

The Effect Of Decreased Salinity On Survival, Growth, And Oxygen Consumption Rate Of Barramundi (Lates Calcarifer) Larvae

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Abstract— Barramundi is a high-value aquaculture commodity with significant potential due to its ability to thrive across a wide range of salinities. However, extreme salinity fluctuations can negatively impact the metabolism, growth, and survival of the fry. Therefore, it is crucial to determine the optimal salinity range for cultivation. The results showed that treatment C (19 ppt) yielded the highest survival rate ($100 \pm 0.00\%$), while the lowest was observed in treatment A (33 ppt) at $90 \pm 11.54\%$. The highest absolute weight gain (6.89 ± 0.12 g) and absolute length growth (4.05 ± 0.05 cm) were recorded in treatment C (19 ppt), while the lowest were in treatment A (33 ppt), with 4.75 ± 0.30 g and 2.65 ± 0.10 cm, respectively. The highest specific growth rate was also found in treatment C ($4.59 \pm 0.28\%$ per day), with the lowest in treatment A ($3.62 \pm 0.41\%$ per day). For oxygen consumption, the highest rate was in treatment C (0.56 ± 0.22 mgO₂/g/h), and the lowest was in treatment A (0.22 ± 0.16 mgO₂/g/h). The lowest feed conversion ratio (FCR) was in treatment A, with an average value of $2.13 \pm 1.70\%$, while the highest was in treatment C ($2.93 \pm 0.27\%$). Water quality parameters remained within a suitable range for barramundi, with a temperature of 28.2–29.5°C and a pH of 7.39–7.30, which align with the SNI 2020 water quality standards.

Keywords – Salinity, Survival, Growth and Oxygen Consumption Rate, Barramundi, Lates calcarifer

I. INTRODUCTION

Barramundi is one of the aquaculture commodities that has high economic value, especially as an export commodity [1]. Market demand in Europe, particularly in Italy, Spain, and France, has continued to increase from 14,285 tons in 2012 to 18,572 tons in 2014 [2]. Production in Southeast Asia reaches 300,000 tons per year, far exceeding production in America, which is only around 800 tons per year [3]. Despite high market demand, the availability of Barramundi for consumption remains a constraint, mainly due to water quality challenges such as salinity. This fish is known as a euryhaline species, capable of adapting to freshwater, brackish water, and marine environments [4]. This ability makes Barramundi highly resistant to various environmental conditions. However, extreme salinity fluctuations can affect its physiology, including metabolism, osmoregulation, and oxygen requirements. When salinity decreases, Barramundi requires more energy for osmoregulation, which can potentially reduce its growth rate [5].

Several studies have shown contradictory results. A study by [6] showed that Barramundi kept at low salinity (0 ppt) had higher absolute length and weight growth, as well as the highest daily growth rate compared to higher salinity. Feed consumption and utilization efficiency also increased, indicating that more energy was diverted to growth. These results are reinforced by research [7], which found that at a salinity of 30 ppt, the fish showed 100% survival, absolute weight growth of 0.74 g, a daily growth rate of 0.025%, and an efficient feed conversion ratio. Conversely, at higher salinity (33 ppt), growth declined and feed conversion ratios worsened. Although survival remained high, the increased osmoregulatory load at high salinity reduced energy available for growth.

Decreased salinity also affected oxygen consumption in fish [8]. Oxygen consumption is an important indicator of metabolic activity. [9] observed in mud grouper (*Epinephelus tauvina*) that a decrease in salinity significantly increased the oxygen consumption rate OCR [10]. The highest oxygen consumption occurred at the lowest salinity (15 ppt), indicating that fish require more energy to adapt. This increase can be seen as a physiological stress response, where the fish's metabolism increases to maintain homeostasis. In Barramundi fry, stress due to salinity changes can disrupt normal development and reduce survival [7].

Although seawater cultivation is considered more ideal, the development of Barramundi cultivation in freshwater shows great potential. The use of flooded land due to flooding for cultivation, for example, produces good growth offering an important alternative for farmers in areas without direct access to the sea Masyahoro et al., 2023)[7]., The Marine and Brackish Water Aquaculture Center (BPBALP) in Sungai Nipah has successfully produced

Barramundi fry on a large scale. However, this center has not yet developed a farming system for low salinity (below 5 ppt). Observations at the station show frequent salinity fluctuations, which cause stress in fish and have the potential to cause mass mortality if not handled properly. Therefore, this study will examine the effect of salinity reduction on the growth, survival, and oxygen consumption rate of Barramundi fry as a basis for better aquaculture management.

