Modular system pond cultivation model for the survival of milkfish (Chanos chanos): case study of Pangkajene Kepulauan Regency, Indonesia

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Abstract

This study aims to to analyze survival rates in milkfish modular cultivation systems and their correlation with fluctuations in temperature and salt content. The modular system method was used, with three plots: plot A as the nursery plot, plot B as the first rearing plot, and plot C as the enlargement plot 2. The research was conducted over one year with three maintenance cycles, each cycle lasting four months. The organisms were placed in plot A for a period of 1–8 months. Thus, in one year, plot A gets the opportunity to rest for four months while preparing, then in grow-out plot 1 and grow-out plot 2 for two months each, so that each grow-out plot gets the opportunity to rest while preparing for the next maintenance cycle. Results revealed the temperature, salt content, pH, and dissolved oxygen were within the optimal range, with an average value of 29.4^0C., pH of 6.9, and dissolved oxygen of 31 ppm. However, the salt content fluctuated a lot, with values ranging between 5 and 45 ppt with an average value of 26.9 ppm. The average survival rate was 91% with a correlation of R^2 = 0.906 (cycle 1), 95% with a correlation of R^2 = 0.890 (cycle 2), and 97% with a correlation of R^2 = 0.997 (cycle 3). To conclude, the modular cultivation system, apart from increasing survival rates, can also improve the pond soil environment. This system is highly suitable as a promising approach for sustainable fisheries development in the region.

INTRODUCTION

Pangkajene dan Kepulauan (Pangkep) Regency, located in South Sulawesi, Indonesia, is a coastal regency with a coastline that spans 250 km. The islands in the regency have a coastline length of 207.43 km, which accounts for 82.97% of the total coastline, while the mainland coastline measures 42.57 km or 17.03% (BPS, 2020). These features present a significant potential for developing capture fisheries and aquaculture, including pond and offshore aquaculture, making Pangkep Regency an area of interest for researchers and nature scientists looking to study marine biodiversity and ecosystem dynamics.

The Islands have a potential coastline of 207.43 km for capture fisheries, which is distributed in three sub-districts, namely Tupabiring, Liukang Tangngaya, and Kalmas. This region has high potential for developing offshore aquaculture, including seaweed cultivation, fish and shrimp cultivation with the Floating Net Cages (Keramba Jaring Apung, KJA) system, and other sustainable aquaculture practices. The Islands also offer opportunities for pond aquaculture, particularly for milkfish and different varieties of shrimp, as there are suitable areas for pond farming on several islands. These findings have been documented in various scientific studies, including Fauziah (2019), Garcia (1990), and Garg and Bhatnagar (2003).

Six coastal sub-districts in South Sulawesi, Indonesia, namely Mandalle, Segeri, Ma’rang, Labakkang, Bungoro, and Pangkajene, are home to scattered pond farming areas that cover a total of 10,201.00 hectares. Some of the pond farming areas in Pangkep Regency have historical significance as the oldest milkfish ponds in South Sulawesi and the eastern part of Indonesia, making them a significant milkfish producer. This has earned Pangkep the distinction of being the only regency in Indonesia known as the ‘Milkfish City,’ as it is the largest producer of milkfish in South Sulawesi and even eastern Indonesia. The unique flavor of the grilled milkfish found in various Indonesian cities can be attributed to the specific taste of the milkfish produced in this region. These findings were reported by Amsari et al. (2017), in their study on the milkfish industry in South Sulawesi.

As the global population continues to increase, the demand for fish and shrimp also rises, particularly in Indonesia. To meet this demand, there have been efforts to increase production through both land extensification and intensification. However, these efforts have led to new environmental challenges. Extensification has resulted in the conversion of paddy fields and mangroves into ponds, which can have serious impacts on biodiversity and ecosystem services. Intensification, on the other hand, has resulted in the use of chemical fertilizers, agricultural lime, and medicines without proper environmental management, leading to soil complexity and decreased natural food availability in ponds. As a consequence, milkfish production has suffered. To address these issues, there is a need for sustainable aquaculture practices that consider both ecological and economic factors (Barman et al., 2005; Sambu, 2013; Bhatnagar, 2010).

The decline in pond production, particularly of milkfish, has created a pressing need for alternative sources of income for Pangkep's farmers. Many have transitioned to more lucrative professions to support their families. To revitalize Pangkep's reputation as the "Milkfish City," a modular milkfish farming system could be implemented. This system involves moving fish from one plot to another, which can improve survival and growth rates. Additionally, reclamation techniques such as drying, basic soil processing, and the use of livestock manure may help restore the environment, which has become saturated due to current technology. By utilizing these methods, we can create a more sustainable and profitable farming system while also improving the ecosystem's health.

The implementation of a modular model for fish seed stocking can effectively ensure a continuous supply of fish seeds. By purchasing fish seeds in large quantities and stocking them in nursery plots for multiple maintenance cycles, this system can offer fish seeds as needed and promote better survival rates. Stocking fish seeds can facilitate acclimatization and adaptation, which are crucial processes for the success of fish populations. Additionally, this approach can reduce the pressure on wild fish populations, promoting sustainable fisheries management practices (Tsai et al., 1970; Lawson, 1995; Garg & Bhatnagar, 2003; Bhatnagar, 2010). The objectives of this research are: (1) to analyze the fluctuation of water quality parameters during the maintenance cycles, (2) to analyze the survival rate in the modular milkfish farming system and its correlation with temperature and salinity fluctuations.

MATERIALS AND METHODS

Study Setting

This study was conducted over a period of one year, from September 2021 to August 2022, in Manakku Village, which is located in the Labakkang District of the Pangkep Regency in South Sulawesi, Indonesia. Manakku Village was selected as the research site to represent coastal villages in Labakkang District that engage in fish farming practices. The research location is depicted in Fig. 1. The study was designed to adhere to scientific principles and methodologies to ensure the reliability and validity of the findings.

LABAKKANG DISTRICT MAP

Tools and Materials

The research was conducted using a comprehensive set of tools and materials, including precision instruments such as a refractometer, pH meter, soil tester, and thermometer, as well as basic tools such as a pen, pencil, compass, ruler, hoe, crowbar, shovel, small boat, and roller meter. The materials used in the research included paper, questionnaires, and scientific references such as books on village potential, sub-districts, and districts, as well as reports of research results, theses, dissertations, and peer-reviewed research articles. These tools and materials were carefully selected to ensure the accuracy and reliability of the data collected and analyzed.

Data Collection Techniques

In the present study, the data can be classified into two broad categories: primary data and secondary data. Secondary data was obtained from prior research studies, literature reviews, published reports, student research papers, theses, dissertations, and journals at different levels, ranging from local to international. On the other hand, primary data was collected through field observations and experiments conducted using a modular cultivation system.

Research Procedures

Before conducting any research on aquaculture, several factors need to be determined to ensure the accuracy and validity of the results. These factors include (1) the selection of an appropriate research location, (2) the careful selection of a representative research sample, (3) the utilization of an appropriate technology package, (4) the establishment of a suitable stocking period, and (5) the consideration of the construction design of the pond selected for the research or test. It is important to note that the selection of an appropriate research location is crucial for the success of the study. In this study, the Muhammadiyah University of Makassar educational pond was chosen as the research location due to its suitability for the research objectives and the availability of the necessary resources.

Location Determination

Before conducting any research, it is imperative to carefully select the study site, taking into account its representativeness of the larger ecosystem. In this particular study, the research was carried out in Manakku Village, situated in Labakkang District, Pangkep Regency, South Sulawesi Province, Indonesia, which was chosen for its ecological relevance and suitability for the research objectives.

