Evaluating Growth of Oyster (*Crassostrea spp.)* Using Different Culture Techniques in Ilocos, Northern Philippines

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Abstract

Oysters are cultured using various methods, each with a distinct effect on growth and yield. Understanding the efficacy of these culture methods is essential for optimizing production and ensuring sustainable aquaculture practices. This study aims to compare the growth increment of oysters (Crassostrea spp.) in terms of body weight, shell length, and weight of oyster meat over four months using three culture methods—floating bag, suspended tray, and hanging oyster shell employing a complete randomized design model (CRD) consisting of three treatments with three replications. Findings show that the hanging oyster shell method produces oysters with the highest body weight (21.2 g), indicating that this method might encourage ideal growth conditions. On the other hand, the floating bag method yielded a considerable size of oyster shell length (32.3 mm) and the highest meat weight (6.92 g), indicating that it can produce oysters that are sizeable. Statistical analysis revealed significant differences among the three culture methods for both total body weight ($F(2, 42)=11.40$ $P<.001$), and oyster meat weight ($F(2,42)=8.056$, $P=.001$. In contrast, there was no significant difference observed in oyster shell length across the different methods ($F(2,42)=1.64$, $P=.206$). The findings demonstrate that the hanging oyster shell method yielded the highest overall growth increment, while the floating bag method proved most effective for producing heavier oyster meat. However, as environmental variables were not directly measured during the study, these results should be interpreted as method-specific performance outcomes within the local estuary rather than a definitive assessment of optimal environmental conditions.

Keywords*: oyster, growth increment, floating bag, suspended tray, hanging oyster shell*

Introduction

Oyster farming is globally recognized as one of the earliest forms of aquaculture, and this has experienced significant growth in recent years (Botta *et al*., 2020). Oysters are among the most economically significant aquaculture commodities both globally and in the Philippines, where species such as the slipper oyster (*Magallana bilineata*) serve as key drivers of coastal livelihoods (Lebata-Ramos *et al*., 2022). Beyond their commercial value, oysters function as vital ecological engineers across subtidal and intertidal zones (Korringa, 1951; Yonge, 1960; Guy *et al*., 2018; Jamil *et al*., 2024). In these habitats, they provide extensive ecosystem services-including water filtration, structured biogenic habitat creation and nutrient regulation - that enhance overall marine and estuarine ecosystem health (Cranfield *et al*., 2003; Jamil *et al*., 2024; Rubino *et al*., 2024).Nationally, oyster farming provides a significant source of income in many rural coastal towns across the archipelago, particularly for marginalized fisherfolk who are often susceptible to natural disasters and live below the poverty line (Rodolfo and Lapus, 2021). The Philippines witnessed a rise in oyster farming productivity during 2001, 2007, 2010, and 2013, attributed to the availability of better-quality spats and favorable water conditions (Besana *et al*., 2019), which led to the harvesting of larger, fully grown oysters.

In the Ilocos region, specifically Ilocos Sur, oyster producers commonly employ three distinct culture techniques: long line hanging, raft hanging, and stake (tulos) methods. Oyster-growing locations in the area include estuaries, rivers, and fishponds (Domingo, Raboy, and Ramos, 2021). These activities are crucial for the livelihoods of local dwellers and fisherfolk.

Beyond their economic and ecological significance, oysters are also valued for their nutritional content and status as a seafood delicacy. With comparison to the flesh of other shellfish and terrestrial animals, oysters were shown to be a rich source of protein, lipids, minerals, and carbohydrates (Rustia *et al*., 2025) thus, their role as a valuable food source is implicit. Anatomically and ecologically, oysters are bivalve mollusc characterized by two permanent, calcified valves that enclose and protect an unsegmented, soft body which expands as the

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organism matiures. True oysters belong to the family *Ostreidae* - which includes major aquaculture genera such as *Ostrea*, *Crassostrea*, *Magallana*, and *Saccostrea* - distinguished from related groups like *Gryphaeidae*. Althoiugh over a hundred oyster species are recognized globally, only a select few are commercially cultivated on an industrial scale (Quayle, 1980; Sigwart *et al*., 2021). They are filter feeders that play a vital role in maintaining the health of aquatic ecosystems by improving water quality.

