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Effect Of Macroalgae Feed Type on Abalone Growth and Survival (*Haliotis squamata*) on the Cultivation System Polyculture with Nemo Fish (*Clownfish*)

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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

Abalone (*Haliotis squamata*) or sea snails are also *called awabi*, *mutton fish*, and *sea ear*. Abalone cultivation (*Haliotis squamata*) has quite good prospects, considering that the demand for Asian markets such as Japan, China, and Singapore is increasing. The world's demand for abalone is increasing in line with the increasing need for a diversity of protein sources. In addition to abalone, other leading commodities in marine aquaculture are nemo fish (*Clownfish*). Nemo fish has high

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economic value both in the local and international markets with a wide range of market-markets such as Australia, Japan, Germany and France. Increasing the production of these two commodities can be cultivated in one container called polyculture. Polyculture is cultivation by keeping more than one type of fish or species in the same container. The application of polyculture techniques is expected to increase the carrying capacity or carrying capacity of cultivation containers. The success of polyculture will determine the growth and sustainability of abalone and nemo fish cultivation activities. This study uses an experimental method with a Complete Random Design with the treatment of macroalgae feed types consisting of 5 types, namely: This treatment was carried out with 5 treatments and 3 repetitions, namely: *Gracilaria* sp. (A), *Ulva lactuca* (B), *Caulerpa* (C), *Kappaphycus alvarezii* (D), *Sargasum* (E). The five types of treatments were repeated 3 times so that 15 experimental units were obtained. The results of the research that have been carried out, show that the difference in macroalgae in the maintenance of abalone mussels with nemo fish has a real influence on the growth (absolute length and absolute weight) and the survival rate of abalone mussels (*Haliotis squamata*) and nemo fish (*Clownfish*) which are the best in the maintenance with macroalgae *Gracillaria* sp.

Keywords: Haliotis squamata; clownfish; polyculture; macroalgae; mutton fish; macroalgae feed.

1. INTRODUCTION

Abalone (*Haliotis squamata*) or sea snails are also *called awabi*, *mutton fish*, and *sea ear*. Abalone cultivation (*Haliotis squamata*) has quite good prospects, considering that the demand for Asian markets such as Japan, China, and Singapore is increasing. The world's demand for abalone is increasing in line with the increasing need for a diversity of protein sources [1]. Abalone is classified as an animal that has exotic value and has high economic value. In certain areas, the type of abalone (*H. squamata*) in live conditions is sold at a price of Rp. 2000,000,-/kg [1]. Abalone mussels also have a fairly high selling value, reaching Rp 600,000,-/kg in the export market [1]. In addition to abalone, another leading commodity in marine aquaculture is nemo fish (*Clownfish*). Nemo fish has high economic value both in the local and international markets with a wide range of market markets such as Australia, Japan, Germany and France [2]. Nemo fish has an attractive appearance, bright color beauty, small size and agile movements [3]. The largest species can grow up to 18 cm, while the smallest can only reach 10 cm. The price of this fish is around Rp. 13,000 per head [4].

Increasing the production of these two commodities can be cultivated in one container called polyculture. Polyculture is cultivation by keeping more than one type of fish or species in the same container. The application of polyculture techniques is expected to increase the carrying capacity or carrying capacity of cultivation containers [5]. Ekas Bay has the potential to become a location for abalone mussel polyculture (*Haliotis squamata*) with nemo fish (*Clownfish*), and production growth remains stable without being affected by land. The choice of polyculture between abalone (*Haliotis squamata*) and nemo fish (*Clownfish*) is because the two commodities are suitable and do not harm each other in terms of movement space and feed provided. Therefore, it is necessary to conduct research on the Effect of Different Macroalgae Feed Types on the Growth and Survival of Abalone (*Haliotis squamata*) and Nemo Fish (*Clownfish*) with Polyculture System Cultivation. The success of polyculture will determine the growth and sustainability of abalone and nemo fish cultivation activities.