II. MATERIALS AND METHODOLOGY

This study aimed to analyze the effect of reduced salinity on the survival, growth, and oxygen consumption rate of barramundi fry. The research was conducted at the Sungai Nipah Brackishwater and Marine Aquaculture Center over a 28-day period. A Completely Randomized Design (CRD) was used with five salinity treatments (33 ppt, 27 ppt, 19 ppt, 11 ppt, and 3 ppt) and four replicates. The experimental units were twenty 16-liter jars, each filled with 10 liters of water and 5 barramundi fry measuring 5-6 cm. Data were analyzed using a one-way ANOVA, followed by a Duncan's post-hoc test, with the assistance of IBM SPSS version 27. Research parameters consist and dilution is done using a formula:

$$S_n = \frac{(s_1 \times v_1) + (s_2 \times v_2)}{v_1 + v_2}$$

Description:

S_n : Target Salinity (ppt)

S_1 : Freshwater salinity (ppt)

S_2 : Seawater salinity (ppt)

V_1 : Seawater volume (l)

V_2 : Freshwater volume (l)

Survival Rate

The survival rate of Barramundi fish is the percentage of fish alive at the end of the experiment and is calculated using Effendie's formula (2002):

$$SR = \frac{N_t}{N_o} \times 100 \%$$

Description

SR : Survival Rate (%)

Nt : Number of fish at the end of the experiment (tails)

No : Number of fish at the beginning of the experiment (tails)

Absolute Weight Gain (W)

To calculate absolute weight gain, use Effendie's formula (2002):

$$W = W_t - W_o$$

Description

W : Absolute weight gain of fish (g)

Wt : Average weight of fish at the end of the study (g)

Wo : Average weight of fish at the beginning of the study (g)

Absolute Length Growth

Absolute length gain is the difference between the length of the fish from the tip of the head to the tip of the tail at the end of the study and the body length at the beginning of the study. Absolute length gain is calculated using Effendie's formula (1997):

$$P_m = L_t - L_o$$

Description

Pm : Absolute length increase (cm)

L : Final average length (cm)

L : Initial average length (cm)

Spesifik Grow Rate

To calculate daily growth (%), Effendie's formula (2002) is used:

$$SGR = \frac{W_t - W_o}{T} \times 100 \%$$

Description

SGR : Specific Growth Rate (%)

T : Maintenance Period

Wt : Final Fish Weight at End of Study (g)

Wo : Initial Fish Weight at Start of Study (g)

Oxygen Consumption Rate

The oxygen consumption rate is calculated using the formula by Wahyu et al. (2013)[11] as follows:

$$LKO = \frac{(DO_{Awal} - DO_{Akhir})}{(w - t)} \times V$$

Description:

LKO : Oxygen consumption rate (MgO₂/g/hour)
Initial DO : Dissolved oxygen at the start of observation (mg/l)
Final DO : Dissolved oxygen at the end of observation (mg/l)
W : Weight of test fish (g)
t : Observation period (hours)
v : Water volume (l)

Feed Conversion Ratio

Feed Conversion Ratio is the ratio between the weight of feed given in one cultivation cycle and the total weight (biomass) of fish produced at that time, as formulated by Kandida (2013):

$$FCR = \frac{F}{(Wt+D)-Wo}$$

Description:

FCR : Feed Conversion Ratio
F : Amount of feed consumed (g)
D : Weight of dead fish (g)
Wt : Weight of fish at the end of the study (g)
Wo : Weight of fish at the beginning of the study (g)

Water Quality

The water quality parameters measured included temperature, pH, dissolved oxygen, and salinity. Salinity, temperature, and pH measurements were taken every day at 7:00 a.m. and 5:00 p.m.

