APPLICABILITY OF COBB-DOUGLAS ECONOMIC MODEL ON LONGLINE CULTURE OF MUSSEL *Perna viridis* (LINNAEUS, 1758) IN SAMAR, PHILIPPINES

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In Partial Fulfillment
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APPROVAL SHEET

In partial fulfillment of the requirements for the degree, **MASTER IN FISHERIES TECHNOLOGY**, this thesis entitled **"APPLICABILITY OF COBB-DOUGLAS ECONOMIC MODEL ON LONGLINE CULTURE OF MUSSEL *Perna viridis* (LINNAEUS, 1758) IN SAMAR, PHILIPPINES"**, has been prepared and submitted by **NOEME DIOCTON-PAJARILLO**, who having passed the comprehensive examination and pre-oral defense is hereby recommended for final oral examination.

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TO GOD BE THE GLORY.

The Researcher

DEDICATION

This study is wholeheartedly dedicated to my family, who have been my source of inspiration and gave me strength when I thought of giving up, who continually provide their moral, spiritual, emotional, and financial support.

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And lastly, I dedicated this research study to the Almighty God, thank you for the guidance, strength, power of mind, protection and skills and for giving a healthy life. All of these, I offer to you.

ABSTRACT

This study's general objective was to determine the applicability of Cobb-Douglas Economic Model on Logline Culture of Mussels in Catbalogan City, Jiabong, Tarangnan, and Villareal, Samar, Philippines. The profitability model of traditional (stake and wigwam) and long line culture methods were considered in this study based on data collected in the different pre-identified areas where mussels are grown in the municipalities of Samar, Philippines. Focused-group discussion (FGD), one on one interview, and ethno survey were conducted. This includes field visits and site observation in collecting data. The multiple regression equation implies that increasing most factors would result in a higher mussed seed production apart from the brood-stock size and the mussel bed's age. Further increasing such positively correlated variables and decreasing negatively correlated variables by one unit will increase production by 50.49 times. The equation implies that increasing one unit of all the variables except the mussel bed's age will increase production by 5.23 times, which is very significant. The coefficient of determination was computed as 99.28 percent, which means that the combination of the variables is very highly correlated to mussels' production in the data gathered. Analysis of variance revealed that fitting all the model variables produces a significant correlation to the yield (kg) of mussel production. The Cobb-Douglas model is applicable in describing long line culture for mussel production in Samar, Philippines. The long line culture method has a higher NPV than the stake/wigwam method. With the long line culture system, the country need not worry

that coastal areas will become shallow and cause the loss of culture sites – threats posed by the old stake method.

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CHAPTER 1

THE PROBLEM AND ITS SETTING

Introduction

The mussel industry is an essential component of the aquaculture sector in the Philippines. Mussels are cheap sources of protein, and mussel farming provides additional income and livelihood to fisherfolk in many coastal areas, especially in Samar, which needs little capital outlay. Despite these benefits of mussel farming, there has not been a significant increase in mussels' production in the past years. This can be traced to its low cost in the community, little market demand, poor sanitary quality, the occurrence of red tides, and unpredictable supply (DOST-PCCARD), and the traditional culture method used by mussel farmers.

Ironically, many mussel farmers in Samar still use the traditional farming method of mussel culture, with only a few adopting the new technology. A significant number of these mussel farmers are not mindful of how longline culture can have a massive impact on the economy. After that, studies on this new model have focused on technocrats, policymakers, academicians, economists, and aquaculture practitioners.

In economics, a production function is an equation that describes the relationship between input and output or what goes into making a particular product. On the other hand, the Cobb-Douglas production function is a specific standard equation applied to describe how much output or inputs are required in the production process, with capital and labor as input factors.

Douglas and Cobb's production functions are commonly used in macroeconomics and microeconomics models because they have several convenient and realistic properties. Economic models fulfill two functions. The first is to describe some aspects of the reality of an economic phenomenon. The second is to assist economists in considering the economic conditions. To fulfill both functions, economic models become simplified versions of reality, removing many real-life variables. Making models easier to understand, but it may also be less descriptive of the economic reality.

In this study, the economic approach examines the two different cultural methods' production model's profitability. The purpose is to show the differences in capital investment and potential profit between these two methods. Through this analysis, farmers and investors have the opportunity to evaluate their economic performance. Consequently, the return on investment becomes the prime consideration in making business decisions.