1.1 Research Methods

This study uses an experimental method with a Complete Random Design with the treatment of macroalgae feed types consisting of 5 types. This treatment was carried out with 5 treatments and 3 repetitions, namely:

P1 : *Gracilaria* sp. as feed (A)
P2 : *Ulva lactuca* as feed (B)
P3 : *Caulerpa* as feed (C)
P4 : *Kappaphycus alvarezii* as feed (D)
P5 : *Sargasum* as feed (E)

The five types of treatment were repeated 3 times so that 15 experimental units were obtained. Each experimental unit was then arranged in a floating net cage unit. The construction of the research layout design can be seen in Fig. 1 below:

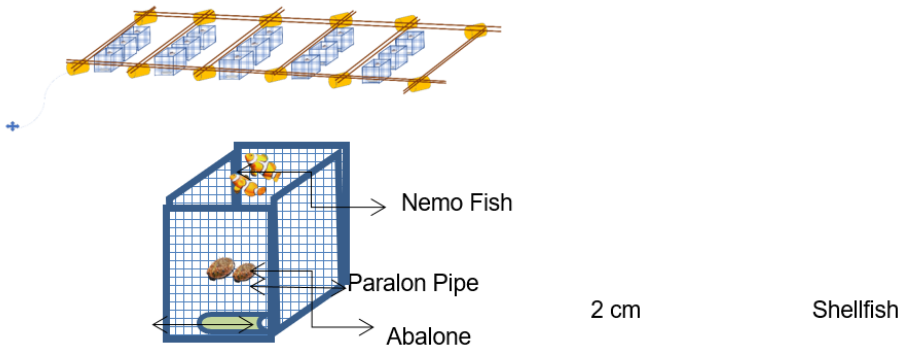

Fig. 1. Assemble floating net cages and construction of research layout

1.2 Research Procedure

Research preparations are carried out such as the preparation of tools, materials, and biota. The tools used in this study are waring sewn squares measuring 1 x 1 cm and tools to measure water quality such as pH meters, do meters, refractometers and thermometers. The biota used is 10 nemo fish measuring 2 cm and 25 abalone seeds measuring 2 cm. The maintenance container in this study is a waring measuring 1m x 1m. The depth used in this study is 1 meter. The nemo fish and abalone shells used were obtained from the Lombok Marine Aquaculture Fisheries Center (BPBL) Sekotong.

In the initial stage, the biota acclimatization process is carried out by soaking the biota together with plastic packing for 15 minutes using a container that has been filled with seawater to equalize the water temperature in the plastic bag and the water temperature in the open sea. Then open the plastic packing so that Biota can adjust well. This acclimatization lasts for a week.

After preparing the tools and materials, the next thing is to spread abalone and nemo fish seeds by inserting seeds into each waring that has been given a paralon pipe substrate. The density used is 25 abalone shells with a size of 2 cm. After that, each container is attached to a weight on the container and lowered at a depth of 1 m.

Length measurement and weight weighing of abalone and nemo fish seeds are carried out every 2 weeks. To measure the length of the shell, it can be done by opening the maintenance container and measuring the length of the dorsal using a caliper. As for measuring the length of the Star pomfret using a ruler.

Then water quality observation was carried out at the research location, which was to measure physical parameters such as temperature, current speed and depth, chemical parameters such as pH and salinity which are carried out every 15 days, namely 0 days, 15 days, 30 days, 45 days and 60 days.

1.3 Test Parameters

The main parameters tested in this study are growth parameters (absolute length growth and absolute weight growth), survival rate, and Data Analysis.

1.4 Growth Parameters

Growth parameters are determined by the formula [6]. The absolute length growth is calculated using the formula: Li=Lt-Lo. Absolute weight growth, W=Wt-Wo. Absolute length growth (%/day); Lt= Fish end length (cm); Lo= Initial length of fish (cm); Li= Absolute Long Growth Rate. Absolute Weight Growth Wt= Average weight at the end of the study (g), Wo= Average Weight at the beginning of the study (g), dan W= Absolute weight growth (g).