Despite their importance, oyster production faces several significant challenges. Globally, oyster populations have substantially declined due to overharvesting, habitat degradation (Ilac *et al*., 2024), damaging fishing methods, and environmental deterioration. In the Philippines, after periods of growth, productivity has become unpredictable in locations with a history of red tides, sewage-related water pollution, and low water quality. Furthermore, regular typhoons frequently destroy oyster crops, leading to fewer spatfalls, slower spat growth, and smaller market sizes. Financial constraints and limited resources often hinder the restoration and replacement of damaged farm infrastructure (such as bamboo poles). To address these challenges, there is a clear need to investigate new culture sites and techniques. Bailliel and Grabowski, (2019) cited that understanding how biophysical variables influence oyster recruitment, survivorship, and growth is essential for guiding future sustainable restoration efforts. It is also imperative to develop and adopt innovative oyster grow-out cultures that are well-suited to local conditions, aiming to generate local-specific technology that can enhance income, broaden markets, and elevate the common oyster to a true seafood delicacy.

Furthermore, oysters can be cultivated using various techniques, including hanging, racking, and placing methods on rock substrate (Zainura *et al*., 2016). Prior studies have indicated that the hanging and sinking raft method yielded the highest survival rates (84%). Rosanawita *et al*. (2017) highlighted that when using the floating method, densities of 35 ind / 1500 cm^2 were found to produce the best growth results compared to higher densities. Lebata-Ramos *et al*. (2021) investigated conventional methods (tires and oyster shells) alongside novel techniques (pouches and trays) hung from floating rafts to enhance oyster yield. Their findings revealed that oysters cultured in pouches achieved the highest mean shell length and body weight, with growth rates in trays and pouches being almost identical. Crucially, these new techniques resulted in single, larger, and meatier oysters after a shorter culture period, with similar survival rates in both trays and pouches at harvest. In another study, Lebata-Ramos (2023) compared oyster growth and survival using pouches in ponds and rivers, noting that while pond-reared oysters had lower meat yield, river-reared oysters demonstrated significantly higher growth rates in length and weight. The choice of cultivation technique can also influence the oyster's ecological niche by altering its environment.

Oyster thrives in diverse habitats characterized by variations in temperature, salinity, and the quality and quantity of available food. Their physiological activity is profoundly influenced by the ambient water's salinity and temperature, as oysters are unable to regulate these conditions in their bodily fluids (Bayne, 2017). Growth, a primary economic objective in oyster production, is determined by an organism's physiological responses to environmental variables, alongside internal factors like genetic variations. A species' ecological niche is defined by the resources it requires and its integration within the environment, with individual variation playing a role in population niche breadth (Smaal and van Duren, 2019). Understanding how biophysical variables impact oyster recruitment, survivorship, and growth is critical for developing sustainable restoration strategies.

Meanwhile, the concept of carrying capacity in bivalve culture is applied to assess the production potential of culture areas and to address potential negative environmental impacts and conflicts with other resource users. It is important to note that different oyster culture techniques may alter an area's carrying capacity, thereby requiring adjustments in ideal stocking densities. Global oyster populations have experienced significant declines due to factors such as overharvesting, habitat degradation, damaging fishing methods, and general environmental deterioration.

It is observed that oyster farming in Ilocos Sur predominantly relies on traditional methods, such as long line hanging, raft hanging, and stake (tulos) methods, which often lead to inconsistent yields. While oyster cultivation is a vital coastal livelihood, regional development is hindered by a critical knowledge gap: the lack of localized, comparative data on method performance. Current mariculture literature fails to evaluate how different oyster culture techniques perform when subjected to the specific environmental and hydrological conditions of the Ilocos region. Consequently, stakeholders lack empirical evidence regarding which methods optimize growth, survival rates, and economic returns under local conditions. This study directly addresses this empirical deficit by evaluating and comparing floating bag method, suspended tray method, and hanging oyster shell method, establishing a rigorous baseline to guide sustainable regional production and future mariculture development.

