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The Growth Performance of Abalone Shells (*Haliotis squamata*) with Different Types of Macroalgae Feeding in Polycultural Cultivation with Snubnose Pompano (*Trachinotus blochii*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Polyculture system is one of the cultivation efforts by using two different types of biota in the same environment at the same time. Abalone (*Haliotis squamata*) and Snubnose pompano (*Trachinotus blochii*) are two species that show complementary potential in polyculture systems. In

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polyculture systems, Abalone feed is generally macroalgae. Different types of macroalgae can have different impacts on the growth and survival of Abalone and snubnose pompano in polyculture systems. Therefore, this study aimed to analyze the growth performance of Abalone mussels by feeding different macroalgae. This study used an experimental method with a complete randomized design (CRD). The results showed that different types of macroalgae feed in the maintenance of Abalone mussels with snubnose pompano had a significant effect on growth (absolute length and absolute weight) and the best survival of Abalone (*Haliotis squamata*) was in maintenance with *Gracilaria* sp

Keywords: Haliotis squamata; macroalgae; polyculture; Trachinotus blochii; marine aquaculture; environmental sustainability; net cage.

1. INTRODUCTION

Marine aquaculture is an activity that utilizes the potential of the sea as a cultivation medium and has developed over time. One form of development in cultivation activities is the polyculture system. Polyculture is the rearing of two or more species of organisms in one cultivation environment, where each cultivated species does not compete with each other in obtaining food, so that they can grow optimally. Polyculture system is one of the cultivation efforts by using two different types of biota in the same environment at the same time [1,2]. Several factors such as increased productivity, resource efficiency, environmental sustainability, economic resilience and improved health and reduced disease make this polyculture system very profitable compared to the monoculture system [3]. Abalone (*Haliotis squamata*) and Snubnose pompano (*Trachinotus blochii*) are two species that show complementary potential in polyculture systems. Abalone is a group of marine molluscs known as seven-eyed clams [4]. Abalone production from cultivation has long been developed. However, Abalone farming activities still have constraints such as seed availability, slow growth, feed management, and so on [5]. Snubnose pompano has fast growth, is resistant to disease, and is quite easy to maintain. Snubnose pompano is an omnivore as it is revealed by its dentition [2]. Based on research [3], the application of polyculture technology makes fish farming more efficient in terms of expenses and increases income.

Feed also plays an important role in polyculture. and feed generally use In polyculture systems is macroalgae. Macroalgae is an attractive option due to its high nutritional content. In addition, different types of macroalgae can have different impacts on the growth and survival of Abalone and Snubnose pompano in polyculture systems. Though, it has discovered from research [2], that the growth of Snubnose pompano and green mussels is not significantly different whether they are reared in monoculture or polyculture systems, that is, the culture systems do not interfere with the productivity of each commodity; however, the polyculture system can produce two commodities at the same time so that the potential profit from the polyculture system is greater. Therefore, this study aimed to analyze the growth performance of Abalone mussels fed with different types of macroalgae.

2. MATERIALS AND METHODS

2.1 Time and Place

This research was carried out in January – March, 2024 at the Ekas Bay Floating Net Cage, Ekas Village, Jerowaru District, East Lombok Regency, West Nusa Tenggara Province. Oxygen levels were observed in the Aquatic Environment Laboratory, Faculty of Agriculture, Aquaculture Study Program, University of Mataram.

2.2 Research Methods

This research used an experimental method with a completely randomized design (CRD) with treatment of macroalgae feed types consisting of 5 types, namely:

P1 : *Gracilaria* sp.
P2 : *Ulva lactuca*
P3 : *Caulerpa*
P4 : *Kappaphycus alvarezii*
P5 : *Sargassum*

The five treatments were repeated 3 times, resulting in 15 experimental units. Each experimental unit was then arranged in one unit of Floating Net Cage. The construction of the research design can be seen in Fig. 1.