1.5 Survival Rate

The Survival rate parameter is determined by the formula [6]: SR=Nt/N0x100%. SR= Survival rate (%); Nt= Number of abalone and nemo shells at the end of the study (tail); No= The number of abalone mussels and nemo fish at the beginning of the study (tail).

1.6 Data Analysis

The data obtained from the results of this study such as absolute length growth, absolute weight, and survival rate of abalone mussels with nemo

fish will be analyzed using Analysis of Variant (ANOVA) at a significant level of 0.05, if the results obtained are significantly different ($p<0.05$), then it is carried out by the Duncan test and homogeneity test to obtain the location of the significance of the data obtained. Meanwhile, water quality data is presented in a descriptive manner.

2. RESULTS AND DISCUSSION

2.1 Results

2.1.1 Absolute length growth

The results of a 60-day study in the waters of Ekas Bay, East Lombok with different macroalgae feeds showed that the average absolute length growth of abalone obtained ranges from 0.55 – 0.89 as can be seen in Fig. 2.

The results of the is anova one way test that have been carried out have real differences between treatments. The result of the Duncan test analysis was that the absolute length growth of P1 (0.89 ± 0.103^{b}) was significantly different from P5 (0.55 ± 0.023^{a}) but not significantly different from P2 (0.69 ± 0.115^{ab}) and P3 (0.6 ± 0.04^{a}). The P2 (0.69 ± 0.115^{ab}) treatment was not significantly different from the P3 (0.6 ± 0.04^{a}) and P4 (0.76 ± 0.227^{ab}) treatments. Based on the results obtained, the best treatment is the P1 (0.89 ± 0.103^{b}) treatment.

Different types of macroalgae show that the average growth of the absolute length of nemo obtained ranges from 1.1 – 2.15 as can be seen in Fig. 3.

The results of the anova test that have been carried out have real differences between treatments. The result of the Duncan test analysis was that the absolute length growth of P1 (2.15 ± 0.140^{b}) was significantly different from P5 (1.1 ± 0.178^{a}) but not significantly different from P3 (1.23 ± 0.21^{a}). The P2 (1.4 ± 0.200^{a}) treatment was not significantly different from the P3 (1.23 ± 0.21^{a}) and P4 (1.89 ± 0.376^{b}) treatments. Based on the results obtained, the best treatment is the P1 (2.15 ± 0.140^{b}) treatment.

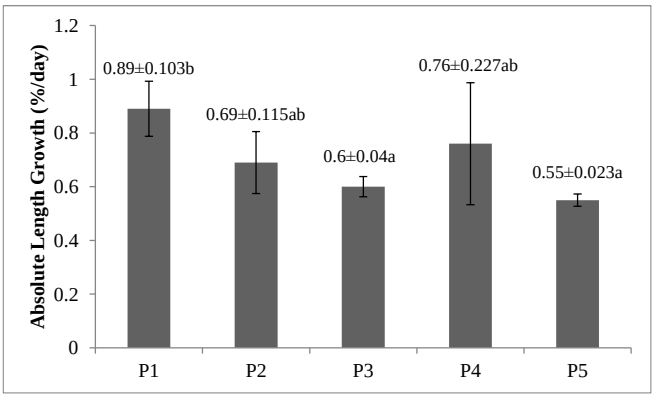

Fig. 2. Growth chart of absolute length of Abalone clams (*Haliotis squamata*)

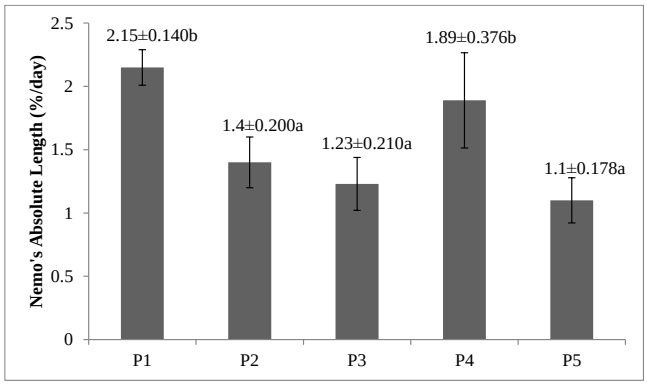

Fig. 3. Nemo (*Clownfish*) long growth chart

2.1.2 Absolute weight growth

The results of the study that has been carried out for 60 days in the waters of Ekas Bay, East Lombok with different macroalgae types of feed show that the average absolute weight growth of abalone obtained ranges from 0.75 – 1.25 as can be seen in the following Fig. 4.