This study aimed to evaluate the growth of oysters (*Crassostrea spp.*) using three culture methods. Specifically, it aimed to determine the growth of oyster (*Crassostrea spp*.) in terms of mean body weight (g) and mean shell length (mm) using the following methods, floating bag method, suspended tray method, and hanging oyster shell; ascertain yield of oyster in terms of final weight(g) of oyster meat using the methods mentioned above; and assess the significant differences in the growth increment and yield of oysters using the methods as mentioned earlier. It is hypothesized that there is no significant differences in the growth performance particularly mean body weight and shell length, and meat yield of oysters (*Crassostrea spp.)* among the floating bag, suspended tray, and hanging oyster shell culture methods.

Materials and Methods

This study utilized the experimental type of research. The experimental set-up consists of the long line hanging method (oyster hangings), trays suspended in rafts, and floating bags. A completely randomized design model (CRD) with three treatments and three replications was used. While the study acknowledges that environmental conditions such as salinity and temperature profoundly influence oyster physiological activity, the specific monitoring and analysis of these variables were outside the scope of the current study.

The study was conducted along the estuary in Nalvo, Sta. Maria, Ilocos Sur, wherein a natural population of oysters can be found. The Provincial Oyster Farm uses it as a spat collection area. Figure 1 shows the experimental area for this study.

Preparation of the experimental set-up

Oyster spats were procured from the Provincial Oyster Farm in Nalvo, Sta. Maria, Ilocos Sur. In setting the experimental area, three (3) replications for each method were considered. The following procedures were done for each method. *Hanging method using spatted oyster shells*. The long line hanging method of spatted oyster hangings usually practiced by the oyster growers in the province was adopted in this study. Fifty spatted oyster hangings were procured from the Provincial Oyster Farm, and these were suspended in bamboo poles wherein bamboo pole platforms were tied to the post at about 0.50 m below zero tide level. *Suspended Tray Method.* For the tray method, five (5) plastic screen trays measuring 42.75 X 30.48 cm were used. Each tray was stocked with 50 oyster spats suspended in bamboo lines. *Floating Bag Method*. For the floating bag method, five (5) plastic screen bags measuring 42.75 X 30.48 cm were stocked with 50 oyster spats. These were also suspended individually in the floating rafts, as demonstrated in Figure 5.

Culture management

The culture period was four months from stocking. The set-up was regularly monitored and cleaned. Observations during the 4-month culture period were adequately noted.