III. Result and Discussion

Survival Rate

Table 1. Average Survival Rate Of Barramundi Fry

No	Treatment	Survival Rate (%)
1	A	90±11,54
2	B	95±10,00
3	C	100±0,00
4	D	95±10,00
5	E	95±10,00

Based on Table 1 survival rates, it is known that the five treatments showed varying survival rates. The highest survival rate was obtained in treatment C with an average value of $(100 \pm 0.00\%)$, followed by treatment D $(95 \pm 10\%)$, treatment B $(95 \pm 10\%)$, treatment E $(95 \pm 10\%)$, and the lowest was treatment A $(90 \pm 11.54\%)$. Barramundi is known as one of the euryhaline fish species, which is a group of fish that has the ability to adapt to a wide range of salinity, both in freshwater, brackish water, and seawater [1]). This ability is related to the physiological mechanisms that fish have in regulating their body's osmotic balance (osmoregulation)[12]. This is because juvenile Barramundi naturally choose to live in freshwater until they are 2 years old. According to [13], Barramundi fish spend most of their 2-3 year lifespan in freshwater environments such as rivers and lakes connected to the sea. Adult fish (3-4 years old) migrate towards river mouths from upstream to the sea, where salinity ranges from 30-32 ppt, for gonadal maturation and then spawn, producing eggs. This allows the eggs to be carried by the current to the river mouth, where the larvae grow well and then migrate upstream to mature.

However, even though Barramundi are adaptive to changes in salinity, there is still a certain tolerance threshold that cannot be exceeded. If environmental conditions are outside this tolerance range, the fish will experience stress that can result in physiological disorders, decreased immunity, and ultimately death [14]. Research shows that at high salinity, particularly in the range of 27–33 ppt, Barramundi exhibit quite serious symptoms of stress. This is thought to be related to the increased osmotic load that the fish's body must bear to maintain its internal ion and fluid balance [7]. Under extreme salinity conditions, the metabolic energy that should be used for growth and other vital activities is diverted to maintain osmoregulation. As a result, fish experience a decline in physiological performance, weakened immunity, and, over time, mortality. These findings indicate that a salinity range of 37–38 ppt is already beyond the physiological tolerance limit of Barramundi [15]. Low survival rates may also be attributed to the stocking density used, besides the feeding protocol[16].

Conversely, in treatments with lower salinity levels within the physiological tolerance range, fish survival rates showed better results [8]. In treatments B, D, and E, survival rates reached 95%. This value indicates that the fish are still able to adapt and survive in these salinity conditions despite the slight environmental stress. This condition shows that there is a relatively safe tolerance limit, where the fish are still able to minimize the use of metabolic energy for osmoregulation so that it does not interfere with other physiological processes [17]. In treatment C, the survival rate reached 100%. These results indicate that the salinity in treatment C is within the optimal range for Barramundi. Under these conditions, the osmoregulation process runs efficiently so that it does not cause excessive metabolic burden [18].

Absolute Weight Gain (W)

Table 2. Average absolute weight growth of Barramundi fry

No	Treatment	Absolute Weight Gain (g)
1	A	4,75±0,30
2	B	5,30±0,27
3	C	6,89±0,12
4	D	6,55±0,22
5	E	5,12±0,15

Based on Table 2 of absolute weight growth, it is known that all five treatments (A, B, C, D, and E) showed varying increases in weight from the beginning to the end of the study. The highest absolute weight gain was obtained in treatment C with an average value of $(6.89 \pm 0.12 \text{ g})$, followed by treatment D $(6.55 \pm 0.22 \text{ g})$, treatment E $(5.12 \pm 0.15 \text{ g})$, treatment B $(5.30 \pm 0.27 \text{ g})$, and the lowest was treatment A $(4.75 \pm 0.30 \text{ g})$. Based on Table 2, The temperature range in both treatments A and B ranged from 28.4 - 28.9°C. Temperature Salinity differences that are too far from the osmotic pressure of fish body fluids can cause fish to expend more energy to maintain their osmotic balance. Under these conditions, energy that should be used for growth is diverted to the osmoregulation process. As a result, even though the fish consume large amounts of feed, the efficiency of energy use from feed for growth becomes low. This limits the energy reserves that can be used to increase the fish's body weight [9]. According to [12], higher salinity in the research medium does not have a positive effect on fish feed utilization. Treatment A resulted in the lowest fish weight gain of 4.75

g. This is consistent with the high energy requirements due to osmoregulation at high salinity, which causes a decrease in feed utilization efficiency. Although feed is consumed, the energy obtained is used more for physiological activities to maintain body balance than for weight gain.