Modular Pond Design

Modular system cultivation is a well-established agricultural technique, where farmers move between different plots with varying maintenance periods. This system has been used in various regions for a long time, but it lacks proper structuring (Bosmo et.al., 2016; A'yun and Takarina, 2017; Baiduri et al., 2019). The modular pond design consists of three plots, with specific areas designated for each stage of the cultivation process. Plot A serves as the nursery plot, with an area of 10% of the total trial plot. It has a maintenance period of 1–8 months. Plot B, with an area of 30%, is used for the second maintenance period of approximately two months. Finally, Plot C is used for the third maintenance period, with an area of 60% of the total trial area and a maintenance duration of approximately two months. The design or construction of research ponds is presented in Fig. 2. This modular system cultivation technique has proven to be effective in optimizing crop yield and reducing the risk of pest infestation and soil degradation.

Technology Package Determination

The research at hand proposes the implementation of a semi-intensive monoculture cultivation system for milkfish. The system involves varying stocking densities for each rearing cycle, as follows: (1) the nursery plot, also known as Plot A, with a stocking density of 90 individuals per cubic meter (90 e cor m-3) or 9,000 individuals per cycle, (2) the second-period maintenance plot, also known as Plot B, with a stocking density of 1 individual per cubic meter (1 m-3), and (3) the third-period maintenance plot, also known as Plot C, with a stocking density of 0.5 individuals per cubic meter (0.5 m-3), resulting in a stocking number of 5,000 individuals per hectare (5,000 Ha^{-1}).

Determination of Stocking Period

The present study was conducted over a period of one year, from September 2021 to August 2022, in order to investigate the efficacy of a modular system for crop cultivation. The experimental setup involved three maintenance cycles or periods, each lasting four months, and comprising the following phases: (1) the initial period from September to December, (2) the intermediate period from January to April, and (3) the final period from May to August. The maintenance schedule for the entire year has been detailed in Table 1, and was designed to minimize any potential confounding factors and ensure the validity of the results obtained.

Table 1 Maintenance schedule for fish farming systems milkfish in a modular manner

Month	Maintenance schedule					
	Cycle 1		Cycle 2		Cycle 3	
October						
November						
December						
January						
February						
March						
April						
May						
June						
July						
August						
September						

Water Quality Data

The data pertaining to water quality parameters, namely temperature, salinity, pH and dissolved oxygen, are measured and analyzed during each maintenance cycle of Plot B and Plot C. The resulting values are then averaged to obtain a representative measure of each parameter. The analysis of these water quality parameters is crucial in understanding the correlation between survival rate and growth rate of aquatic organisms with respect to fluctuations in temperature and salt content. The results of this analysis are presented in a graphical format.

Analysis Model

The analysis models used in the research include (1) viability formula (SR), (2) correlation formula between fluctuations in salt levels and survival rates, and (3) business feasibility analysis formula both per cycle and in total over three cycles.

Survival formula

Survival or survival rate is the percentage of the number of fish alive at the end of the rearing period compared to the number of fish at the beginning of rearing. The survival rate is calculated using the formula (Aris et al., 2021):

$$SR = NtNo \times 100\%$$

Information :

SR = Survival

Nt = Number of fish at the end of the study (tails)

N0 = Number of fish at the start of the study (tails)

Correlation formula

To determine the relationship between survival rate and growth rate with fluctuations in temperature and salt content of cultivated organisms, it can be analyzed using the formula approach introduced by Ali and Sambas (2007) as follows:

$$Y = a + bX1 + bX2 + bX3$$

Y : Survival and Growth Rate

a : Pond area (Considered the same)

x1 : Tide Fluctuations

x2 : Temperature Fluctuations

x3 : Fluctuations in Salt Levels3

Data Analysis

The research methodology employed in this study included both quantitative and qualitative analyses. The quantitative analysis focused on numerical data while the qualitative analysis provided a deeper understanding of the phenomena under investigation. The results of these analyses were then interpreted using a descriptive approach to effectively communicate the findings. This approach allowed for a comprehensive and rigorous evaluation of the research objectives, ensuring scientific soundness in the final outcomes.

RESULTS

General Description

Manakku Village is a coastal settlement located in Labakkang District, Pangkep Regency. It is situated at the confluence of three water bodies, namely the Lompoa River in the north, the Cakarri River in the east, and the Bontoala River in the south. The western boundary of the village is formed by the coastal waters of the Makassar Strait. From a geographical perspective, the village is a unique ecosystem that is home to a diverse range of flora and fauna. The village is surrounded by mangrove forests, which serve as a natural barrier against coastal erosion, and provide a habitat for a variety of aquatic and terrestrial species. The village is also home to several endemic species of birds and reptiles, making it a popular destination for nature enthusiasts and researchers. Administratively, Manakku Village shares its northern border with Gentung Village, its eastern border with Labakkang Village, its southern border with Pundatabaji Village, and its western border with the Makassar Strait.

Ecological Conditions of Ponds

As supporting data in this research, the ecological conditions of the ponds that are described in this study are (1) distance from the beach and elevation, (2) average tides, (3) tide periods, (4) pond construction, and (5) modular system pond design. Manakku Village is located approximately 5 km inland from the beach, and the agricultural land in the village is irrigated by two large rivers - the Lompoa River to the north and the Bontoala River to the south. The elevation of Manakku Village from the sea level is between 0-1.5 meters, which makes it vulnerable to the ingress of salt water into the rice fields that are close to the pond land. The tidal conditions are highly variable, ranging between 0-1.5 meters. The West Coast of South Sulawesi is a region that experiences three tidal periods in a year, namely the afternoon tidal period from September to February, the morning tidal period from March to August, and a transition tidal period in September and March. During these transitional periods, the tide conditions have not yet entered the pond, which is referred to as "Konda sibilant" by the Pangkep people. Aquatic organism cultivation in a pond is heavily reliant on the condition and construction of the pond itself.

Pond Preparation and Design

The success or failure of a pond or pond cultivation depends on how the preparations, including (1) drying (2) improving pond construction, (3) processing the pond bottom soil, (4) liming, (5) pest control and disease, (6) fertilization, and (7) natural food growth in ponds. The preparation of ponds or water bodies serves several objectives, which are explained below: (1) *Drying ponds*: The primary objective of drying ponds is to facilitate maintenance activities such as repairing embankments, processing the bottom soil of the pond, and controlling pests and diseases. Liming is an essential activity during pond drying, as it helps break the cycle of pests and diseases and neutralizes the pH of the pond soil; (2) *Improving pond construction*: The construction of ponds must be done with precision to ensure efficient management of aquatic organisms. This objective is achieved by optimizing the pond's size, shape, and depth, and ensuring adequate water exchange and circulation; (3) *Processing the bottom soil of ponds*: The structure and texture of the soil at the bottom of the pond must be improved to promote the growth of aquatic organisms. Processing the bottom soil also helps break the cycle of pests and diseases, removes toxic substances such as NH3 and H2S, and neutralizes the pH of the soil; (4) *Liming*: The purposeful application of lime to the soil helps increase its pH, which is essential for the growth of aquatic organisms; (5) *Control of pests and diseases*: The control of pests and diseases is critical to improving the survival and growth rate of aquatic organisms. This objective is achieved by implementing appropriate measures such as the use of natural predators, biological control agents, and chemical pesticides; (6) *Targeted fertilization*: Fertilization is essential to provide the necessary nutrients for the soil to function optimally. This objective is achieved by adding organic and inorganic fertilizers to the pond water, which promotes the growth of phytoplankton and zooplankton; (7) *Growing natural food*: The sustainable availability of natural food is critical to the growth and survival of aquatic organisms. This objective is achieved by promoting the growth of natural food sources such as algae, aquatic plants, and zooplankton in the pond water.

Water Quality

The parameters of water quality, being the primary cultivation medium for aquatic organisms, play a crucial role in supporting their survival and growth rate. Therefore, it is imperative to ensure that the water quality meets the necessary requirements for the cultivation process. To that end, monitoring and measuring the average water quality during cultivation activities is crucial. The resulting data can be presented in a tabulated format, such as Table 2, to provide a comprehensive understanding of the water quality parameters that affect the cultivated organisms.

