocking densities significantly affect the weekly growth rate (LPPM). The initial weekly oyster length growth ranged from 2.61-3.87 mm/week every week for 12 samplings. In the Gigieng estuary, Aceh Province, it ranged from 2.4 cm to 3.72 cm. The range of oyster sizes is thought to be due to very intensive oyster fishing which affects the size in nature [1]. Oysters obtained in ponds can reach a length of 5-9 cm. The ponds will always be flooded with water and relatively always have food available, so oysters can take advantage of it at any time. Alue Naga ponds are quite effective for oyster growth because of the stable environment and sufficient food [10]. Stable water conditions indicate available food sources for the organisms being studied [12]. Stable conditions explain that the waters of living organisms are minimal in predators and competitors [13].

Water quality is one of the factors that affect oyster growth, poor water quality will affect oyster metabolism. Crassostrea can live in a temperature range of 5-35 ºC with an optimum range of 11-34 ºC and still survive at a temperature of -5 ºC [14]. Oysters can live in waters with a pH between 6.8-9.25. However, if it is less or more than the pH range, the oyster meat will die or become abnormal [15]. Oyster meat can tolerate a salinity range of 10-30 (optimum 20-30%) [16]. Oyster meat can still survive for 5 days in waters containing > 1 mg/1 dissolved oxygen [17]. This is in line with the results of observations in the field, where the water quality obtained is in the normal range, where the results of measuring water quality parameters for temperature, pH and DO are still within tolerance for oyster growth in Alue Naga. The results obtained ranged from salinity reaching 30 ppm, the pH obtained for oyster growth reached 8.7. For the temperature in the growth of oyster meat reached 28 ºC. While for DO in growth ranged from 4.8 mg/L.

4. Conclusions

The results of this study indicate that different stocking densities have a significant effect ($P<0.05$) on the growth of absolute length (PM), absolute weight (BM), and weekly length growth rate (LPPM). The best oyster growth was in treatment A with a density of 30 ind/1500 cm, absolute length with an average value of 46.51 mm and an average weight of 35.23 grams, while the weekly growth rate reached 3.87 mm/week.

References

1. C. Octavina, F. Yulianda, M. Krisanti, Structure of meat oyster community in the Kuala Gigieng estuary waters, Aceh Besar District, Aceh Province. *Depik* **3(2)**, 108–117 (2014).
2. I. Astuti, S. Karina, I. Dewiyanti, Analysis of heavy metal content of Pb in oysters *Crassostrea cucullata* on the coast of Krueng Raya, Aceh Besar. *Sci. J. Mar. Fish. Stud.* **1(1)**, 104–113 (2016).
3. P. F. Silulu, F. B. Boneka, G. F. Mamangkey, Biodiversity of oysters (*Mollusca, Bivalvia*) in the intertidal zone of West Halmahera, North Maluku. *Platax* **1(2)**, 67–73 (2013).
4. H. Wang, L. Qian, A. Wang, X. Guo, Occurrence and distribution of *Crassostrea sikamea* (Amemiya 1928) in China. *J. Shellfish Res.* **32(2)**, 439–446 (2013).
5. I. Maisuri, I. Dewiyanti, Ichsan, Growth of meat oysters (*Crassostrea* sp.) in oyster cultivation in Alue Naga waters, Banda Aceh (2020).
6. M. I. Effendie, *Fisheries Biology Methods*. Dwi Sri Library Foundation, Bogor (1997).
7. N. S. Taufiq, R. Hartati, J. Cullen, J. M. Masjhoer, Growth of pearl oysters (*Pinctada maxima*) at different densities. *J. Mar. Sci.* **12(1)**, 31–38 (2007).
8. S. Astuti, T. Resmiati, S. Diana, Analysis of the contents of the oyster stomach of *Crasstrotrea* sp. from Batukaras waters, Ciamis. *Bionatura J.* **3(2)**, 77–88 (2001).
9. R. Zainura, R. Rusydi, M. Khalil, Study of oyster (*Crassostrea* sp.) enlargement through different layout designs. *Acta Aquat. J.* **3(2)**, 54–61 (2016).
10. D. Arfiati, The ability of three types of oysters in phytoplankton biofilters. Postgraduate Program, Brawijaya University, Malang (2007).

11. I. Rusydi, I. Dewiyanti, M. Maisuri, D. F. Putra, C. Octavina, N. Nurfadillah, W. Wulandari, Growth of oyster (*Crassostrea* sp.) with different stocking density in Alue Naga waters, Banda Aceh Indonesia. *IOP Conf. Ser.: Earth Environ. Sci.* **674**, 012082 (2021).
12. I. Rusydi, Meldayani, S. A. E. Rahimi, Wulantari, Aprilia, D. Rianjuanda, K. Melanie, S. A. Akbar, The effect of different spat collectors on attachment and growth of oyster spat (*Crassostrea gigas*) in Alue Naga. *IOP Conf. Ser.: Earth Environ. Sci.* **1221(1)**, 012069 (2023).
13. S. Jin, X. Yan, H. Zhang, W. Fan, Weight-length relationships and Fulton's condition factors of skipjack tuna (*Katsuwonus pelamis*) in the western and central Pacific Ocean. *PeerJ* **9**, 1–11 (2015).
14. Z. A. Muchlisin, M. Musman, M. N. Siti-Azizah, Length-weight relationship and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, Aceh Province, Indonesia. *J. Appl. Ichthyol.* **26**, 949–953 (2010).
15. S. Nehring, NOBANIS—Invasive alien species fact sheet: *Crassostrea gigas*. Online database of the North European and Baltic Network on Invasive Alien Species (2006).
16. S. Diederich, High survival and growth rates introduced by Pacific oysters may cause restrictions on habitat use by native mussels in the Wadden Sea. *J. Exp. Mar. Biol. Ecol.* **328(2)**, 211–227 (2006).
17. R. Mann, J. M. Harding, M. Southworth, Reconstructing precolonial oyster demographics in the Chesapeake Bay, USA. *Estuar. Coast. Shelf Sci.* **85**, 217–222 (2009).
18. A. K. Sparks, J. L. Broswell, J. G. Mackin, Studies on the comparative utilization of oxygen by living and dead humans. *Proc. Natl. Shellfish. Assoc.* **48**, 92–102 (1958).