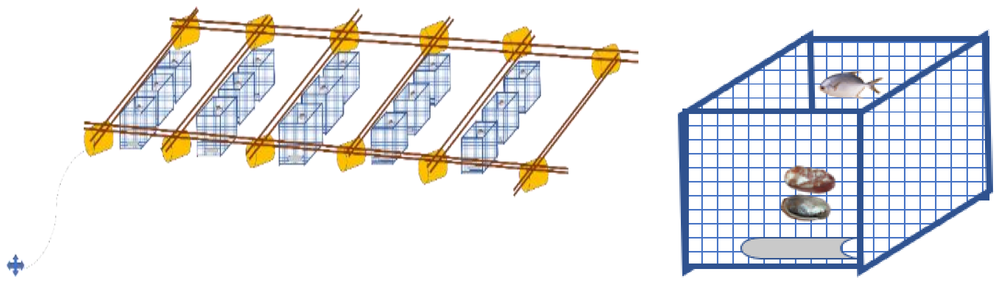

Fig. 1. Floating net cage raft and waring construction

2.3 Research Procedure

Research preparations were carried out such as preparation of tools, materials and biota. The tools used in this research were wirings sewn into squares measuring 1 x 1 cm as well as tools for measuring water quality such as pH meters, dissolved oxygen (DO) meters, refractometers and thermometers. The biota used was 10 Snubnose pompano measuring 5 cm and 25 Abalone seeds measuring 2 cm. The maintenance environment in this study is a waring measuring 1m x 1m. The depth used in this research is 1 meter. The Snubnose pompano and Abalone shells used were obtained from the Lombok Sea Cultivation Fisheries Center Sekotong.

In the initial stage, the biota acclimatization process was carried out by immersing the biota with plastic packing for 15 minutes into a environment that has been filled with sea water to equalize the water temperature in the plastic bag and the water temperature in the open sea. Then the plastic packing was opened so that the biota can adjust well to the temperature of the open sea. This acclimatization lasted for a week.

After preparing the tools and materials, Abalone clam seeds and Snubnose pompano were stocked by inserting the seeds into each net that had been given a substrate of paralon pipes. The density used was 25 Abalone clam seeds with a size of 2 cm. After that, each environment was fitted with a weight on the environment and lowered to a depth of 1 m.

Length measurement and weighing of Abalone and Snubnose pompano fries were done every 2 weeks.

Then water quality observations were made at the research site, by measuring physical parameters such as temperature, current speed and depth, chemical parameters such as pH and salinity which were carried out every 15 days, namely 0 days, 15 days, 30 days, 45 days and 60 days.

2.4 Test Parameters

The main parameters tested in this research were growth parameters (absolute growth in length and weight) and survival rate.

2.5 Growth Parameters

Growth parameters were determined using the formula of Muchlisin et al. [6] Absolute length growth was calculated by the formula: $L = L2 - L1$. $L2$ = total length at the end of the study (cm), $L1$ = total length at the beginning of of the study (cm) and the absolute weight growth was calculated using the formula: $GR = Wt - Wo$ where Wt = average body weight at the end of the study (g), Wo = average body weight at the start of the study (g).

2.6 Survival Rate

Survival rate parameters are determined using the [6] formula: $SR=Nt/N0x100\%$. SR= Survival rate (%); Nt= Number of biota at the end of the study (tail); N0= Number of biota at the start of the study (tail).

2.7 Data Analysis

Data obtained from research results such as growth in absolute length, absolute weight, and survival rate of Abalone and Snubnose pompano was analyzed using Analysis of Variance (ANOVA) at a significance level of 0.05, if the results are significantly different. ($p<0.05$), then the Duncan test and homogeneity test were carried out to find the significance of the data obtained. Water quality data was presented descriptively.

3. RESULTS

3.1 Absolute Length Growth

The results of research that has been conducted for 60 days in the waters of Ekas Bay, East Lombok with different types of macroalgae feed show that the average absolute length growth of Abalone obtained ranges from 0.69 - 1.02 as can be seen in Fig. 2.