Table 2
Average water quality parameters for one year in three maintenance cycles

Month	Water Quality Parameter			
	Temperature	Salt Content	pH	Oxygen
October	32	45	6.5	26
November	31	43	6.9	28
December	28	15	7.0	29
January	27	5	7,5	30
February	27	16	7,5	35
March	28	20	7,5	35
April	29	23	7,4	37
May	29	25	7,3	36
June	29	26	7,1	35
July	30	30	7,0	33
August	31	35	6,7	27
September	32	40	6,5	26
Average	**29.4**	**26.9**	**6.9**	**31**

The water quality parameters were measured during a single cultivation cycle with three maintenance cycles in two rearing plots. The fluctuations observed during the year will be presented in Fig. 3. The tidal fluctuations significantly impact several water quality parameters such as oxygen, temperature, and salinity. The salinity parameter is particularly affected due to the temperature fluctuations.

Survival Rate

In recent times, there have been concerns raised by the pond farming community in Pangkep and the city of Bandung regarding the low survival rate of fish and shrimp farming. However, with the implementation of a modular cultivation system, there has been a marked improvement in the sustainability of fish cultivation. Trials of cultivating milkfish using this system have produced highly encouraging results, with the average survival rate exceeding 90%, as presented in Table 3. These findings indicate the efficacy of modular cultivation systems in enhancing the survival rates of fish and shrimp, and underscore the need for further research in this area. During the third cycle, the survival rate peaked at 97% during the maintenance period from June to September

Table 3
Average survival rate of milkfish over three maintenance cycles

Sampling	Maintenance Cycle		
	Cycle 1	Cycle 2	Cycle 3
1	92	96	98
2	90	94	96
Average	**91**	**95**	**97**

Correlation of Survival Rates

The findings from the analysis of the survival rate of milkfish cultivation using a modular cultivation system, as presented in Table 3, indicate that the adaptive capacity of milkfish increases with the duration of their stay in the nursery plots. The survival rate showed a sequential increase from cycle to cycle, with 91% in the first cycle, 95% in the second, and 97% in the third. Moreover, the relationship between fluctuations in temperature and salt content and the survival rates is explained in Fig. 4, highlighting the importance of these factors in the cultivation of milkfish using a modular system.

First cycle

Figure 5a presented above elucidates the correlation between temperature and the survival rate of milkfish during the first cycle. The equation Y = 1.8x + 34 with a correlation coefficient of R^2 = 0.952 suggests that 95% of the variation in survival rate can be explained by temperature. In Fig. 5b, the correlation between salinity and the survival rate of milkfish in the first cycle is presented. The equation Y = 14.8x + 64, with a correlation value of R^2 = 0.906, indicates that salinity has a significant influence on the survival rate of milkfish, with 90% of the variation in survival rate being attributed to salinity.

Second cycle

The graph presented in Fig. 5a elucidates the correlation between temperature and the survival rate of milkfish during the second cycle. The correlation equation obtained was Y = 0.7x + 26.5, with a correlation coefficient (R^2) of 0.978, indicating that 97% of the variation in the survival rate can be attributed to temperature. In the context of milkfish culture, salinity and temperature are two critical abiotic factors that significantly impact the survival rate of milkfish. Figure 4d illustrates the correlation between salinity and the survival rate of milkfish in the second cycle, where the equation Y = 3x + 13.5 represents the relationship between salinity and survival rate, with a correlation value of R2 = 0.890.

Third cycle

In Fig. 6a, the correlation between temperature and the survival rate of milkfish in the third cycle is elucidated as Y = In. The following information pertains to the correlation between salinity and the survival rate of milkfish in the second cycle. According to Fig. 6b, the correlation can be expressed as Y = 4.7x + 21, with a correlation value of R2 = 0.997.

DISCUSSION

Based on the study conducted by the BPD in 2021, it was found that the Manakku Village has a pond area of 453.00 hectares, which constitutes 17.32% of the total pond area in the Labakkang District and 4.44% of the Pangkep Regency's overall area. The farmers in Manakku Village predominantly use three types of cultivation systems: (1) fish monoculture, (2) shrimp monoculture, and (3) fish and shrimp polyculture. For the purpose of this research, the milkfish monoculture cultivation system will be employed. Furthermore, three levels of technology packages have been implemented in the village, namely (1) traditional plus cultivation system, which covers approximately 75% of the farms, (2) semi-intensive cultivation system, which covers around 20%, and (3) intensive cultivation system, which covers only about 5% of the farms. It's worth noting that the intensive cultivation system's application in the village is relatively short-lived.

Intensive cultivation systems, which rely heavily on agricultural technologies, can often lead to short-term gains but are not sustainable in the long run. These systems often force nature to produce beyond its carrying capacity, leading to environmental degradation and depletion. Such practices can result in barren and rugged lands that take a long time to recover. To ensure sustainable agriculture, it is essential to adopt ecologically and climate-based practices that work in harmony with nature. The location of the pond land in Manakku Village is promising, as it is surrounded by water sources, including the coastal waters of the Makassar Strait and three rivers, namely the Lompoa River to the North, the Cakarri River to the East, and the Bontoala River to the South. However, recent field interviews have revealed that it is challenging to find mustard greens or pond workers in the area. This is likely because the pond products are not profitable enough to meet household living needs, and many are seeking alternative jobs that offer better economic opportunities. Therefore, it is crucial to develop sustainable agricultural practices that are economically viable and promote environmental conservation (BPD, 2021).

One of the challenges faced by pond farmers is the low survival rate of milkfish, which can sometimes be as low as 50%. Previous research studies (Budiasti et al., 2015; Barman et al., 2012) have reported slow growth rates and suspected that in addition to seed quality, pond quality may be a contributing factor, particularly in cases where ponds have reached saturation levels (Aris et al., 2021). To address this issue, farmers have explored the use of modular cultivation systems or relocation, as aquatic organisms tend to thrive in new environments. These findings highlight the importance of considering both seed quality and pond management strategies to improve milkfish survival and growth rates in pond farming (Lin, 1985; Lawson, 1995; Lekang, 2007; Barman et al., 2012).

The elevation of Manakku Village from the sea level is between 0-1.5 meters. As a result, the rice fields that are susceptible to saltwater intrusion may be converted into pond land, which can have significant impacts on the ecology of the area. Moreover, the tidal conditions are highly variable, ranging between 0-1.5 meters. However, scientific research has shown that the average tide height is between 0.8–1.2 meters. During certain months, such as December and May, high tides reaching 1.5 meters occur only during a full moon. This phenomenon has led to the opening of new fishponds, which are vulnerable to intrusion by foreign water during high tides. This inconsistency in saltwater seepage poses a significant challenge for rice field maintenance. Consequently, many rice fields are being converted into fish ponds. However, this conversion is also not without its challenges, as regular saltwater intrusion is necessary for the fish ponds to function effectively. As a solution, many new ponds are being constructed with drilled wells to ensure regular saltwater seepage, thereby allowing for the effective conversion of rice fields into fish ponds.

The Manakku Village has annual ups and downs in tidal patterns require farmers to adapt their fish and shrimp stocking schedules to reduce mortality rates. The fluctuations in salt levels during these tidal transitions are closely related to the osmoregulation process of fish and shrimp. High salt levels are necessary during their young age, while low salt levels are required in old age. Therefore, the farmers must monitor the salt levels closely and adjust their farming practices accordingly to ensure optimal growth and survival rates (Lekang, 2007).