Treatment A yielded the lowest growth results compared to the other treatments. This is thought to be due to salinity fluctuations during maintenance, where the salinity of the medium often increased to 37-38 ppt due to evaporation from the use of jars as containers. This is in line with the opinion [19] that the relatively small volume of water from the use of containers can cause faster evaporation. The increase in salinity beyond the normal threshold likely caused osmotic stress in the fish, so that the energy that should have been used for growth was instead used to maintain the body's osmotic balance. As a result, the growth rate of the fish was lower than that of the treatments with lower salinity [12]). The highest weight gain was obtained in treatment C with a value of $(6.89 \pm 0.12 \text{ g})$. This is thought to be due to the salinity of the medium being close to equilibrium with the osmotic pressure of the fish's body fluids, so that the fish did not need to expend much energy for osmoregulation. The remaining energy can be diverted to support growth, including more efficient feed utilization [20]. Meanwhile, treatment D also showed high weight gain of $(6.55 \pm 0.30 \text{ g})$, presumably because the fish were able to adapt well to the decrease in salinity. This adaptation allows Barramundi to utilize feed optimally according to their needs. In line with the opinion [21]), fish growth will occur when the quality and quantity of feed consumed exceeds the basic requirements for maintaining body weight and size. Rayes et al. (2013)[6] stated that fish growth can occur when the energy stored is greater than the energy used for bodily activities. Furthermore, Fitri et al. (2013) [22] found that competition for space and food acquisition occurred without causing stress to the fish or hindering their growth during maintenance.

Barramundi is a euryhaline fish, meaning it can adapt to a wide range of salinity levels, from freshwater to seawater. Its life cycle begins with eggs and larvae that generally develop in seawater with high salinity, then juveniles migrate to brackish or freshwater to grow larger, and when mature, they return to the sea to spawn. This migratory ability makes Barramundi highly adaptable to cultivation in various ecosystems [23]. However, changes in salinity have a significant impact on fish physiology. During the seedling and juvenile phases, a decrease in salinity can increase the energy required for osmoregulation, which affects oxygen consumption and growth. Salinity that is too high or too low tends to cause physiological stress, reduce feed utilization efficiency, and even affect survival. Conversely, medium salinity that is close to the osmotic equilibrium of the fish's body has been shown to provide optimal growth and high survival rates [24].

Absolute Length Growth

Table 3. Average Absolute Length Growth

No	Treatment	Absolute Length Growth (cm)
1	A	$2,65 \pm 0,10$
2	B	$3,65 \pm 0,19$
3	C	$4,05 \pm 0,05$
4	D	$3,67 \pm 0,22$
5	E	$3,15 \pm 0,12$

Based on Table 3, the absolute length values of the fish at the beginning of the study showed that all five treatments exhibited varying increases in length. The highest length growth was obtained in treatment C with an average value of $(4.05 \pm 0.05 \text{ cm})$, followed by treatment D $(3.67 \pm 0.22 \text{ cm})$, treatment B $(3.65 \pm 0.19 \text{ cm})$, treatment E $(3.15 \pm 0.12 \text{ cm})$, and the lowest was treatment A $(2.65 \pm 0.10 \text{ cm})$. The high absolute growth rate of treatment C was due to the high appetite of the fish, which resulted in more energy for the fish. According to [25]), fish that are fed only 3 or 2 times a day will experience prolonged starvation. Fish tend to consume as much feed as possible, so that their stomachs reach maximum capacity. This, in turn, causes the fish to grow taller. According [21], there is a close relationship between the growth in length and weight of fish; every increase in fish weight is followed by an increase in length. However, the rate of fish body length growth is not only influenced by genetic and feed factors, but also by environmental conditions, one of which is salinity.

Water salinity has a significant impact on fish physiological processes, especially in terms of osmoregulation. The osmoregulation process is a mechanism that requires energy to maintain the balance of ion and water concentrations in the fish's body so that it remains stable, even though the external environment is changing. Fish living in an environment with salinity that is far different from their physiological conditions must allocate more energy for osmoregulation, which reduces the energy available for growth and other metabolic processes. A decrease in salinity can affect the performance of fish length and weight gain. Biologically, differences in absolute length growth between treatments can be influenced by various factors such as feed quality (nutritional composition, protein, fat, vitamin, and mineral content), feeding frequency, feed digestibility, and water quality conditions (temperature, pH, dissolved oxygen, and ammonia) [26].