The results of the anova test that have been carried out have real differences between treatments. The result of the Duncan test analysis was that the absolute weight growth of P1 (1.25 ± 0.010^{c}) was significantly different from P5 (0.75 ± 0.181^{a}) but not significantly different from P2 (0.9 ± 0.093^{ab}) and P3 (1.05 ± 0.186^{bc}). P3 (1.05 ± 0.186^{bc}) treatment is not significantly different from P4 (1.19 ± 0.164^{c}) treatment. Based on the results obtained, the best treatment is the P1 (1.25 ± 0.010^{c}) treatment.

Different types of macroalgae show the average growth of the absolute weight of nemo obtained ranging from 0.9 – 1.28 as can be seen in Fig. 5.

The results of the anova test that have been carried out have real differences between treatments. The result of the Duncan test analysis was that the absolute weight growth of P1 (1.28 ± 0.015^{d}) was significantly different from P5 (0.9 ± 0.029^{a}) but not significantly different from P2 (1.09 ± 0.061^{bc}) and P3 (0.99 ± 0.115^{ab}). The P2 (1.09 ± 0.061^{bc}) treatment was not significantly different from the P4 (1.17 ± 0.064^{cd}) treatment. Based on the results obtained, the best treatment is the P1 (1.28 ± 0.015^{d}) treatment.

2.2 Survival Rate

The results of the study that has been carried out for 60 days in the waters of Ekas Bay, East Lombok with different types of macroalgae show that the average survival of the abalone obtained ranges from 58.67% – 86.67% as can be seen in Fig. 6.

The results of the anova test that have been carried out have real differences between treatments. The results of the Duncan test analysis were that the survival of pomfret fish at P1 was significantly different from P5 but not significantly different from P3 and P4. The P2 treatment was not significantly different from the P3 and P4 treatments. Based on the results obtained, the best treatment is the P1 treatment.

Different types of macroalgae show that the average survival of the nemo obtained ranges from 66.67% – 86.67% as can be seen in Fig. 7.

The results of the anova test that have been carried out have real differences between treatments. The results of the Duncan test analysis were that the survival of P1 abalone was significantly different from P3 and P5 but not significantly different from P2 and P4. Based on the results obtained, the best treatment is the P1 treatment.

2.3 Water Quality

In the maintenance of abalone mussels (*Haliotis squamata*) and nemo fish (*Clownfish*), water quality is an important factor in supporting the growth and survival of abalone mussels (*Haliotis squamata*) and nemo fish (*Clownfish*). The water quality during research activities in the waters of Ekas Bay, East Lombok is presented in Table 1.

The water quality in the waters of Ekas Bay, East Lombok during maintenance is in the normal range and can support the growth and survival rate of abalone mussels (*Haliotis squamata*) and nemo fish (*Clownfish*) that are well cultivated.