The results of the ANOVA test carried out showed significant differences between treatments. The results of Duncan's test analysis showed that the absolute length growth of P1 was significantly different from P5 but not significantly different from P2 and P3. Treatment P2 was not significantly different from treatments P3 and P4. Based on the results obtained, the best treatment is P1 treatment.

The average absolute length growth of Snubnose pompano obtained ranged from 1.99 – 3.37 as shown in Fig.3.

The results of the ANOVA test carried out showed significant differences between treatments. The results of the Duncan test analysis of absolute length growth for P1 were significantly different from P5 but not significantly different from P3. Treatment P2 was not significantly different from treatments P3 and P4. Based on the results obtained, the best treatment is P1 treatment.

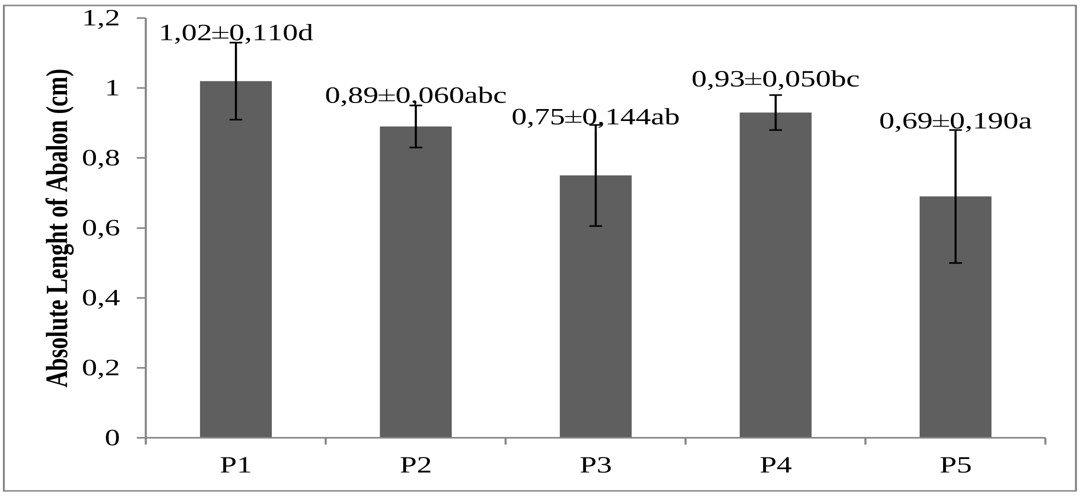

Fig. 2. Graph of absolute length growth of Abalone (*Haliotis squamata*)

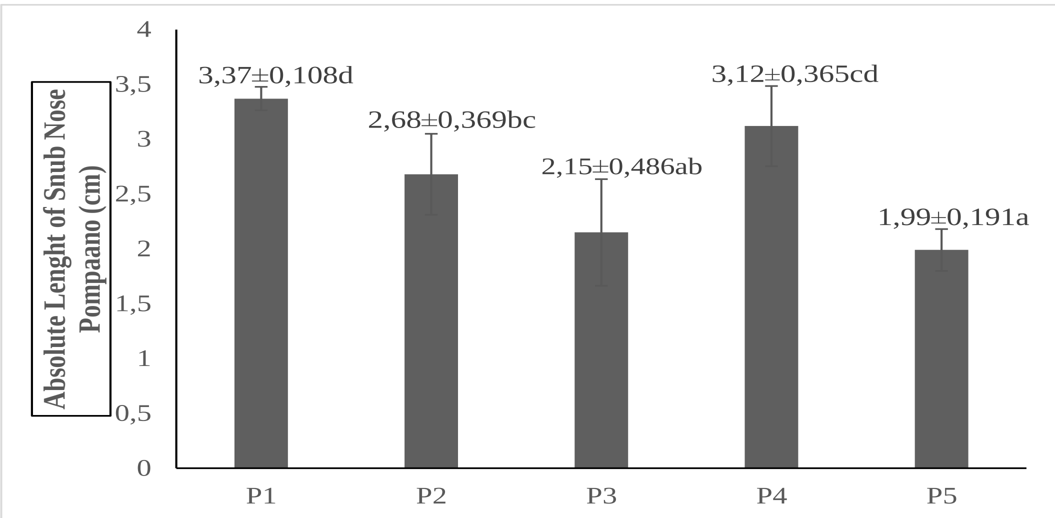

Fig. 3. Graph of absolute length growth of Snubnose Pompano (*Trachinotus blochii*)