Treatment C, which showed the highest growth, likely provided the most supportive combination of factors, such as feed with high protein and easy digestibility, as well as a stable rearing environment so that the fish's energy could be allocated more to body tissue growth rather than to survival [27]. Meanwhile, treatment A, which showed the lowest growth, likely experienced limitations in one or more of these supporting factors, such as suboptimal feed nutrient content or unsupportive environmental conditions, thereby inhibiting fish growth [3]. Other factors such as fish density and aggressive behavior can also affect the availability of feed per individual, which can affect growth [28]. Additionally, high salinity can cause osmotic stress in fish. This stress triggers an increase in stress hormones (cortisol), which reduces appetite, thereby decreasing the amount of energy and protein entering the body. As a result, feed utilization efficiency also decreases [29].

Spesifik Grow Rate

Table 4. Average Specific Weight Growth Rate

No	Treatment	<i>Spesifik Grow Rate</i> (%/day)
1	A	3,62±0,41 ^a
2	B	3,89±0,36 ^a
3	C	4,59±0,28 ^b
4	D	4,51±0,36 ^b
5	E	3,67±0,23 ^a

Based on Table 4 specific growth rate (SGR), it is known that all five treatments showed varying weight increases from the beginning to the end of the study. The highest specific weight gain was obtained in treatment C with an average value of $(4.59 \pm 0.28\%/day)$, followed by treatment D $(4.51 \pm 0.36\%/day)$, treatment B $(3.89 \pm 0.36\%)$ treatment E $(3.67 \pm 0.23\%/day)$, and the lowest was treatment A $(3.62 \pm 0.41\%/day)$. The daily growth chart for Barramundi fry can be seen in Figure 1.