Aquatic organism cultivation in a pond is heavily reliant on the condition and construction of the pond itself. According to studies conducted by Lin (1985), Lawson (1995), and Lekang (2007), a pond unit comprises of bunds, channels, and doors. The dike, which functions as a water-holding structure, must be solid and free from leaks. The channel connecting the water source and the pond must be of an appropriate width to match the outside perimeter of the pond and be free from grass, rubbish, and sediment to withstand currents. Moreover, the pond unit must include systems to regulate the volume of water in the pond. These factors are critical to the success or failure of aquatic organism cultivation and must be considered when constructing and maintaining a pond (Tsai et al., 1970; Lawson, 1995; Garg & Bhatnagar, 2003; Bhatnagar, 2010)

The construction of a pond involves various interconnected systems, including the pond bottom, the bottom of the door, and the channels (Buschman et al., 2004; Rangka & Asaad, 2010). In order to achieve the desired cultivation goals, it is essential that the pond bottom is higher than the bottom of the gate, the bottom of the gate is higher than the bottom of the channel, and the bottom of the channel is higher than the lowest tide in coastal waters. This ensures that water management can be achieved through gravity, without the need for a pumping system. Proper design of the pond and its components is crucial for the maintenance of a healthy aquatic ecosystem and the sustainability of the cultivation practices (Tsai et al., 1970; Lawson, 1995; Garg & Bhatnagar, 2003; Bhatnagar, 2010)

According to the findings of our observations, it has been noted that the construction of ponds in Manakku Village often fails to comply with the recommended technical guidelines for constructing ponds. The following observations can be made in a sequential order: (1) The pond bottoms are often shallow, which limits their capacity to accommodate large volumes of water. This can potentially lead to water scarcity and affect the aquatic ecosystem within the pond; (2) The bunds, or embankments, are often found to be low and prone to leaks and seepage. As a result, maintaining the desired water level in the pond becomes a challenge, which can have a significant impact on the aquatic habitat's health and diversity; (3) The main and hatch doors of the ponds are generally narrow, which can limit their ability to regulate the water volume effectively. This can result in the accumulation of water in some areas and water scarcity in others, which can lead to imbalances in the aquatic ecosystem; (4) The narrow channels leading to the ponds often contain grass, rubbish, and sediment, which can impede the flow of water in and out of the pond unit. This can lead to water stagnation, which can adversely affect the health and diversity of aquatic life within the pond. It is essential to adhere to the recommended technical guidelines for pond construction to ensure the proper functioning of aquatic ecosystems within the pond.

The seven pond preparation steps must be carried out thoroughly because they are interrelated to achieve the goal of cultivating aquatic organisms (Lawson et al., 1995; Garg and Bhatnagar 2003; Bhatnagar,2010; Lekang,2007). Previous research has shown that the low survival rate and slow growth rate of milkfish in ponds is a major challenge faced by pond farmers (Bhatnagar, 2003; Bhatnagar, 2010; Lekang, 2007). According to Bhatnagar (2003), poor quality seeds and the condition of ponds that have already reached saturation are among the factors causing low fish survival and slow growth rates. To overcome the issue of saturated pond soil, proper preparation and provision of nutrition to ponds are required, such as the provision of manure. However, in general, pond farmers do not consider pond preparation to be very essential. Therefore, it is necessary to raise awareness among farmers about the importance of pond preparation and the provision of proper nutrition to improve the survival rate and growth rate of milkfish (Tsai et al.,1970; Lawson, 1995; Garg & Bhatnagar, 2003; Liao et al., 2004; Bhatnagar,2010).

The issue of pond land saturation can be addressed through the use of a modular cultivation system, which involves the movement of the cultivation system from one plot to another within a single maintenance cycle (Jamerlan et al., 2014; Hanke et al., 2020). This system allows for the occupation of multiple plots by the cultivated organisms during one rearing cycle. In the present study, milkfish will be used as the cultivated organisms and will occupy three plots. Plot A will serve as the nursery plot and will function as a seed reservoir for a year, providing acclimatization and seed production capabilities. Plot B will serve as the first stage of the enlargement plot, with a maintenance period of approximately two months. Lastly, plot C will serve as the second stage of the enlargement plot, with a maintenance period of approximately two months.

The present study was conducted over a period of one year, and involved three stages or maintenance cycles. Each maintenance cycle lasted for a duration of four months, during which two rearing plots were utilized for the cultivation of organisms. The two grow-out plots, namely plot B and plot C, were provided with the same opportunity of two months each for the pond preparation period as previously described - from drying to growing natural food. The modular cultivation system employed in this study offers a potential solution to improve the survival and growth rate of milkfish (Santander et al., 2015; Saraswaty et al., 2017; Rinaldi et al., 2019). The construction of modular cultivation system ponds.

The results indicate that the overall average of the measured parameters is still within the optimal range for plant growth. However, the salt content in the water during August, September, October, and November was found to be above the optimal range for milkfish cultivation. Despite this, the milkfish were able to survive during these months, but could only be harvested during the third cycle in August and September. In contrast, during the start of the first cycle in October and November, and as we enter December and January, the growth of milkfish accelerates faster. According to experts in the field (Villalus & Ungguni, 1983; Swan, 1997; Burt et al., 2011; Banman et al., 2012; Cheng et al., 2018; Aris et al., 2021), all aquatic organisms require salt levels for their maturity, including milkfish. It is essential to note that fluctuations in the salt levels of the water during the year can have a significant impact on aquatic life.

The present study revealed that tidal fluctuations significantly impact several water quality parameters such as oxygen, temperature, and salinity. The salinity parameter is particularly affected due to the temperature fluctuations. The research conducted by Kale (2016), Amsari et al. (2017), Guanzon et al. (2004), Muanif et al. (2019), Astuti & Warsa (2020) indicates that there is a direct linear correlation between temperature and salinity. An increase in water temperature by 1–2 degrees Celsius leads to an increase in salinity by 1–2 ppt. These findings have been supported by various other researchers as well (Jania, 2006; Portner, 2009; Aris et al., 2021).

The present study's finding suggest that a longer nursery period, which involves stunting or restraining the growth rate of the fish seeds, can lead to higher survival rates. This is consistent with prior research in the field and highlights the importance of carefully managing the growth and development of milkfish in aquaculture settings (Tsai et al., 1970; Malle et al., 2019; Fauziah, 2019; Amsari et al., 2019; Borlongan et al., 2003; Mwangamilo & Jiddaw, 2003; Pramata. Et al., 2017; Ofori et al., 2018).

The first cycle recorded a low survival rate of 91%, which can be attributed to the high temperature of 32°C. Previous studies have shown that aquatic organisms, including milkfish, have a range of optimal temperatures that support their survival rate (Ismail et al., 1993; Santander et al., 2015; Ramadhani et al., 2021; Adul et al., 2022). The literature suggests that the high survival rate for milkfish (Chanos chanos) is within the range of 27–31°C, which is consistent with the results obtained by several researchers (Tsai et al., 1970; Lawson, 1995; Garg & Bhatnagar, 2003; Liao et.al, 2004; Bhatnagar, 2010).

The results suggest that salinity has a slightly lower impact on survival rates compared to temperature, owing to the relative stability of salinity as compared to temperature fluctuations. It is noteworthy that a survival rate of 91% was achieved at a salinity of 42 ppt, which can be attributed to the euryhaline nature of milkfish, as it is capable of surviving in a range of salinities from 0–50 ppt (Mmochi & Mwandya, 2003; Chang et al., 2019; Beeltram et al., 2020; Barman et al., 2021), although milkfish require an optimal salinity range of 10–25 ppt (Adul et al., 2022).

During the second cycle, the survival rate of milkfish showed a significant improvement, reaching 95%. However, this rate is still lower than that observed during the third cycle, which was 97%. The increase in the survival rate during the second cycle can be attributed to a decrease of 1 degree Celsius in the highest temperature, which fell within the tolerable range of 27–31°C for milkfish survival, as reported in previous studies (Adul et al., 2022; Ismail et al., 1993). Similar findings were reported by Salam and Darmawati (2017), thereby providing additional support to the notion that milkfish survival is optimal within this temperature range (Kumagai, 1990; Jaikumar et al., 2013).