3.2 Absolute Weight Growth

The results of research carried out for 60 days in the waters of Ekas Bay, East Lombok with various types of macroalgae feed showed that the average absolute length growth of Abalone obtained ranged from 0.74 – 1.29 as shown in Fig. 4.

The results of the ANOVA test carried out showed significant differences between treatments. The results of the Duncan test analysis of the absolute weight growth of P1 were significantly different from P5 but not significantly different from P3 and P2. Treatment P2 was not significantly different from treatment P4. Based on the results obtained, the best treatment is P1 treatment.

The average absolute weight growth of Abalone obtained ranged from 2.07 – 3.38 as shown in Fig. 5.

The results of the ANOVA test carried out showed significant differences between treatments. The results of the Duncan test analysis of the absolute weight growth of P1 were significantly different from P5 but not significantly different from P2 and P3. Treatment P2 was not significantly different from treatment P4. Based on the results obtained, the best treatment is P1 treatment..

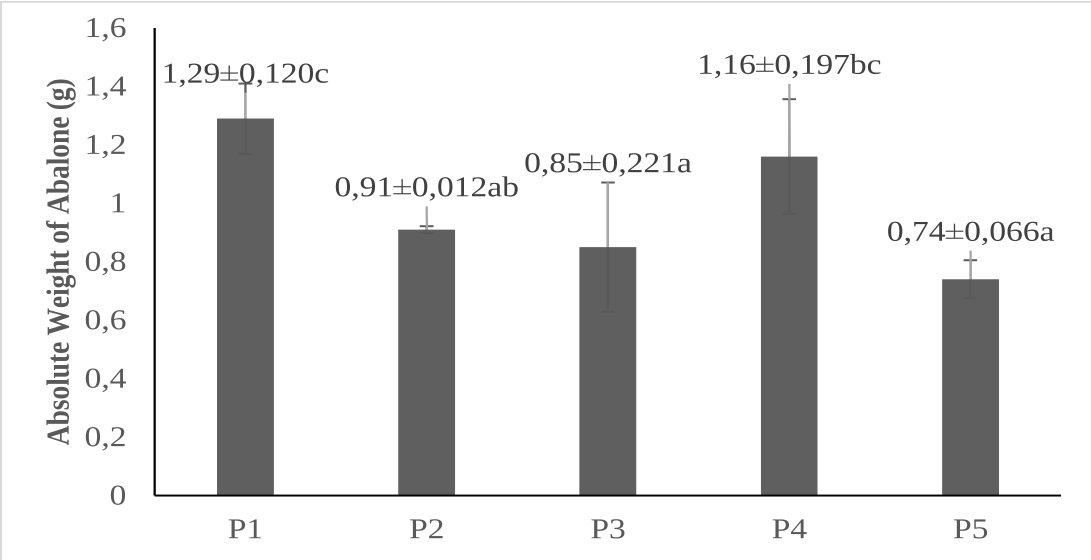

Fig. 4. Absolute weight growth graph of abalone (*Haliotis squamata*)