Objectives of the Study

This study's general objective was to determine the applicability Cobb-Douglas Economic Model of Longline Culture of Mussels in Catbalogan City, Jiabong, Tarangnan, and Villareal, Samar, Philippines. Specifically, this study aimed to:

1. Evaluate a model for technical efficiency of mussel production; and

2. Assess the current level of profitability of mussel production in Samar, Philippines.

Significance of the Study

The relevance or importance of this study to the different sectors are as follows: Policymakers use economic models as a decision tool in managing renewable resources like mussels. This study gave a big picture of the mussel industry in Samar as a function of economic activities and food security. As to the contribution to science and technology, modeling plays an essential niche in the industry. To future researchers, modeling could be applied to other fishery industries in predicting profit and production models.

Definition of Terms

The following terms are defined to come up with a clear and better understanding of the research.

Benefit-cost ratio. The benefit-cost ratio (also called the B/C ratio) is the sum of the present value of benefits or revenues to the sum of discounted costs.

Bouchot culture. Bouchot culture is mainly undertaken in France. This is also called the stake culture or pole culture. What is being used are big branches or trunks of an oak tree with 4–6 m in length and with staked of 0.7 m apart on soft and muddy bottoms of the intertidal zone during low tide. Mussel seeds are collected on coco-fiber ropes, which are stretched out horizontally on poles.

Cobb-Douglas Production Function. It reflects the relationships between its inputs - namely physical capital and labor - and the amount of output produced. It is a means for calculating the impact of changes in the inputs, the relevant efficiencies, and the production activity yields.

Economic Model. An economic model is a hypothetical concept that embodies economic measures using variables in logical and quantitative correlations. It is a simple method using mathematical and other techniques created to show complicated processes.

Internal rate of return. It is the discount rate making the net present worth of the incremental cash flow equals to zero. When using the IRR, the selection criterion is to accept all independent projects with an IRR greater than the opportunity cost of capital.

Longline layout and design. It consists of a mainline of at least 18-mm diameter polypropylene (PP) rope. The length of the mainline may vary from 20-100 meters depending on the size of the culture area; more significant areas such as offshore or open waters may accommodate longer longlines than in estuaries where size may depend on the width of the river. Recycled plastic containers are used as floats tied to the main rope at 1 to 3-meter intervals and may be modified by increasing the containers' numbers as necessary. The main rope is anchored at the bottom by a mooring device (DOST-PCAARRD).

Net benefit-investment ratio. The net benefit-investment ratio (also called the N/K ratio). The N/K is computed by dividing the present worth of the net benefits by the investment's present worth.

Net farm income. Net farm income ensures the farm's ability to operate in the future, estimated as operating profit minus fixed costs.

Net present worth. The net present worth (often abbreviated as NPW, also known as net present value or NPV) is the sum of the present values for each year's net benefit or net cash flow minus the sum of the discounted costs minus the initial investment cost. Net present worth may be interpreted as the present income stream generated from an investment. When NPV is greater than zero (positive), the decision criterion is to accept a project.

Net Profit. Net profit is an indicator of profitability. It measures the prospects of farm operation in the long run. This was calculated as gross revenues minus total cost.

Operating Profit. A favorable operating profit ensures continuous operation of the farm in the short run. Operating profit is computed as gross revenues minus variable costs.

Return on investment. Return of asset is computed by dividing the net profit plus interest on the loan by the investment amount. The return on investment measures the actual earnings of the money invested.

Stake (tulos) method. The staking method is midway between the rack and bottom methods. Bamboo poles, 4-6 m in length, are stake at the bottom in rows which can be found approximately 3.0 m deep and above and with 0.5-1 m apart during low tide. Bamboo poles are kept in place in areas where the water current is strong by nailing long horizontal bamboo supports between rows.

Wigwam culture. The wigwam method requires a central bamboo pole serving as the pivot from which eight full-length bamboo poles are made to radiate by firmly staking the butt ends into the bottom and nailing the ends to the central pole in a wigwam fashion. The stakes are driven 1.5 m apart and 2 m away from the pivot. To give additional support to the structure, bamboo braces are nailed to the outside frame horizontally and above the low tide mark. Spats settle on the bamboos and are allowed to grow to the marketable size in 8–10 months.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND STUDIES

In view of the researcher's desire to obtain information relevant to this study, an intensive search for related literature and studies in manuals, books, published and unpublished articles, and other foreign and local reading materials was reviewed.