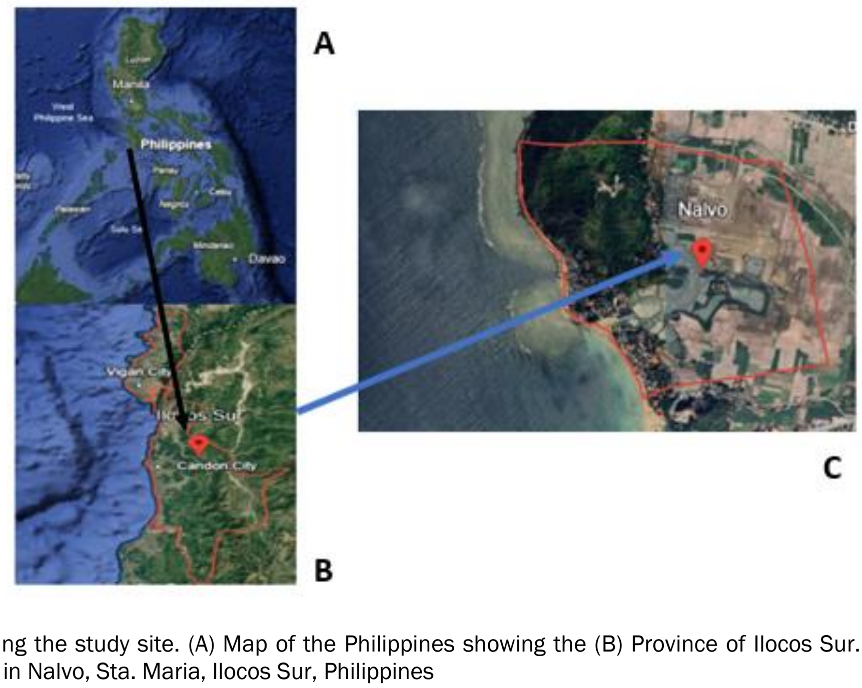

Figure 1. Map showing the study site. (A) Map of the Philippines showing the (B) Province of Ilocos Sur. (C) Map showing the study area in Nalvo, Sta. Maria, Ilocos Sur, Philippines

Data gathering

The initial mean shell length (mm) and body weight (g) were recorded before stocking as manifested in Figure 6. To evaluate the oyster's growth increment, the mean final lengths (mm) and weight (g) of the oyster cultured from the different methods were also recorded, where, five (5) samples from each replication were measured. The mean final weight (g) of oyster meat was also recorded to determine the yield from each method.

Statistical analysis

The data were subjected to statistical analysis using pooled data rather than replication means. This include mean to describe the body weight, shell length, and oyster meat during the four months culture period, ANOVA to determine the significant differences in the oyster's growth increment wherein, the individual oysters were treated as the experimental units for the analysis, and Tukey HSD to compare mean body weight, shell length, and oyster meat using the three-culture method.

Results and Discussion

Growth of oysters in terms of body weight and shell length

The growth increment of oyster, as shown in Figure 2 and Figure 3, reared using the hanging oyster method during the 4-month culture period appeared to be the highest (21.2 g), while floating bag and suspended tray methods yielded a gain of 19.5g and 13.2g, respectively. This result on the growth of oysters in terms of body weight differs from the findings of Lebata-Ramos, *et al*. (2021), wherein after the grow-out culture period, the mean body weight of oysters was significantly highest in those reared in pouches, followed by those in trays, then those harvested from oyster shells. These findings also differ from the findings of Capinpin *et al*. (2023), wherein both single and clustered oysters cultured in trays yielded higher growth in terms of weight gain than those cultured in pockets.

The total increase in shell length (mm) was high across the three culture methods. The growth of oysters was highest in the floating bag method (32.3 mm), and the lowest was in the hanging oyster shell method (31.3mm). It is evident in this study that the culture environment, the estuary, dramatically affects their growth rates, both for length and weight. The observed growth rates in the estuary may be influenced by local environmental dynamics. It is possible that plankton biomass and suspended organic matter were enhanced by nutrient inputs associated with estuarine mixing during culture period. While the floating bag method's efficiency in collecting suspended food particles suggest a potential advantage in nutrient acquisition, further research incorporating biophysical monitoring is required to confirm the specific impact of these variables. In addition, oysters use their shells to ward off predators, so their length grows faster than their weight. Similarly, the growth pattern of their shell length increases more quickly than their body weight, according to Octavina *et al*. (2015). Also, Pagaoa *et al*. (2025) stated that in order to reduce the risk of contamination and ensure the sustainability of oyster farming in Ilocos Sur, routine monitoring and adherence to environmental standards are essential.

As a culture method, the floating bag efficiently collects suspended food, such as zooplankton and phytoplankton, as well as other organic materials important for the growth and survival of filter-feeding organisms like oysters. Oysters raised in floating bags also showed no signs of crab predation. The result of this study regarding body weight gain diverges from other recent Philippine research, reflecting a high degree of site-specificity in oyster culture. While Lebata-Ramos *et al*. (2021), found that oysters in pouches outperformed those on oyster shells, this study observed the highest growth increment in the hanging oyster shell method (21.2g). The study site's specific estuarine mixing may have created a different distribution of plankton biomass and nutrient inputs compared to the locations used in the previous studies. For instance, the floating bags documented efficiency in collecting suspended foods may have provided a more significant advantage in the nutrient-rich discharges of the estuary than in other environments. Ultimately, these findings underscore a critical knowledge gap in Philippine mariculture, that the performance of a culture method is not universal but is instead a direct physiological response to localized biophysical variables.