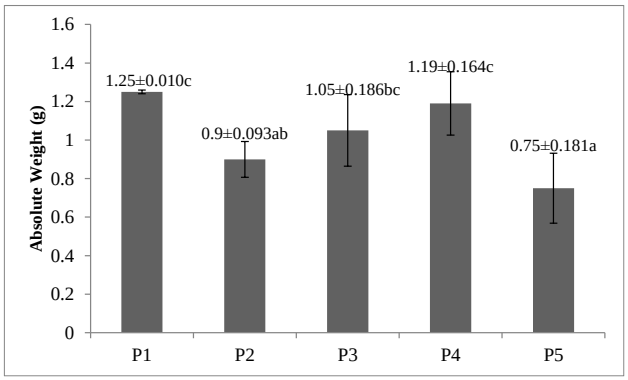

Fig. 4. Growth chart of absolute weight of Abalone clams (*Haliotis squamata)*

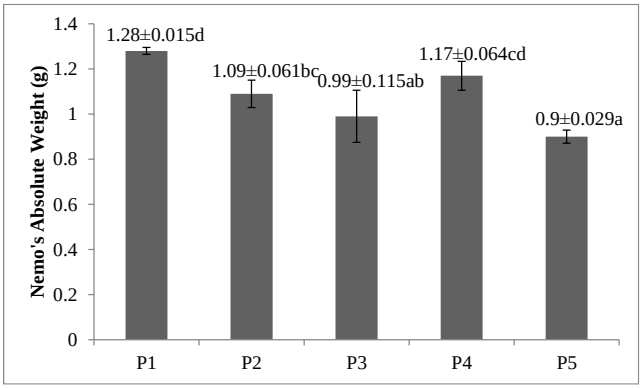

Fig. 5. Growth graph of the absolute weight of Nemo fish (*clownfish*)

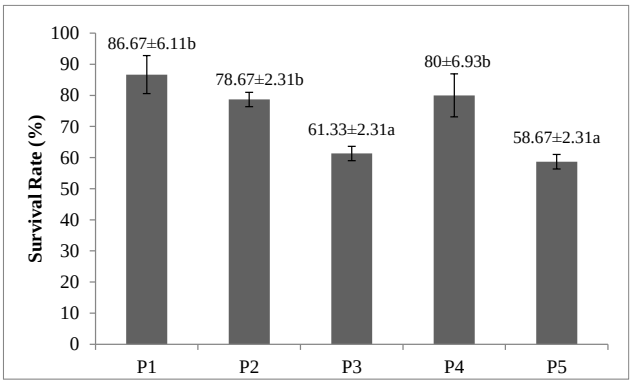

Fig. 6. Abalone mussel survival chart (*Haliotis squamata*)

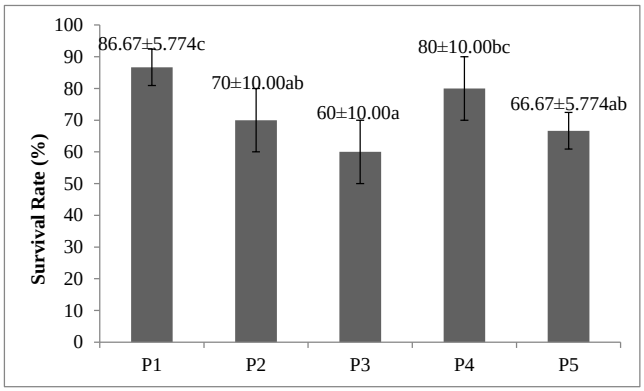

Fig. 7. Nemo fish (*Clownfish*) survival chart

Table 1. Water quality measurement results

No.	Parameters	Obtained Range	Ideal Range	Reference
1.	Ammonia (mg/l)	0,3 - 0.5	<1	Nurfajrie *et al*., [14]
2.	DO (ppm)	5,5-6,5	>5	Hayati *et al*., [15]
3.	Current Speed (m/s)	0,2-0,5	0,1-0,3	Pebriani & Dewi [16]
4.	Brightness (m)	5,5-6,5	4,6-6,5	Junaidi [17]
5.	pH	7,8 - 8	7,5-8,7	Pebriani & Dewi [16]
6.	Salinity (ppt)	30-33	30-35	Pebriani & Dewi [16]
7.	Temperature (°C)	27-30°	27-32°	Purwaningsih *et al*., [18]