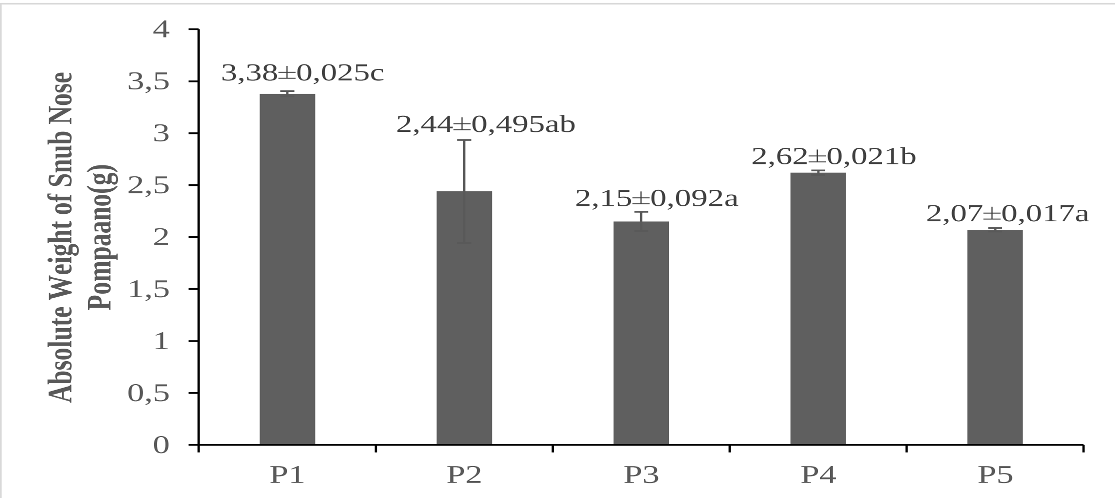

Fig. 5. Graph of absolute weight growth of Snubnose pompano (*Trachinotus blochii*)

3.3 Survival Rate

The results of research conducted for 60 days in the waters of Ekas Bay, East Lombok with various types of macroalgae, showed that the average survival rate for Snubnose Pompano was between 63.33 - 90, as seen in Fig. 6.

The results of the ANOVA test carried out showed significant differences between treatments. The results of the Duncan test analysis of Snubnose pompano survival at P1 were significantly different from P5 but not significantly different from P3 and P4. Treatment P2 was not significantly different from treatments P3 and P4. Treatment P Based on the results obtained, the best treatment is treatment P1.

The average survival rate of Abalone obtained ranged from 58.67 – 85.33 as shown in Fig. 7.

The results of the ANOVA test carried out showed significant differences between treatments. The results of the Duncan test analysis of survival of P1 Abalone were significantly different from P3 and P5 but not significantly different from P2 and P4. Based on the results obtained, the best treatment is P1 treatment.

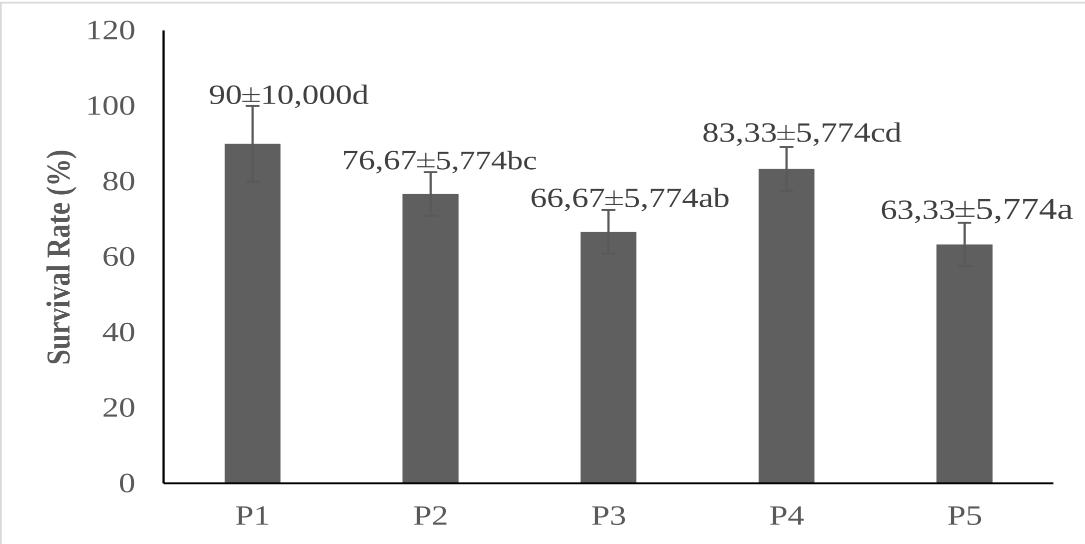

Fig. 6. Survival graph for snubnose pompano (*Trachinotus blochii*)