Approximately 89% of the variation in survival rate can be explained by the variation in salinity. However, it is essential to note that the impact of salinity on survival rate is relatively lower compared to temperature. This is primarily because temperature fluctuates more significantly than salinity. The survival rate of milkfish is significantly affected by temperature, especially during sudden temperature changes. On the other hand, salinity is relatively stable and less variable than temperature. Based on the data presented in the figure, it can be observed that a survival rate of 95% is achieved at a salinity range of 42–45 ppt. This is possible because milkfish is one of the euryhaline aquatic organisms that can tolerate a wide range of salinity, from 0 to 50 ppt. However, it is important to note that milkfish prefers an optimal salinity range of 10–25 ppt. In summary, the correlation between salinity and survival rate of milkfish is significant, but its impact is relatively lower than temperature. The optimal salinity range for milkfish culture is between 10–25 ppt, although the species can tolerate a wider range of salinity (Tsai et al., 1970; Lawson, 1995; Garg & Bhatnagar, 2003; Liao et al., 2004; Bhatnagar, 2010).

The third cycle exhibited a noteworthy increase in the survival rate of milkfish, which escalated to 97%. This improvement was attributed to the fact that the highest temperature in the third cycle was lowered by 1 degree to 31oC, which falls within the range of temperature that milkfish can endure, as evidenced by previous research (Tsai et al., 1970; Lawson, 1995; Garg & Bhatnagar, 2003; Liao et al., 2004; Bhatnagar, 2010). The aforementioned research highlights the high survival rates of milkfish (*Chanos chanos*) within the range of 27-31oC degrees Celsius. Similar results were also obtained in the research findings of Salam and Darmawati (2017).

Approximately 99% of the variation in survival rate can be attributed to variation in salinity. It is important to note that the influence of salinity on survival rates is lower than that of temperature, as temperature is more prone to fluctuation while salinity remains relatively stable. Nonetheless, based on the data presented in the above figure, it can be seen that a survival rate of 95% is achieved at a salinity of 42–45 ppt. This is possible because milkfish are euryhaline, meaning they are capable of living in a wide range of salinity levels, from 0–50 ppt (Borlongan, 1992; Borlongan & Caloso, 1993; Borlongan & Caloso, 1994; Barman et al., 2021). However, it is worth noting that milkfish require an optimal salinity range of 10–25 ppt for optimal survival and growth (Requintiana et al., .2006; Wu Lie, 2012; Davidson et al., 2014; Adul et al., 2022).

CONCLUSION

Based on the results of the data analysis of the modular system of cultivating milkfish in Manakku Village for one year with three maintenance cycles, this study draws the following conclusions: (1) fluctuations were observed in water quality parameters, including temperature, salinity, pH, and dissolved oxygen. While temperature, pH, and dissolved oxygen remained within the optimal range for milkfish cultivation, fluctuations in salinity were observed outside this range, indicating suboptimal conditions for milkfish growth and survival. (2) The average survival rate of milkfish was found to be 91% with a correlation of R^2 = 0.906 (cycle 1), 95% with a correlation of R^2 = 0.890 (cycle 2) and 97% with a correlation of R^2 = 0.997 (cycle 3). These findings suggest that the modular system of cultivating milkfish in Manakku Village can be improved by optimizing salinity levels in the water.

Based on the results of scientific research on milkfish cultivation, the modular cultivation system not only enhances pond production but also has the potential to promote a healthy pond soil environment. Traditionally, complete pond preparation has not been carried out, which involves drying and processing the pond bottom soil and cultivating natural food. However, the modular system is designed to promote sustainable agricultural development, emphasizing ecological sustainability through a comprehensive approach to preparing and processing the pond bottom soil. Such a method allows the land to recover from saturation, which in turn helps improve the overall feasibility of milkfish cultivation. Nonetheless, further research is still required to assess the growth rate and analyze the farmer income related to this method.

Declarations

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

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Author Contribution

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by A.H.S, B.B, A.M., and T.T. The first draft of the manuscript was written by

A.H.S. and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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References

1. Ali and Sambas (2007) Correlation, Regression and Line Analysis in Research. Pustaka Setia, Bandung
2. Amsari, AD (2017) Prospects for Business Development of Tiger Prawn Polyculture Farms (*Panaeus Monodon*) And Milkfish (*Chanos Chanos*) On Mangkudulis Island, Sesayap Hilir District, Tana Tidung Regency, North Kalimantan. Dissertation, Hasanuddin University
3. Aris M, Syazili A, Buton A (2021) Growth and Survival of nener Bandeng (*Chanos chanos*) with different stocking densities.Journal Ilmu Kelautan Kepulauan 4(1):332-349
4. Astuti LP, Warsa A (2020) Survival rate and growth rate of milkfish (*Chanos chanos*, Forsskal1775) seeds in the acclimatization process at Ir. H. DjuandaReservoir. IOP Conf. Ser.: EarthEnviron. Sci., 535: 012046. https://doi.org/10.1088/ 17551315/535/ 1/012046
5. A'yun Q, Takarina ND (2017) Ambient temperature effects on growth of milkfish (*Chanos chanos*)at aquaculture scale in Blanakan, West Java. Presented at the INTERNATIONAL SYMPOSIUM ON CURRENT PROGRESS IN MATHEMATICS AND SCIENCES 2016 (ISCPMS 2016): Proceedings of the 2nd International Symposium on Current Progress in Mathematics and Sciences 2016, Depok, Jawa Barat, Indonesia, p. 030117.http://dx.doi.org/10.1063/1.4991221
6. Baiduri NR, Alitrah BS, Tumangger, Fitriani, Al Fajar B (2018) Level Mortalitas Chanos chanos on Feeding Artemia the Addititon of Vitamin C. J. Jeumpa, 5(1): 28–33
7. Barman UK, Jana SN, Garg SK, Bhatnagar A, Arasu ART (2005) Effect of inland water salinity on growth feed conversion efficiency and intestinal enzyme activity in growing grey mullet, Mugil cephalus (Lin.): Field and laboratory studies. Aquaculture International. 13(3):241-256
8. Bhatnagar A, Singh G (2010) Culture fisheries in village ponds: a multilocation study in Haryana, India. Agriculture and Biology Journal of North America. 1(5):961-968
9. Barman UK, Garg SK, Bahtnagar A (2012) Effect of Different Salinity and Raton Levels on Growth Performance and Nurtive Physiology of Milkfish Chanos chanos (Forsskal)- Field and Laboratory Studies. Fisheries and Aquaculture Journal. Research Article. 53(1):7
10. Beltran Jr. A, Lontoc Z, Conde B, Juan SR, Dizon JR. 2020.World Congress on Engineering and Technology; Innovation and its Sustainability 2018. EAI/Springer Innovations in Communication and Computing.DOI: 10.1007/978-3-030-20904-9_10E-ISSN P-ISSN 2656-7687.