3. DISCUSSION

3.1 Absolute Length Growth

Based on the results of the study on the absolute length growth parameter, it was shown that P1 had the highest value (0.89±0.103), while the lowest value was obtained in P5 (0.55±0.023). This shows that P1 has a combination of balanced nutritional content, good digestibility, and the aroma of *Gracillaria* sp. seaweed which increases the appetite of abalone mussels. Based on research of Banin [7], macroalgae feed *Gracillasia* sp. has a higher protein content compared to other types of seaweed, such as *Ulva* sp., *Caulerpa*, *Kappaphycus alvarezii*, *Sargassum* sp. Protein is essential for the growth and development of abalon, especially for the formation of shells and meat. *Gracillaria* sp. also rich in carbohydrates in the form of fructose and glucose. These carbohydrates provide the energy that abalone needs to be active and grow. In the research of Rosmawati et al. [8], it was stated that *Gracillaria* sp. has a softer texture and is easier to digest by abalone compared to other types of seaweed. Judging from the results of the research that has been carried out, it can be seen that *Gracillaria* sp. has a good level of palatability for abalo (*Haliotis squamata*). This can be seen from the higher feed consumption rate than other types of macroalgae feed.

The growth yield of absolute length is directly proportional to the yield of absolute weight. The highest absolute weight growth was found in P1 which was (1.25±0.010) g and the lowest absolute weight was found in P5 which was (0.75±0.181) g. Slower growth of abalone in Sargassum feed is due to by its firm texture, lower nutrient content, and higher energy requirements to digest it. Based on the research of Bulan et al. [9], it was stated that the high growth rate in abalone using macroalgae feed *Gracillaria* sp. Compared to other macroalgae feed, it is caused by factors, namely, protein content. According to Insani et al. [10], To grow properly, abalone needs feed with a protein content ranging from 20-47%. Of the types of feed used, only Gracillaria sp. with a content of 15% that is close to that range.

The effect of the addition of pellets on the growth of the absolute length of Nemo Fish (Clownfish) gave noticeably different results. The highest absolute length growth of Nemo Fish (Clownfish) is at P1 treatment, with an absolute length growth of (2.15±0.140) cm, and the lowest was in the P5 treatment with a growth of (1.1±0.178) cm. This shows that nemo fish fed in the form of pellets with the addition of the macroalgae Gracillaria sp., experienced higher length growth, as well as a better survival rate compared to nemo fish added with Sargassum macroalgae feed at P5. According to Sibua [11], that pellet feed with the addition of macroalgae *Gracillaria* sp. which contain minerals, amino acids, and vitamins are very good to support the survival of nemo fish so that they have a good immune system to support their growth and development. Absolute growth in fish is also influenced by the environment, and the quality of the feed provided.

Absolute weight growth of nemo fish was highest in P1 at (1.28 ± 0.015) g and lowest in P5 at (0.9 ± 0.029) g. The low value of absolute weight in nemo fish is thought to be due to stress factors at the time of sampling, causing nemo fish to experience a decrease in appetite. In addition, water conditions are also an important factor for nemo fish to absorb nutrients from their food. This is in accordance with the opinion of Ina et al. [12], The better the condition of a water body, the better the resulting growth and vice versa if the water condition is not good, the resulting growth is also not good. The high absolute weight value indicates that nemo fish can coexist with abalone mussels without interfering with the growth of each individual. on research [13], The study found that polyculture using starfish and green mussels yielded similar results, with the two biota not interfering with each other's growth, but with farmers benefiting from being able to harvest and sell two commodities at Loekman et al, [1].

3.2 Survival Rate

Abalone survival rate (SR) by giving a combination of different macroalgae feed gives a real effect. This can be seen from the highest percentage value in the treatment with Gracillaria sp. macroalgae feed which is 86.67% and the lowest survival rate in the treatment with Sargassum macroalgae feed which is 58.67%. This study showed that the lowest feed consumption rate occurred when feeding Sargassum, which has a harder and coarser thalus stem than the feed *Gracilaria* sp, *Ulva* sp, *Caulerpa*, and *Kappaphycus alvarezii*. the low SR value in the treatment with *Sargassum* macroalgae feed is because *Sargassum* has a

harder thallus compared to *Gracillaria* sp.. This is in accordance with the statement [9], abalone has a radula whose only function is to scrape food and it would be very difficult to process hard food.