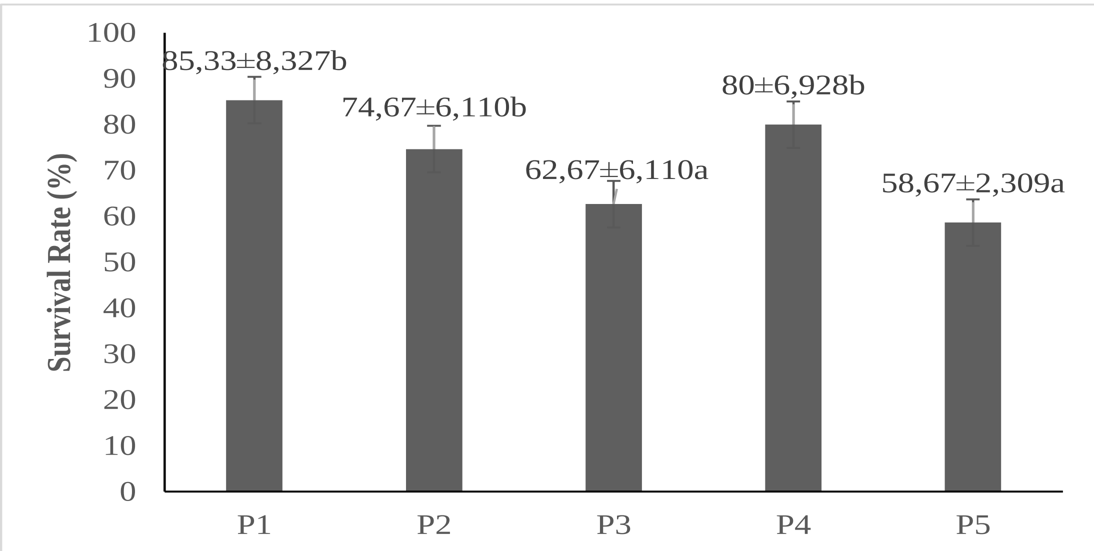

Fig. 7. Graph of survival of abalone (*Haliotis squamata*).

3.4 Water Quality

Water quality is an important factor in supporting the growth and survival of Abalone (*Haliotis squamata*) Snubnose Pompano (*Trachinotus blochii*). Water quality during research activities in the waters of Ekas Bay, East Lombok is presented in Table 1.

Table 1. Water quality measurement results

Parameters	Obtained Range	Ideal Range	Reference
DO	5,5-6,5	>5	[7]
Current Speed	0,2-0,5	0,1-0,5	[8]
pH	7,8-8	7,5-8,7	[8]
Salinity	30-33	30-35	[8]
Temperature	27-30°	27-32°	[9]
Ammonia (mg/l)	0,3 0,5	<1	[4]
Brightness (m)	5,5 – 6,5	4,6-6,5	[10]

The water quality in the waters of Ekas Bay, East Lombok during maintenance is within the normal range and can support the growth and survival of Snubnose pompano (Trachinotus blochii) and Abalone (Haliotis squamata) which are well cultivated