11. BPS.2020. Central Bureau of Statistics for Pangkajene and Islands Regency, South Sulawesi, Indonesia.
12. BPD.2021. Book on the Potential of Manakku Village, Labakkang District, Pangkajene and Islands Regency, Indonesia
13. BPD.2021 Book on the Potential of Manakku Village, Labakkang District, Pangkep Regency, South Sulawesi
14. BPS.2019 Central Bureau of Statistics for Pangkajene Regency and South Sulawesi Islands, Indonesia
15. Budiasti RR, Anggoro S, Djuwito (2015) Osmotic workload and growth characteristics of milkfish (*Chanos Chanos Forskal*) which is cultivated in traditional ponds in Morosari Village and Tambakbulusan Village, Demak Regency, Diponegoro. Journal of Maquares 4(1): 169-176
16. Buschmann AH., Varella D, Hernandez-Gonzales MC, Correa JA (2004) Experimental indoor cultivation of the carrageenophytic red alga Gigartina skottsbergii. Aquaculture 241(2004):357-370
17. Bosma TH, Nguyen AJ, Siahainenia HTP, Tran HN (2016) Shrimp-based livelihoods in mangrove silvo-aquaculture farming systems. Rev Aquac 8(2016): 43– 60
18. Borlongan IG (1992) The essential fatty acid requirement of milkfish (Chanos et al.).Fish Physiol. Biochem. 9: 401-407. https://doi.org/10.1007/BF02274221
19. Borlongan IG, Coloso RM (1993) Requirements of juvenile milkfish (Chanos et al.)for essential amino acids. The Journal of Nutrition 123: 125-132.
20. Borlongan IG, Coloso RM (1994) Leaf meals are protein sources in diets for milkfish Chanoschanos (Forsskal). In: de Silva SS (ed). Fish nutrition research in Asia: Proceedings of the fifth Asian fish nutrition workshop, Udorn Thani, Thailand. Asian Fisheries Society, Special Publication,9:63-67
21. Boyd CE (1979) Water Quality in Warm Water Fish Pond. Auburn University, Alabama
22. Boyd CE (1982) Water quality management for pond fish culture. Elvesier Science Publishers Company Inc, New York
23. Borlongan IG, Eusebio PS, Welsh T (2003) The potential of feed pea (*Pisum sativum*) meal as
24. A protein source in practical diets for milkfish(Chanos et al.). Aquaculture 225: 89–98.
25. Burt JM, Hinch SG, Patterson DA (2011) The importance of parentage in assessing temperature effects on fish early life history: a review of the experimental literature. Rev Fish Biol Fisheries, 21:377–406. DOI: 10.1007/s11160-010-9179-1
26. Chang C, Huang J, Yeh C, Tang C, Hwang L, Lee T (2018) Salinity Effects on Strategies of Glycogen Utilization in Livers of Euryhaline Milkfish (Chanos chanos)under Hypothermal Stress. Frontiers in Physiology, 9(81). DOI: 10.3389/fphys.2018.00081
27. Chang B, Chao W, Yeh S, Kuo D, Yang C. (2019). Biodegradation of Sulfamethoxazole in Milkfish(Chanos chanos) Pond Sediments. Appl. Sci., DOI:10.3390/app9194000
28. Chiang F, Sun C, Yu J (2004) Technical efficiency analysis of milkfish(Chanos chanos) production in Taiwan—an application of the stochastic frontier production function. Aquaculture 230: 99– 116.

DOI:10.1016/j.aquaculture.2003.09.038

29. Davidson J, Good C, Welsh C, Summerfelt ST (2014) Aquacultural Engineering Comparing the effects of high vs. Low nitrate on juvenile rainbow trout's health, performance, and welfare, Oncorhynchus mykiss within water recirculating aquaculture systems Aquaculture Engineering 59:10
30. Fauziah N (2019) Analysis of Factors That Influence the Income of Polyculture Pond Farmers in Bonto Langkasa Village, Minasatene District, Pangkep Regency.Undergraduate Thesis, Hasanuddin University
31. Garcia L (1990) Fishery Biology of Milkfish (Chanos chanos Forskal). Proceedings of the Regional Workshop on Milkfish Culture Development in the South Pacific
32. Garg SK, Jana SN, Bhatnagar A (2003) Effect of inland groundwater salinity on digestibility and other aspects of nutrition physiology in Mugil cephalus and Chanos chanos (Forsskal), In Fish production using brackish water in the arid ecosystem (eds. Garg, S.K. and Arasu, A.R.T.), Ankush Printers, Hisar
33. Guanzon Jr. NG, de Castro-Mallare TR, Lorque FM (2004) Polyculture of milkfish (Chanos chanos(Forsskal) and the red seaweed Gracilariopsis bailinae (Zhang et Xia) in brackish water earthenponds. Aquac Res 35: 423-431. https://doi.org/10.1111/j.1365-2109.2004.01001.x
34. Hanke I, Hassenrück C, Ampe B, Kunzmann A, Gärdes A, Aerts J (2020) Chronic stress under commercial aquaculture conditions: Scale cortisol to identify and quantify potential stressors in milkfish (Chanos chanos) mariculture. Aquaculture 526: 735352. https://doi.org/10.1016/j.aquaculture.2020.735352
35. Jamerlan GS, Coloso RM, Golez NV (2014) Intensive milkfish Chanos chanos in polyculture culture with white shrimp Penaeus indicus or mud crab Scylla serrata in brackish water earthen ponds. Tigbauan, Iloilo, The Philippines: Aquaculture Department, Southeast Asian Fisheries Development Center. Series Aquaculture extension manual, No 57.
36. Jaikumar M, Suresh Kumar C, Robin RS, Karthikeyan P, Nagarjuna A (2013) Milkfish culture: Alternative revenue for Mandapam fisherfolk, Palk Bay, Southeast coast of India. International Journal of Fisheries and Aquatic Sciences 3: 31-43
37. Jaspe CJ, Caipang CMA (2011) Nursery production of hatchery-reared milkfish, Chanos chanos, in earthen ponds. AACL Bioflux 4:627-634
38. Jana SN, Garg SK, Patra BC (2006) Effect of inland water salinity on growth performance and nutritional physiology ingrowing milkfish, Chanos chanos (Forsskal): field and laboratory studies. J. Appl. Ichthyol 22: 25–34
39. Kale VS (2016) Consequence of temperature, Ph, turbidity, and dissolved oxygen water quality parameters. Int J Adv Res Sci EngTechnol 3:186–190
40. Kumagai S (1990) Reproduction and early life history of milkfish *Chanos chanos* in the waters around Panay Island, Philippines. Dissertation, Kyushu University
41. Lawson TB (1995) Fundamentals of Aqua Cultural Engineering. Chapman and Hall, New York
42. Lekang O (2007) Aquaculture Engineering. Blackwell Publishing Ltd, Singapore

43. Lin HS (1985) Some aspects of milkfish ecology. ChineseAmerican Joint Commission for Rural Reconstruction Fish. Ser 7:68-90
44. Liao IC, Huang TS, Tsai WS, Hsueh CM, Chang SL, Leaño EM (2004) Cobia Culture in Taiwan: Current Status and Problems. Aquaculture 237:155-165
45. Malle S, Tawali AB, Tahir MM, Bilang M (2019) Nutrient composition of milkfish (Chanos chanos, Forskal) from Pangkep, South Sulawesi, Indonesia.Mal J Nutr 25(1): 15162. DOI: 10.31246/mjn-2018-0105
46. Mmochi AJ, Mwandya AW (2003) Water quality in the integrated mariculture ponds systems (IMS) at Makoba Bay, Zanzibar, Tanzania. Western Indian Ocean Journal of Marine Science 2: 15-23
47. Muarif Y, Wahyudin, Merdekawati D (2019) Water quality at silvoaquaculture pond in Indramayu regency. IOP Conf. Ser. Earth Environ. Sci. 383(2019):, 012033
48. Mwangamilo JJ, Jiddawi NS (2003) Nutritional Studies and Development of a Practical Feed for Milkfish (Chanos chanos) Culture in Zanzibar, Tanzania. Western Indian Ocean. J.Mar.Sci 2(2): 137–146
49. Ofori-Mensah S, Nunoo FKE, Atsu DK (2018) Effects of stocking density on growth and survival of young Gulf killifish in recirculating aquaculture systems. Journal of Applied Aquaculture 30(4): 297-311
50. Pramata A,Raharjo EI, Farida (2017) The effect of stocking density on the growth rate and survival of gourami fish larvae(*Osphronemus gouramy*). Jurnal Ruaya 5(1): 01-06
51. Prasetio E, Raharjo EI, Ispandi (2016) The effect of stocking density on the growth and survival of Jelawat fish seeds (*Leptobarbus hoeveni*).Jurnal Ruaya, 4(1): 54- 59
52. Pörtner HO (2009) Oxygen- and capacity-limitation of thermal tolerance: a matrix for integrating climate-related stressor effects in marine ecosystems. J.Exp. Biol. 213: 881–893
53. Ramadhani A, Yulianti I, Fianti (2021) Water Quality in Bandeng (*Chanos chanos*) Fish Ponunds in Lamdingin Village Banda Aceh. Journal Phys. Comm. 5 (2) 2021 : 67 – 70
54. Rangka NA, Asaad AIJ (2010) Milkfish Cultivation Technology in South Sulawesi. In: Aquaculture technology innovation forum proceedings. Brackish Water Aquaculture Research Institute, Maros, South Sulawesi, pp. 187-203
55. Requintiana ED, Mmochi AJ, Msuya FE (2006) A Guide to Milkfish Culture in Tanzania Sustainable Coastal Communities and Ecosystem Program. Western Indian Ocean Marine Science Association, Hawaii.
56. Rinaldi AC, Adhawati SS, Mallawa A (2019) Feasibility of Pole-and-Line Fishery: Comparison of Milkfish (Chanoschanos, Forskal) and Anchovy (Stolephorussp.) as LiveBait. IJEAB 4(5): 1567-1572
57. Santander-de Leon SMS, Reichardt W, Peralta-Milan S, Diego-McGlone MLS, Nuñal SN Wei H, Yoshikawa T, Okunishi S, Maeda H (2015) Bacterial community composition of sediments from milkfish Chanos chanos Forsskal farm. Aquaculture Research 1–13.