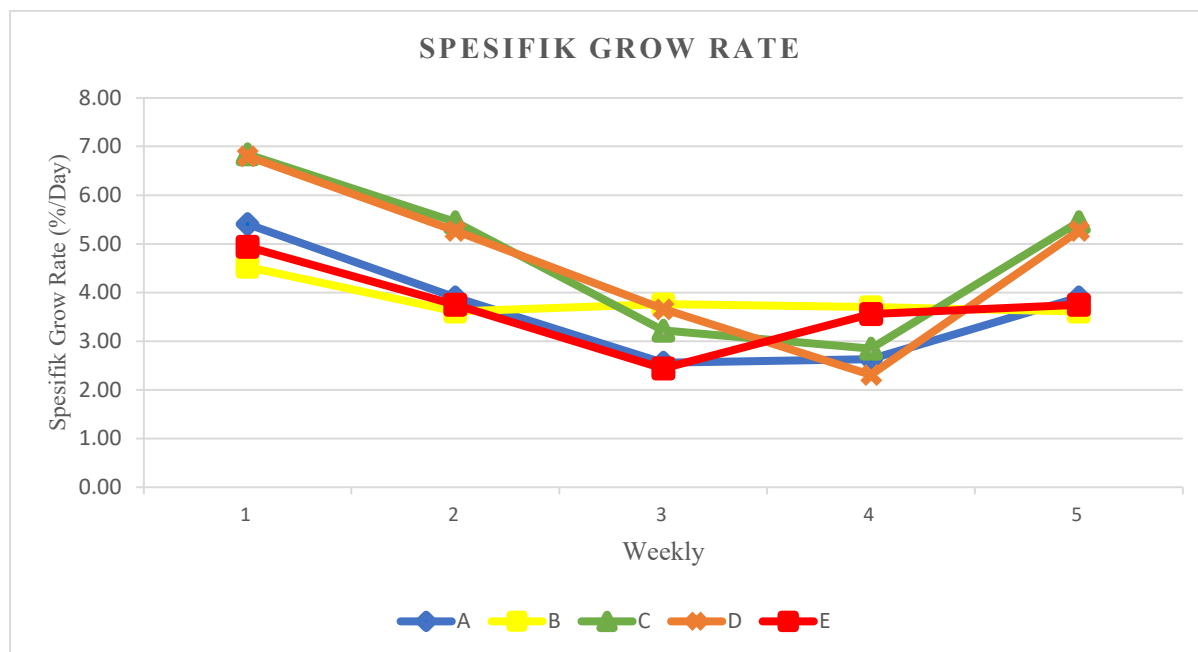


Figure 1. Daily Growth Chart

In the first week, the daily SGR values of Barramundi were relatively high in all treatments, ranging from 4.53% to 6.84%. Treatment C (19 ppt) recorded the highest value of 6.84%, followed by treatment D (11 ppt) at 6.80%. Treatment B (27 ppt) had the lowest value of 4.53%. This shows that at the beginning of cultivation, fish in medium salinity (19–11 ppt) adapted more quickly, resulting in more optimal growth. Entering the second week, there was a slight decrease in SGR in all treatments, although the pattern of superiority remained the same. Treatment C (19 ppt) was still the highest at 5.45%, followed by D (11 ppt) at 5.27%. Treatments A (33 ppt), B (27 ppt), and E (3 ppt) showed lower values, ranging from 3.61% to 3.90%. In the third week, daily SGR tended to decrease in almost all treatments. Treatment A (33 ppt) was only 2.56% and treatment E (3 ppt) was even lower at 2.44%. Treatments C (19 ppt) and D (11 ppt), although declining, remained relatively higher than the other treatments, at 3.22% and 3.66%. This indicates a continued adaptation phase that suppressed the growth rate.

In the fourth week, the SGR values became more varied. Treatment D (11 ppt) recorded a sharp decline to 2.31%, which was the lowest value throughout the observation period. Treatment C (19 ppt) declined to 2.85%. In contrast, treatments A, B, and E were in the range of 2.63%–3.70%, indicating stabilization of growth, albeit at a relatively low level. In the fifth week, growth increased again in several treatments. Treatment C (19 ppt) recorded a sharp increase to 5.45%, which was the highest value at the end of the observation period. Treatment D (11 ppt) also recovered to a value of 5.27%. Meanwhile, treatments A, B, and E remained relatively low, ranging from 3.61% to 3.90%.

Oxygen Consumption Rate

Table 5. Average oxygen consumption rate (OCR)

No	Treatment	Oxygen Consumption Rate (MgO ₂ /g /L)
1	A	0,56±0,22
2	B	0,50±0,24
3	C	0,22±0,16
4	D	0,31±0,16
5	E	0,41±0,31

Based on Table 5, the oxygen consumption rate shows that the five treatments exhibited varying oxygen consumption rates from the beginning to the end of the study. The highest oxygen consumption rate was obtained in treatment A with an average value of (0.56±0.22 mgO₂/g/hour), followed by treatment B (0.50±0.24 mgO₂/g/hour), treatment E (0.41±0.31 mgO₂/g/hour), treatment D (0.31±0.16 mgO₂/g/hour), and the lowest was treatment C (0.22±0.16 mgO₂/g/hour). The average daily oxygen consumption rate for fish can be seen in Figure 2:

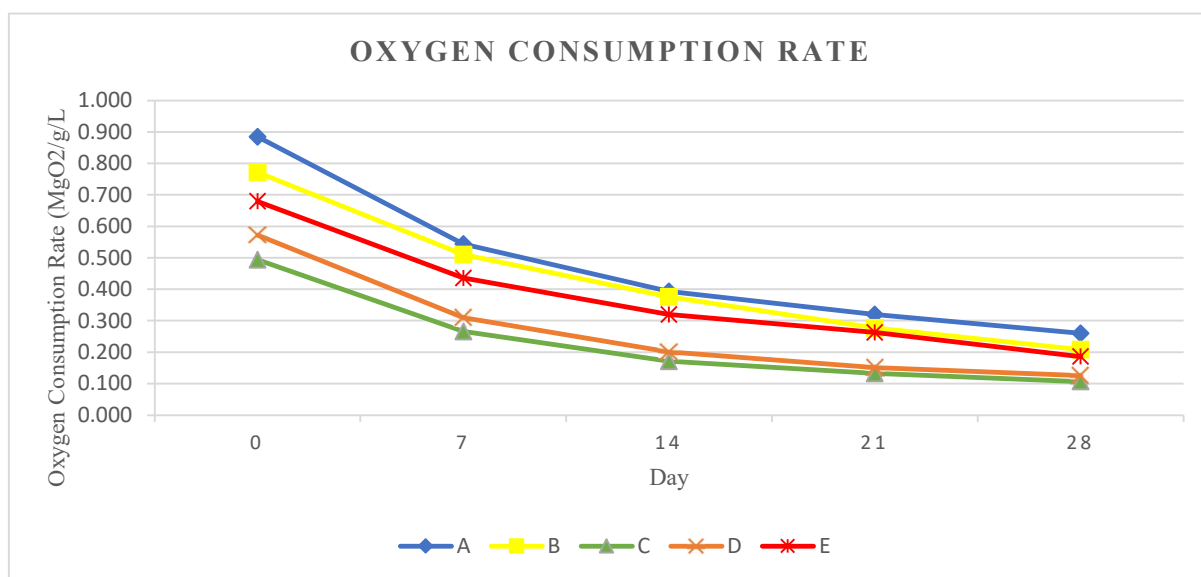


Figure 2. Oxygen Consumption Rate (OCR) Line Graph

The average OCR value for each treatment decreased from observation day 0 to observation day 28. In treatment A, the average OCR value on observation day 0 was 0.885 mgO₂/g/hour, decreasing to an average oxygen consumption of 0.260 mgO₂/g/hour on observation day 28. The average oxygen consumption value on observation day 0 for treatment B was 0.772 mgO₂/g/hour and on observation day 28 it was 0.208 mgO₂/g/hour. Treatment C on day 0 was 0.494 mgO₂/g/hour and on day 28 was 0.107 mgO₂/g/hour, Treatment D on observation day 0 averaged 0.573 mgO₂/g/hour, decreasing on observation day 28 to 0.126 mgO₂/g/hour, and treatment E on observation day 0 was 0.680 mgO₂/g/hour and on observation day 28 was 0.186 mgO₂/g/hour. The graph in Figure 2 shows a downward trend in oxygen consumption rate (OCR) in Barramundi from Day 0 to Day 28 in all treatments. This decline is thought to be related to the fish's adaptation to the rearing environment, where the fish become calmer, thereby reducing their activity and oxygen requirements (Mayda et al., 2023).

At the beginning of the observation (Sampling 1), the highest OCR was recorded in treatment A (0.885 mgO₂/g/hour), while the lowest was in treatment C (0.494 mgO₂/g/hour). This decrease in oxygen consumption was consistent in each subsequent sample. Treatments C and D showed the most significant decrease, while treatments A and B maintained relatively higher LKO values at the end of the study. The high LKO in treatment A may be due to more intense physical activity of the fish, such as swimming and foraging. In addition, an increase in body weight may also be a factor. As weight increases, fish require more energy to move, which increases their oxygen demand. Increased body weight means that the number of cells also increases, which requires more energy, thereby increasing respiration [30]. Summerfelt (2015)[31] also added that young fish tend to have higher OCR due to their more agile movements and optimal organ function and cell regeneration. Oxygen Consumption Rate (OCR) is a physiological parameter that measures fish oxygen consumption at a given time, expressed in mgO₂/g/hour (Khalil et al., 2015)[9]. OCR indirectly reflects the metabolic rate of fish, where metabolism is a description of the energy expenditure of living things during physiological processes (Prakoso et al., 2016). The higher the activity and energy expenditure, the higher the OCR. Several other factors that affect LKO are dissolved oxygen concentration, water volume, measurement duration, and fish weight [32].

The decrease in OCR over time can also be explained by the fish's adaptation to the environment, which reduces the energy requirements for activity and stress response [33]. Factors such as stable water quality, regular feeding, and low stress levels also contribute to a decrease in oxygen demand at the end of the rearing period. In addition, this phenomenon is also related to the size of the fish [34]. In the early stages, when the fish are still small, the metabolic rate is relatively higher per unit of weight, so more oxygen is needed to support growth and movement. However, as the fish grow larger, the specific metabolic rate decreases, which means that the oxygen requirement per unit of fish weight also decreases [35]. This explains why the LKO in Sampling 5 was lower than in Sampling 1 in all treatments; larger fish require relatively less oxygen per gram of body weight than smaller fish.. Different salinities can also affect LKO. When fish are in an environment with salinity that does not match their natural habitat, they must perform osmoregulation to balance the salt levels in their bodies [12]. This process requires a lot of energy, which increases metabolism and, in turn, increases oxygen consumption [9].