4. DISCUSSION

4.1 Absolute Length Growth

Based on the research results, it is known that the highest absolute length growth results for Abalone were found in the P1 treatment or the *Gracilaria* sp seaweed feed treatment. namely 1.02 cm and the lowest in the P5 or *Sargassum* type seaweed feed treatment, namely 0.69 cm. The needs of abalone in the growth of meat and shells require forming substances such as protein and amino acids and unsaturated fatty acids, where the needs of abalone can be met by the use of *Gracilaria* sp. feed [11]. This is thought to be caused by *Gracilaria* sp. Abalone is preferred and consumed more by Abalone so the type of feed is *Gracilaria* sp. can support the growth of Abalone shells compared to other types of food. This is in accordance with the statement of Nurfajrie et al. [4] that by administering G*racilaria* sp. as Abalone feed, it produces the highest growth in shell length compared to other types of feed. Seaweed *Gracilaria* sp. has a high protein content compared to other seaweed, namely 9.36%. In addition, diverse growth is also thought to be due to the ability of abalone to obtain and utilize food that is different from each individual [12].

In this study, the length growth of Snubnose Pompano reached 9.6 cm during 2 months of rearing. Research conducted by Hidayat et al. [2] also explained that Snubnose Pompano kept for 3 months reached a total length of 7.3 cm. Meanwhile, research conducted by Setiadharma et al. [13] also explained that rearing Snubnose Pompano for 4 months reached a total length of 15-18 cm. This shows that Snubnose pompano are able to coexist with Abalone shells without disturbing the growth of Snubnose Pompano. This is in line with the opinion of Hidayat et al. [2] that the implementation of a polyculture system between Snubnose pompano and green mussels does not interfere with the growth of each commodity being cultivated, but instead the cultivator benefits because he can harvest and sell both commodities at once.

4.2 Absolute Weight Growth

Based on the research results, it was obtained that the highest absolute weight value for Abalone in treatment P1 was the macroalgae type *Gracilaria* sp. with a value of 1.29 ± 0.120 g, while the lowest absolute weight value was found in treatment P5, namely the *Sargassum* macroalgae feed type with a value of 0.74 ± 0.066 g. In the macroalgae *Gracilaria* sp. The results obtained were higher compared to treatments using other types of feed. This is in accordance with the opinion of Nurfajrie et al. [4] that *Gracilaria* sp. is a type of feed that can accelerate the growth of Abalone so it is considered suitable for Abalone cultivation. Abalone prefers *Gracilaria* sp. in accordance with research by Nurfajrie et al. [4] The shape and texture of food such as small and smooth stems in *Gracilaria* can also make it easier for Abalone to consume this food. Apart from paying attention to the feed given, attention also needs to be given to Abalones during the sampling process because Abalones are susceptible to stress which can cause the Abalones to lose their appetite [14].

In this study, the optimum weight growth of Snubnose Pompano reached 8.25 g during 2 months of rearing. Research conducted by Hidayat et al. [2] also explained that Snubnose Pompano kept for 3 months reached a total weight of 13.9 g. This shows that Snubnose pompano can coexist with Abalone shells without disturbing Snubnose Pompano growth. The high value of Snubnose Pompano weight is due to the wide space for movement so that it can digest its food well, thus supporting the growth of Snubnose Pompano weight. This is in accordance with the opinion of Ashari et al. [15] who stated that the area of the environment is one of the growth factors that allows fish to move well so that the fish do not get stressed easily and are able to consume the food given for their growth.

4.3 Survival Rate

The best survival of Abalone shells (*Haliotis squamata*) was in treatment P1 with survival of 85.33% and the lowest was in treatment P5 with survival of 58.67%. This shows that the use of different macroalgae feeds gives different results in each treatment. In this study, the main factor affecting abalone mortality was pests in the rearing basket such as small fish and crabs. Pests are nuisance animals in abalone aquaculture and can cause damage and even death to abalone if not handled properly. This is in accordance with the statement of Iskandar et al. [16] which states that pests attached to the abalone shell can inhibit metabolism which causes abalone stress and illness to death.