Yield of oysters using three culture methods

The yield of oysters in terms of meat weight was highest in those cultured in the floating bag method, followed by the suspended tray method, and the lowest was observed in the hanging oyster shell method, as indicated in Figure 4. This is evident by the weights of oyster meat (g) with 6.92g, 5.77g, and 5.51 g for the floating bag, suspended tray, and hanging oyster shell methods, respectively.

On significant differences in growth and yield of oysters

As revealed in Table 1, ANOVA results on the mean body weight of oysters (g) showed significant differences in the different culture methods. This implies

Table 1. Oyster Growth Performance and Yield by Culture Method (Mean ± SE)

Culture Method	Body Weight Increment (g)	Shell Length Increment (mm)	Final Meat Weight (g)
Floating Bag	19.5 ± 1.30	32.3 ± 1.21	6.92 ± 0.26
Suspended Tray	13.2 ± 1.30	32.1 ± 1.21	5.77 ± 0.26
Hanging Oyster Shell	21.2 ± 1.30	31.3 ± 1.21	5.51 ± 0.26

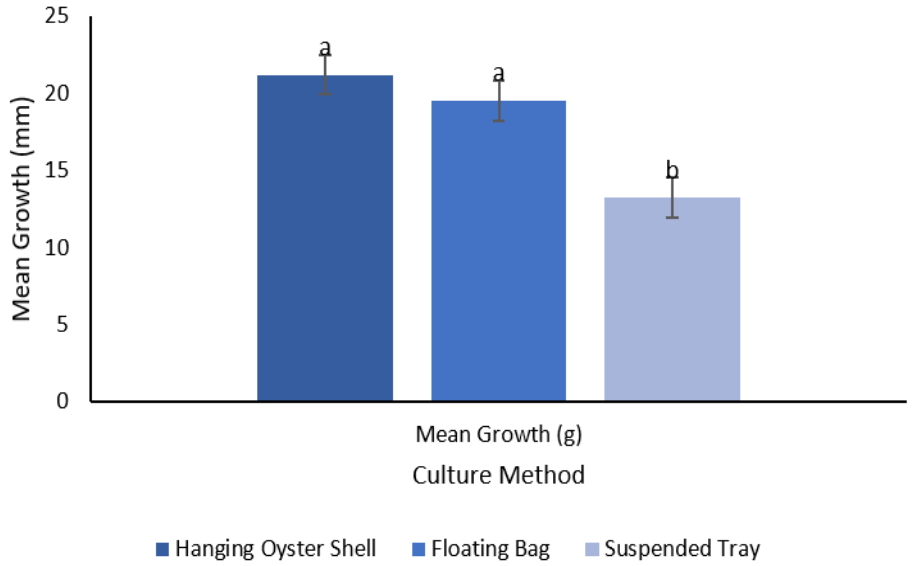

Figure 2. Growth of Oyster (*Crassostrea* spp.) in terms of Body Weight
Note: Means with different letters are significantly different (P<0.05) based on Tukey's HSD test