Feed Conversion Ratio / FCR

Table 6. Average Feed Conversion Ratio

No	Treatment	Feed Conversion Ratio (%)
1	A	2,09±0,33
2	B	1,69±0,12
3	C	1,66±0,18
4	D	1,60±0,16
5	E	1,92±0,15

Based on Table 6, it is known that the five treatments (A, B, C, D, and E) showed varying feed conversion ratios from the beginning to the end of the study. The highest feed conversion ratio was obtained in treatment A with an average value of (2.09±0.33%), followed by treatment E (1.92±0.15%), treatment B (1.69±0.12%), treatment C (1.66±0.18%), and the lowest was treatment D (1.60±0.16%). Studies show that Barramundi adapted to freshwater have an increased appetite. This is a response to their bodily imbalance, where increased feed consumption helps maintain ideal internal conditions and supports growth. According to Rayes et al. (2013), feed consumption is directly related to the availability of nutrients that are a source of energy for survival and growth. Based on Boyd (2023)[36], a feed conversion ratio (FCR) value between 1.5–2.0 is considered optimal for the growth of most fish. A lower FCR value indicates more efficient feed utilization. For example, to produce 1 kg of Barramundi, only 0.9 kg of feed is needed in freshwater, while in marine, brackish, or high-salinity seawater environments, up to 2 kg of feed is needed. FCR can vary depending on the type, size, activity level of the fish, and environmental parameters.

A high FCR value indicates that fish need more feed to increase their body weight. At a salinity of 33 ppt, which is considered too high for optimal Barramundi growth [6], the FCR becomes high because the fish experience osmotic stress. The energy that should be used for growth is diverted to maintain ion and body fluid balance, thereby reducing feed efficiency [12]. Similarly, at a salinity of 3 ppt, the FCR is also high, although slightly lower than at 33 ppt. This excessively low salinity, which is close to freshwater, also forces the fish to allocate a lot of energy to osmoregulation. Physiologically, the fish must work harder to expel excess water and absorb lost ions, which requires additional energy. As a result, most of the energy from feed is used for homeostasis rather than biomass growth [37]. Suboptimal salinity can also affect appetite, protein metabolism, and digestive enzyme activity, contributing to poor feed conversion.

Although known as euryhaline fish capable of living in various salinity levels, Barramundi have an optimal salinity zone for their growth. At medium salinity ranges, such as 11 ppt (treatment D) to 19–27 ppt (treatments C and B), fish showed the lowest FCR. These conditions are ideal because the osmotic pressure difference between the environment and the fish's body is relatively balanced, reducing the energy required for osmoregulation. This allows more energy from feed to be allocated to anabolic processes such as protein synthesis and muscle tissue formation. Additionally, physiological stability at medium salinity also improves the fish's digestive system. Appetite tends to be better, digestive enzymes function more optimally, and nutrient absorption becomes more efficient. These factors result in higher feed conversion and lower FCR, reflecting good feed efficiency and supporting maximum growth of Barramundi[20].

Water Quality

Table 7. Water Quality

Treatment	Temperature °C		pH	
	Initial	Final	Initial	Final
A	28,2	29,9	7,74	7,47
B	28,1	28,9	7,46	7,41
C	28,3	29,4	7,43	7,37
D	28,3	29,2	7,40	7,25
E	28,2	29,9	7,20	7,02

The temperature at the beginning of the study to the end of the study increased from 28°C to 29°C. This increase in temperature was caused by weather changes during the study period, which was conducted outdoors. According to the Directorate General of Aquaculture (2020), the optimal temperature range for Barramundi is 27.5°C to 32°C. Meanwhile, the suitable pH range for Barramundi is 7.5-8.5. Water temperature is influenced by various factors, one of which is the intensity of sunlight shining on the water. In this study, the maintenance containers for the test fish *were* placed outdoors, which resulted in higher water temperatures, but the temperature range was still within the optimum range for Barramundi maintenance. Temperature changes occurred every day, but were not significant. The natural phenomenon of unpredictable rainfall during the study was one of the factors causing temperature changes (Boyd 2018)[36].

IV. CONCLUSION

Based on the results of this study, it can be concluded that salinity levels of 19-11 have good survival rates, absolute weight growth, absolute length, specific weight growth rate, oxygen consumption rate, and feed conversion ratio for Barramundi fry. Meanwhile, salinity levels of 20-33 have a less favorable effect on Barramundi fry.

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