The survival rate of Snubnose pompano was relatively high in each treatment, this shows that Snubnose pompano can live well even though they live side by side with Abalone. Treatment P1 showed the highest survival rate, namely 90%, then the lowest was treatment P5, namely 63.33%. This is thought to be due to the limited space for Snubnose Pompano to move due to the inedible food of the Abalone, so that Snubnose Pompano experience stress to the point of death. This difference in survival rate is caused by internal factors, namely disease, food and age, then external factors, namely stocking density during rearing. This is in accordance with the statement of Hidayat et al. [2] who stated that the survival of Snubnose pompano is influenced by internal factors, namely disease, feed and age, as well as external factors in the form of stocking density which affects the fish's movement space.

4.4 Water Quality

The quality of the cultivation area during the research was considered optimal for the growth and survival of Abalone shells and Snubnose pompano. Ammonia levels during rearing ranged from 0,3 to 0,5 mg/L, which is still considered optimal for Abalone. According to Nurfajrie et al. [4], the range of ammonia levels that can be tolerated by Abalone is less than 1 mg/l.

Dissolved oxygen levels are a very important factor in supporting the survival of Abalone shells. According to Hayati et al. [7], the optimal dissolved oxygen level for Abalone growth and survival is more than 5 ppm. During the research, the dissolved oxygen levels obtained were 5,5-6,5 ppm so this range was considered quite optimal for the growth of Abalone shellfish and Snubnose Pompano. Dissolved oxygen is needed by all living things for respiration, metabolic processes or exchange of substances which then produce energy for growth and reproduction [17].

One of the roles of currents in aquaculture is as circulation of water in the cage unit to clean up uneaten feed, clean up residual organism metabolism and to help the process of circulating fresher oxygen [18]. The current speed obtained during the research was around 0,2-0,3 m/s so this range is considered good for Abalone cultivation because according to Pebriani et al. [8] the optimal current speed range to support Abalone cultivation activities is around 0,1 – 05m/s.

The brightness of the waters at the research location can influence the growth of phytoplankton which acts as additional food for Abalone shells. The growth of phytoplankton depends on the intensity of light entering the water for the photosynthesis process. At the research location the brightness range obtained was 5,5 – 6,5 m. According to Junaidi et al. [10] the optimal range of water brightness needed for the growth of marine biota is 4,5-6,5. So it can be said that the water conditions at the research location are optimal.

pH is a benchmark for determining the condition of waters. Water that has a low pH will result in decreased growth and fish becoming weak and are more susceptible to diseases that are accompanied by high mortality rates [19]. The degree of acidity or pH obtained during the research was in the range of 7,8-8 so this range is still ideal for supporting the growth and survival of Abalone shells. According to [8], the range of acidity levels that can still be tolerated by Abalone shells is 7,5-8,7.

Salinity is one of the important water quality parameters in Abalone farming activities because it can affect the level of osmotic action of Abalone shells. The salinity range obtained during the research was around 34-35 ppt so this range was considered optimal for the survival of Abalone shells. According to Pebriani et al. [8], the salinity range that can be tolerated by Abalone shells is 30-35 ppt. In addition, good salinity to support the survival and growth of Snubnose pompano is 29-32 ppt, if salinity conditions are not in accordance with quality standards, it will affect the life of these fish, both on behavior and physiological processes, as well as fish death [20].

Water temperature is an important factor in Abalone cultivation activities because high and low temperatures can affect other water qualities. The temperature range obtained during the research was 27-30^o so this range can still be tolerated by Abalone shells because according to Purwaningsih et al. [9], the optimal temperature range for cultivating Abalone shells is around 27-32^o. Increased temperature causes metabolism to increase so that growth is not optimal [21].

5. CONCLUSION

Based on the results of research conducted for 60 days in Ekas Bay, it can be concluded that the different types of macroalgae feed in rearing Abalone shells with Snubnose pompano have a real influence on growth (absolute length and absolute weight) and the survival rate of Abalone shells (*Haliotis squamata*) and thus, idicates that Abalone shells (*Haliotis squamata*) is best maintained with seaweed feed type *Gracilaria* sp.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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