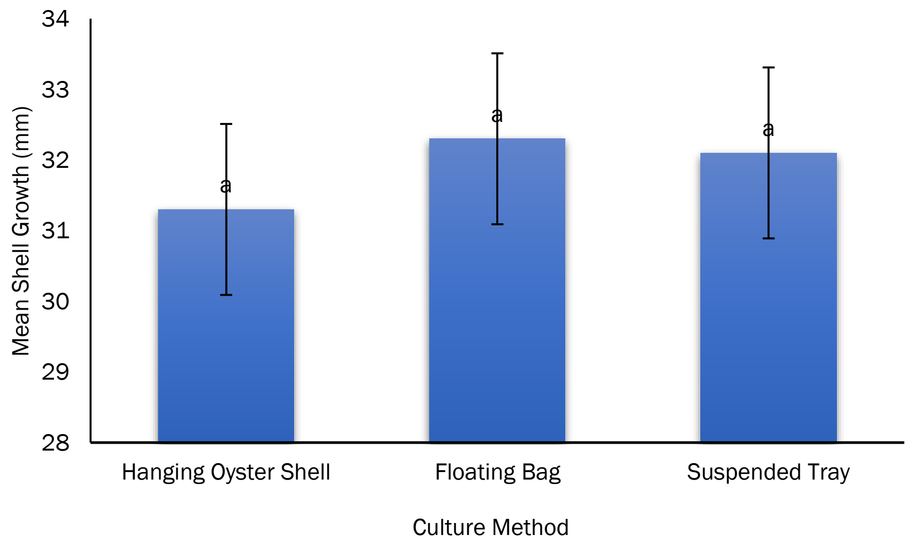

Figure 3. Growth of Oyster ((*Crassostrea* spp.) in terms of Mean Shell Length (mm)
Note: Means with different letters are significantly different (P<0.05) based on Tukey's HSD test

that at least two culture methods yielded significantly different mean body weight(g) of oysters. Further this result implies that the weight of oysters could be influenced by the type of culture methods used.

On culture methods that yielded significant differences in mean body weight (g).

Significant differences were yielded between floating bag and suspended tray methods, and between suspended tray and hanging oyster shell methods. These results imply that the growth of oysters in terms of body weight in the suspended tray is incomparable with the other two methods, namely floating bag and hanging oyster shell methods. Moreover, the effects of floating bag and hanging oyster shell methods on the body weight of oysters are comparable.

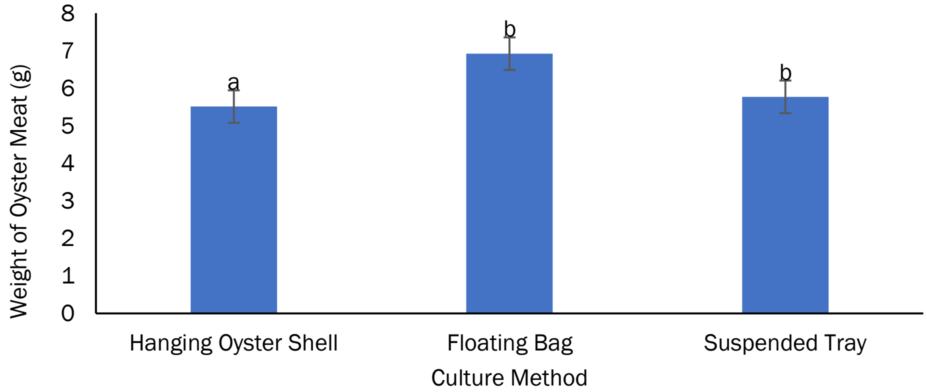

Figure 4. Yield of Oyster (*Crassostrea* spp.) in terms of Final Weight (g) of Oyster Meat
Note: Means with different letters are significantly different (P<0.05) based on Tukey's HSD test