The effect of adding macroalgae to pellet feed on the survival of Nemo Fish (*Clownfish*) provides different survival rates. This can be proven by analyzing the average survival in each treatment given. The highest survival rate was found in abalone and nemo polyculture P1 with *Gracillaria* sp. macroalgae feed at 86.67% and the lowest survival rate was found in abalone and nemo polyculture P3 with *Caulerpa* macroalgae feed at 60%. The high survival rate of nemo fish occurs because feeding pellets with additional macroalgae can increase complete nutritional needs and increase immunity. According to Sibua [11], The use of pellet feed with the addition of *Gracillaria* sp. macroalgae has a significant effect on the growth of nemo fish with the amount of feed given is sufficient and able to survive in uncertain environmental conditions.

3.3 Water Quality

The quality of the waters where abalone mussels and nemo fish were kept during the study was considered optimal for the growth and survival of abalone mussels. The range of ammonia levels during maintenance is 0.3-0.5 mg/L, which is still considered ideal and optimal for abalone. According to Nurfajrie et al. [14], states that the range of ammonia levels that can be tolerated by abalone is less than 1 mg/l.

The measurement results during the study obtained the average value of DO ranging from 5.5-65 ppm. According to Hayati et al. [15], the concentration and availability of dissolved oxygen levels in water are needed by fish and other organisms to live. The good DO range for abalone and nemo fish ranges from 5.0 - 7.0 ppm. Thus DO conditions in Ekas Bay waters are still classified as good for the survival of abalone (*Haliotis squamata*) and nemo fish (*Clownfish*).

Current plays an important role in abalone and nemo fish farming because current speed is an important factor that can affect the amount of dissolved oxygen in the water. The ideal current speed will help nemo with abalone grow and develop optimally, in this study the current speed ranged from 0.2-0.3 m/s. Based on research by Pebriani and Dewi [16], the optimal current speed range to support abalone and nemo fish farming activities is 0.1-05 m/s. So that the current conditions of Ekas Bay waters are still relatively good for the growth and survival of nemo fish abalone shellfish.

Water brightness varies greatly depending on water type, depth, season and human activity, and can also affect the growth of phytoplankton that serve as supplemental food for abalone shellfish and nemo fish. Phytoplankton growth depends on the intensity of light entering the water for photosynthesis. At the study site, the brightness range was 5.5 - 6.5 m. According to Junaidi et al. [17], states that 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 condition of Ekas Bay waters is classified as optimal.

The measurement results during the study obtained an average pH value of 7.8-8. So that in this range it is still ideal to support the growth and survival of abalone shells and nemo fish. According to Pebriani and Dewi [16], the range of acidity that can still be tolerated by abalone shells is 7.5 - 8.7. Thus, the pH condition of Ekas Bay waters can still be tolerated by abalone shells (*Haliotis squamata*) and nemo fish (*Clownfish*).

The measurement results during the study obtained an average salinity value of 30-33 ppt. so that in this range it is considered optimal for the survival of abalone shells and nemo fish. According to Pebriani and Dewi [16], the salinity range that can be tolerated by abalone shells and nemo fish is 31-35 ppt. Salinity is one of the environmental parameters that affect biological processes and directly the growth of organisms as well as the appetite of shellfish and fish. Thus the pH conditions of Ekas Bay waters can still be tolerated by abalone shellfish (*Haliotis squamata*) and nemo fish (*Clownfish*).

The measurement results during the study obtained an average temperature value of 27°C-30°C. Water temperature is one of the important factors in abalone shellfish and nemo fish cultivation activities because high and low temperatures can affect other water quality. According to Purwaningsih and Deskawati [18], the optimal temperature range for abalone mussel cultivation ranges from 27°C-32°C. So that the temperature conditions of Ekas Bay waters can still be tolerated by abalone shellfish (*Haliotis squamata*) and nemo fish (*Clownfish*).

4. CONCLUSION

Based on the results of the research that has been done, it can be concluded that the difference in macroalgae in the maintenance of abalone shellfish with nemo fish has a significant effect on growth (absolute length and absolute weight) as well as the best survival rate of abalone clams (*Haliotis squamata*) and nemo fish (*Clownfish*) in rearing with the macroalgae *Gracillaria* 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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