58. Saraswati SA, Sari AHW (2017) Water quality assessment and pond suitability assessment in efforts to develop milkfish cultivation (*Chanos Chanos Forskal*) in Pemuteran Village, Gerokgak District, Buleleng Regency. Samakia: Jurnal Ilmu Perikanan 8(2): 01-05
59. Sambu AH (2013). Optimizing the management of wanamina ponds (silvofishery) in the coastal area of Sinjai Regency. Dissertation, Institut Pertanian Bogor.
60. Swann LD (1997) A Fish Farmer's Guide to Understanding Water Quality, Aquaculture Extension Illinois, Purdue University, Indiana Sea Grant Program Fact Sheet, AS-503.
61. Tsai SC, Lin HS, and Lin KY (1970) Some factors regarding the mortality of milkfish during the overwintering period. Aquaculture 1:9-30
62. Villaluz AC, Unggui A (1983) Effects of temperature on behavior, growth, development, and survival of young milkfish, *Chanos chanos (Forsskal).* Aquaculture 35:321-330
63. Vlaar JCJ, Valk-Brouwer WG (1987) Aspects of Aquaculture Engineering. Agricultural University Wageningen. Wageningen.
64. Wu Lie (2012) Plankton Diversity in Milkfish Pond Waters at Tapak Tugurejo, Semarang. Shengming Kexue 1(1).

Figures

Figure 1

Map of Labbakang District, Pangkep Regency

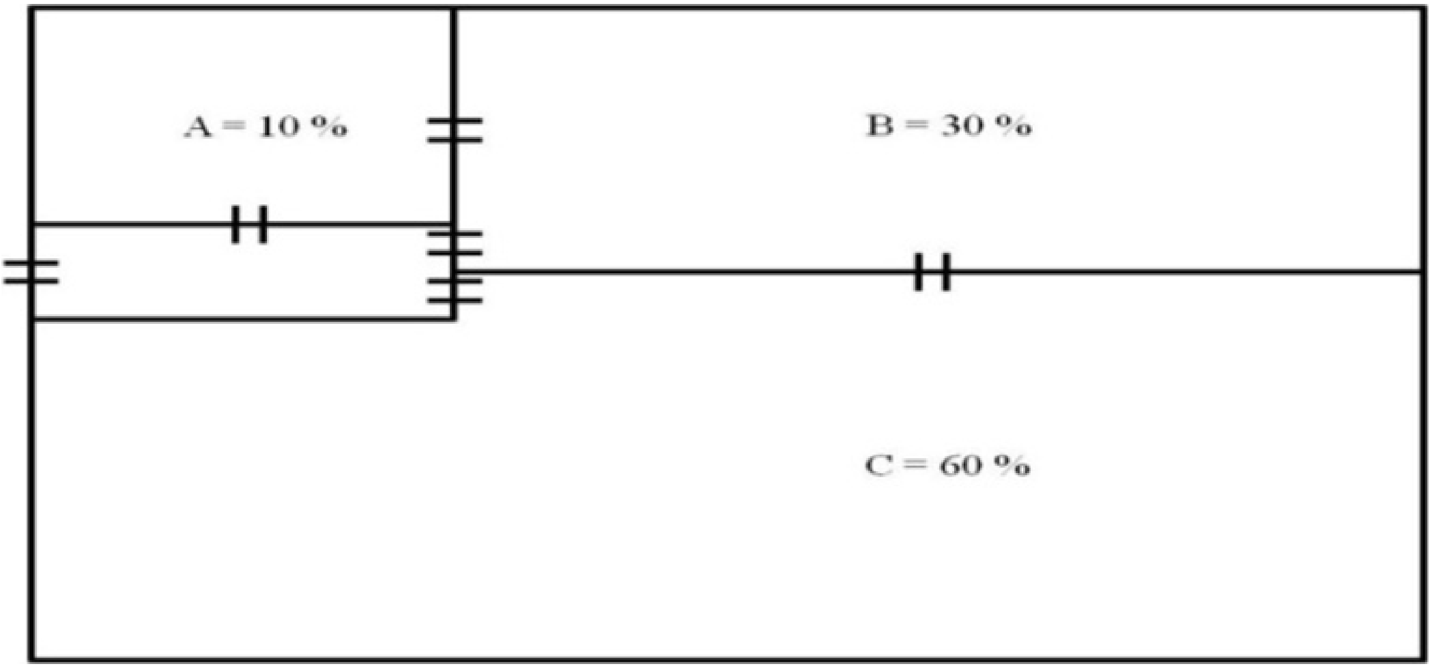

Figure 2

Modular Pond Construction Design. A. 10% = Nursery Plot, B. 30% = Magnification Plot 1, C. 60% = Magnification Plot 2