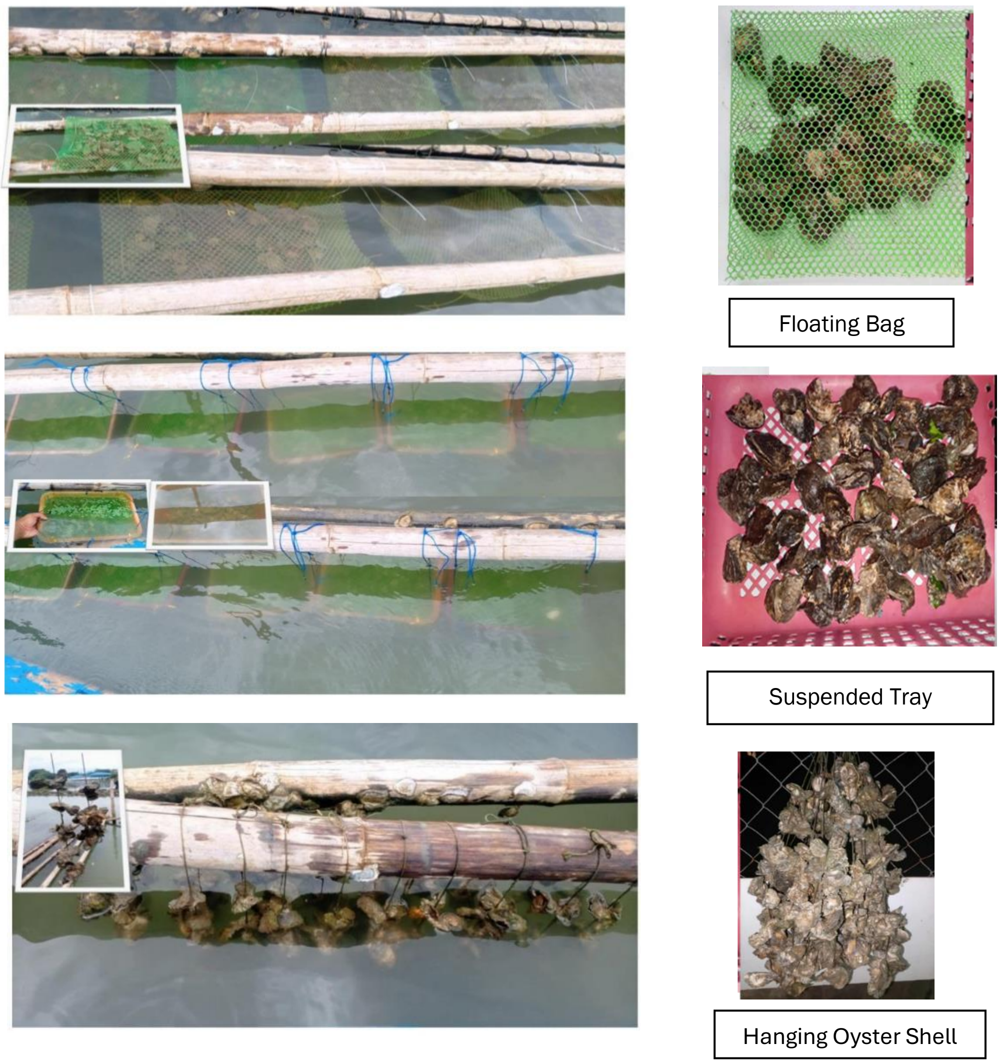

Figure 5. The culture techniques used

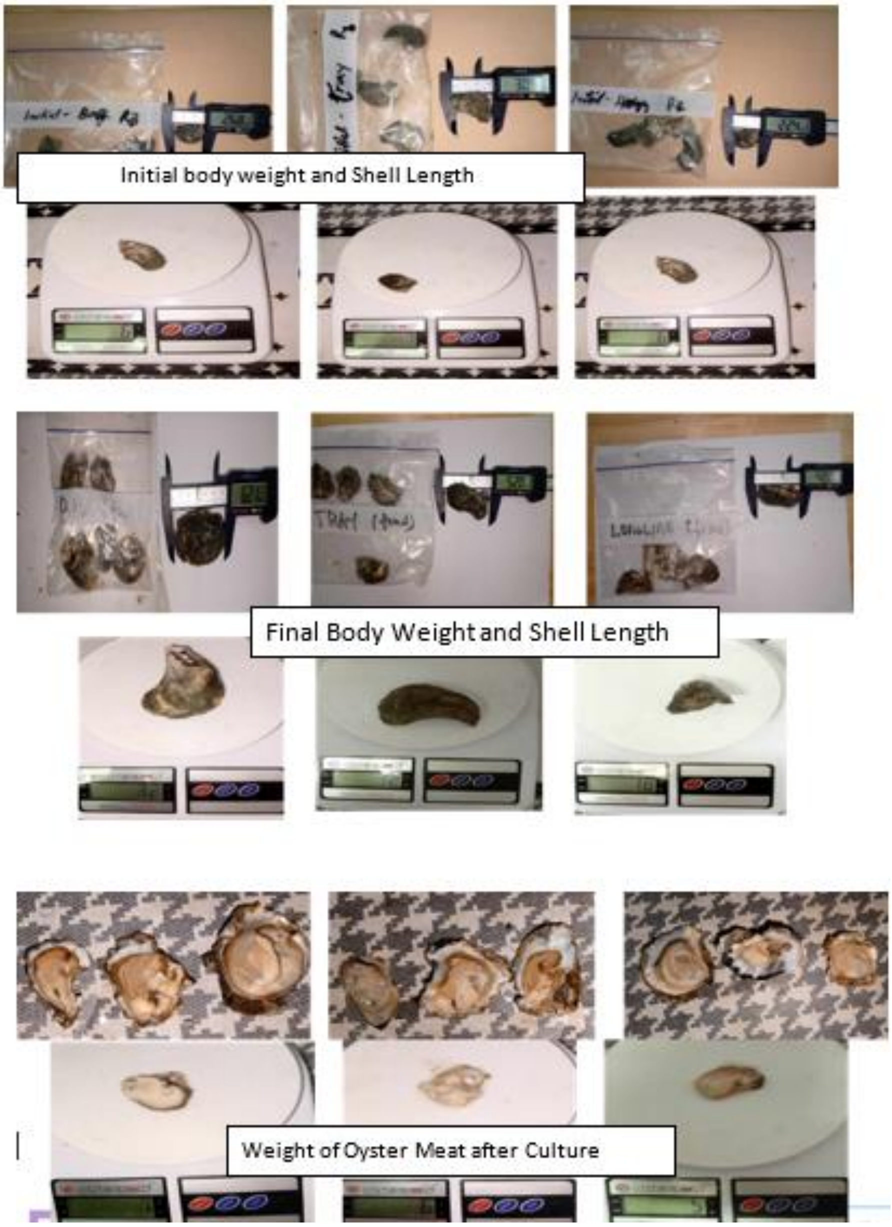

Figure 6. Measurement of the initial and final body weight and shell length of oyster

Anova on the significant differences in the growth of oysters in terms of mean shell length (mm)

In terms of shell length (mm), the growth of oysters showed no significant differences in the different culture methods, which means that the growth of oysters was comparable in all three culture methods. While Capinpin *et al*. (2023) reported that trays yielded higher weight gain than pockets, the current data shows that floating bags produced significantly higher body weight than suspended trays. These differences likely reflect the unique environmental and hydrological conditions of the Ilocos region.

Anova on the significant differences in mean weight (g) of oyster meat

ANOVA results on the mean weight of oyster meat (g) showed significant differences in the different culture methods. This implies that at least two culture methods yielded significantly different mean weight(g) of oyster meat. This indicates that the cultivation method significantly influences soft-tissue biomass accumulation and somatic meat yield. This findings align with broader aquaculture literature demonstrating that grow-out configurations directly regulate bivalve growth, feeding efficiency, and tissue development (Acharjee et al., 2025; Steeves et al., 2018; Yildiz et al., 2011). The result also suggest that the weight of oyster meat could be affected by the type of culture methods used.

Post hoc comparison of mean weight (g) of oyster meat in different culture methods using Tukey HSD

Post hoc comaprisons using Tukey Honestly Significant Differences (HSD) test revealed that oysters rearedin floating bags exhibited significantly greater mean weight compared to those grown in suspended trays and on hanging oyster shells. In contrast, meat weight between the tray and hanging-shell treatments did not differ significantly. These findings corroborate previous investigations indicating that floating bags systems provide superior conditions for bivalve soft-tissue growth and conditions index relative to submerged or lower-strata setups (Clements et al., 2018; Mizuta et al., 2021; Walton et al., 2013). Consequently, the physiological performance of oysters maintained in trays and hanging strings remained comparable, as both systems experience similar vertical food availability and lower energy allocations toward somatic meat accumulation.

Conclusions

The findings demonstrate that the hanging oyster shell method yielded the highest overall growth increment, while the floating bag method proved most effective for producing heavier oyster meat. However, as environmental variables were not directly measured during the study, these results should be interpreted as method-specific performance outcomes within the local estuary rather than a definitive assessment of optimal environmental conditions.

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