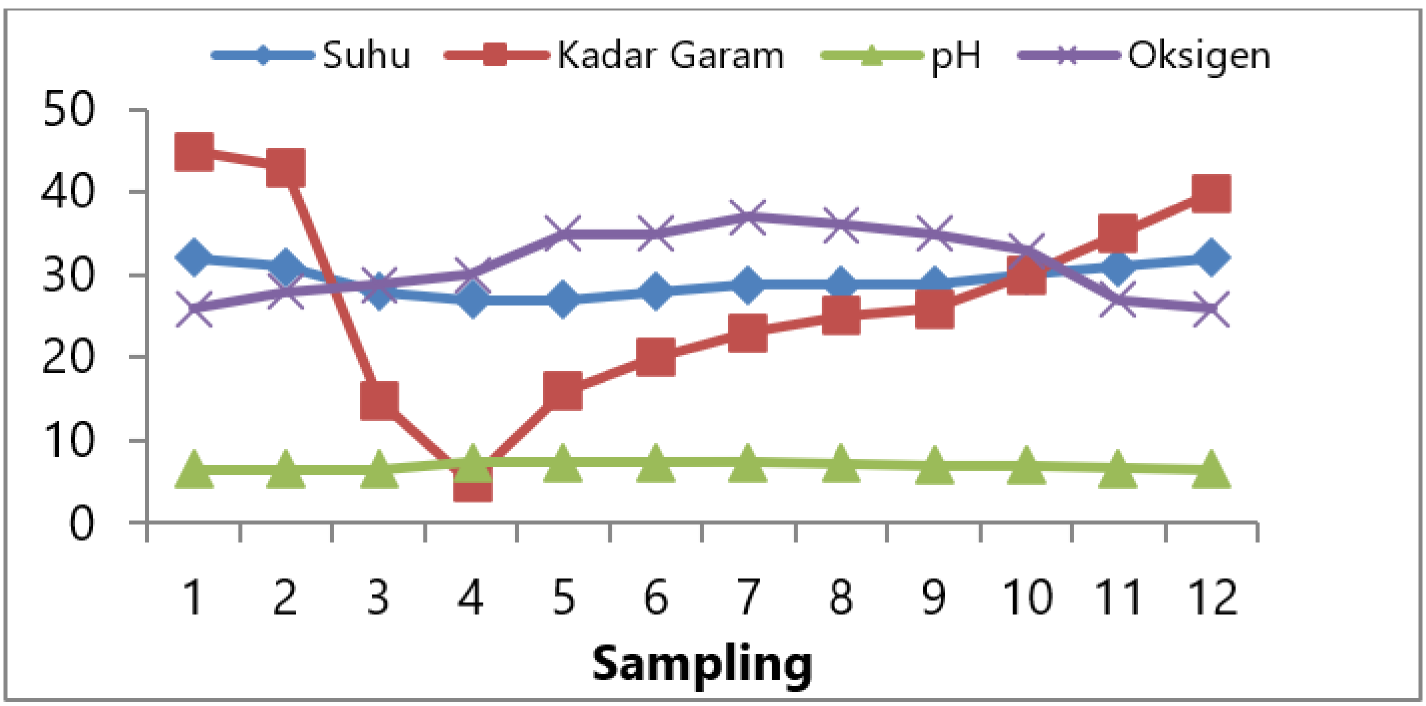

Figure 3

Tidal fluctuations in the coastal waters of the District Labakkang, Pangkep Regency

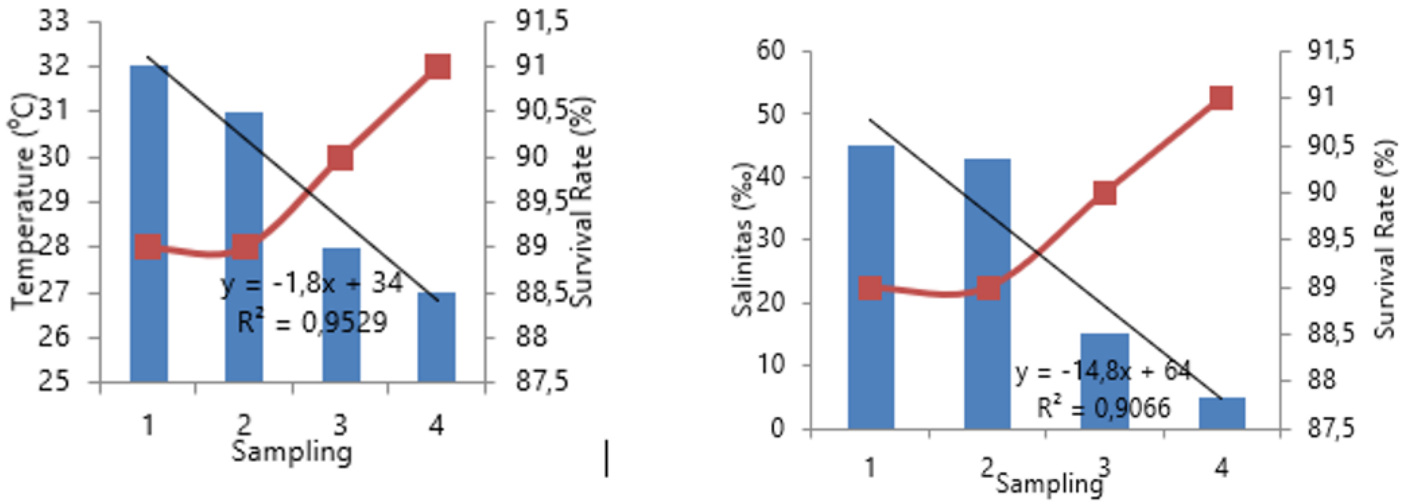

Figure 4

The correlation between fluctuations in temperature and salt content and the survival rates. A. Temperature and Survival Rate, B. Salinity and Survival Rate

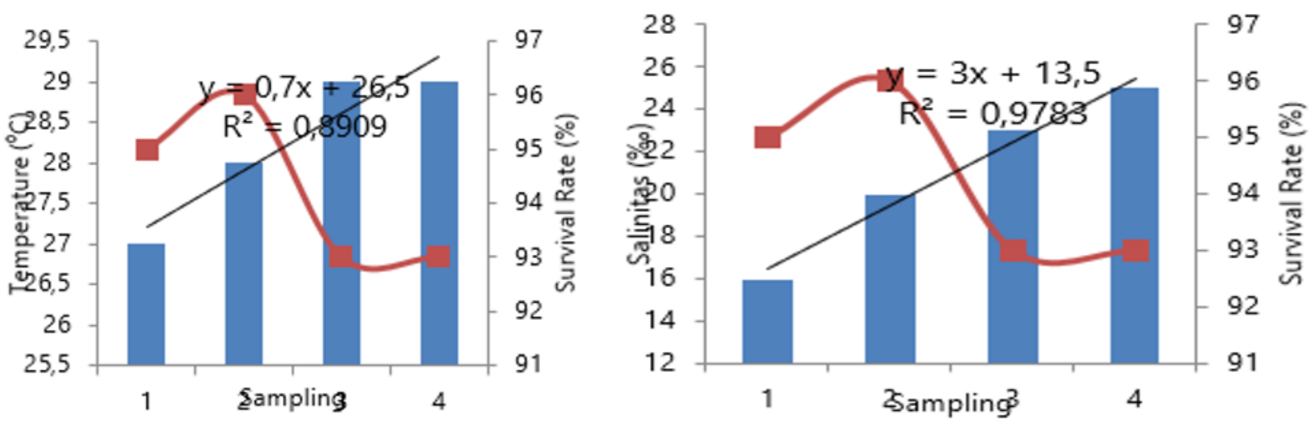

Figure 5

The correlation between salinity and the survival rates in the first cycle. A. Temperature and Survival Rate, B. Salinity and Survival Rate

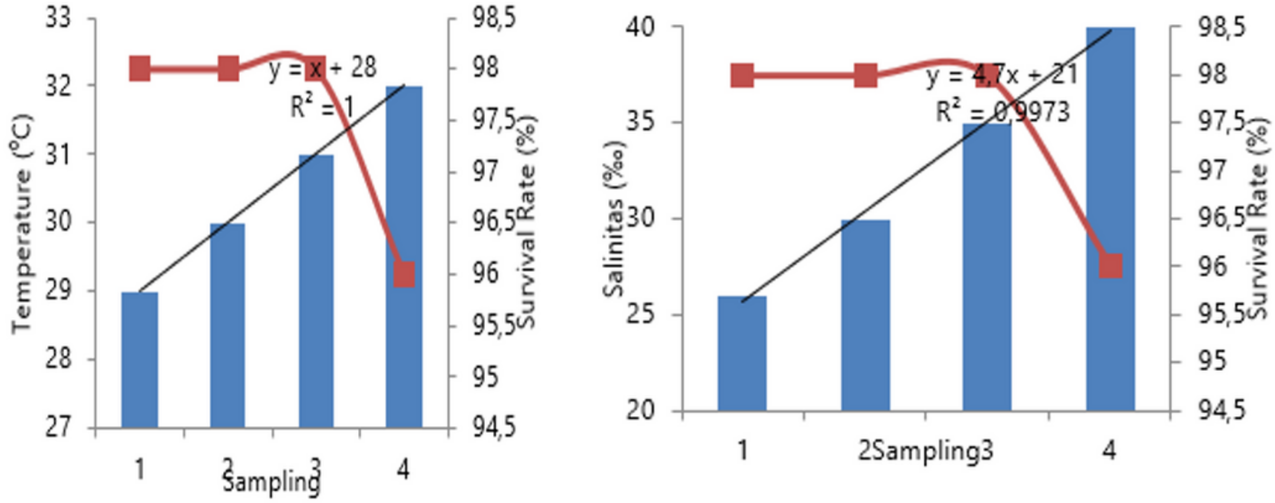

Figure 6

The correlation between salinity and the survival rates in the third cycle. A. Temperature and Survival Rate, B. Salinity and Survival Rate