Related Literature

"Stake" method is a traditional method of growing mussels wherein the "spat" or young mussels are freely attached to the bamboo poles placed in the coastal areas. This technology has been used for four (4) decades for green mussel (*Perna Viridis*: locally known as *tahong)* production that made Samar as a tahong-producing province (Gomba et al., 2018). There is hardly any scientific study on the economic effects of this traditional mussel culture method conducted. The uncontrolled number of spats growing in the bamboo poles results to poor quality, typically small in size and low in meat content. In addition, the stake method is unsustainable as it increases mussel beds' sedimentation, causing the culture area to become shallow. In time, the shallow culture area will no longer be suitable for growing green mussels (Baylon et al., 2015).

Figure 1. The staking mussel farm in Jiabong, Samar along Maqueda Bay (Left) and wigwam mussel farm in Villareal bay along Brgy. Pacao, Villareal, Samar (Right)

Because of the siltation problem caused by the use of bamboo poles in mussel culture, the raft and longline culture method was introduced through the Industry Strategic S & T Program of DOST-PCAARRD which promotes increase and better quality mussel production, while utilizing environment-friendly practices (Fernandez, D. 2017. DOST-PCAARRD).

One alternative to the stake method is the longline method. It is considered a sustainable method for culturing mussels. It is an environment-friendly method since it contributes less siltation than the traditional stake method (Baylon et al., 2017). According to Diocton (2017), mussel longline culture technology (Figure 2 and 3) is more efficient than the traditional stake method since it can produce relatively higher production per unit area, superior quality mussels, and reduce siltation in mussel beds. This method is part of the National Mussel S & T program which is being implemented by the SSU-COFMAS and is funded by DOST-PCAARRD. Mario S. Cano Sr., is one the collaborators who were chosen to test the method.

Figure 2. The University of the Philippines Visayas Pinoy "Longline" Culture System in Barotac Viejo, Iloilo. Photo from the Inland Aquatic Resources Division (IARD).

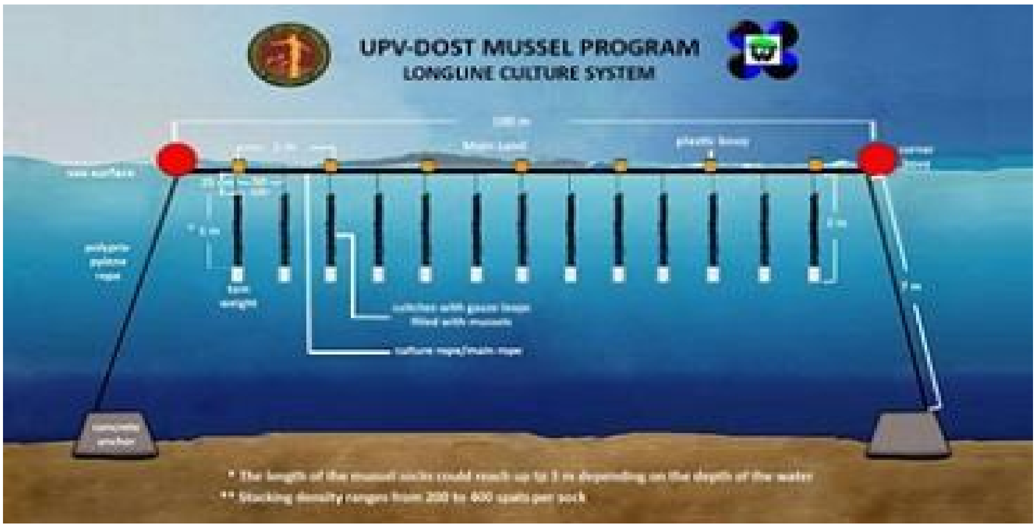

Figure 3. The design of the Pinoy "Longline" culture system. Photo from the UP Visayas.

Aquaculture production in the Philippines has developed through the years. The Philippines was able to generate nearly one million metric tons of aquaculture products in 1997, of which 11 percent were from freshwater (Guerrero, 2000). The world mussel aquaculture production was estimated at 1,801,604 MT, valued at USD 2,231 225,000 (FAO, 2013). China is the world's largest mussel producer, growing more than 400,000 MT of a wide variety of species each year. The Philippines only has a 1% share of the world mussel production (2012-2016 Eastern Visayas Mussel Development Roadmap).

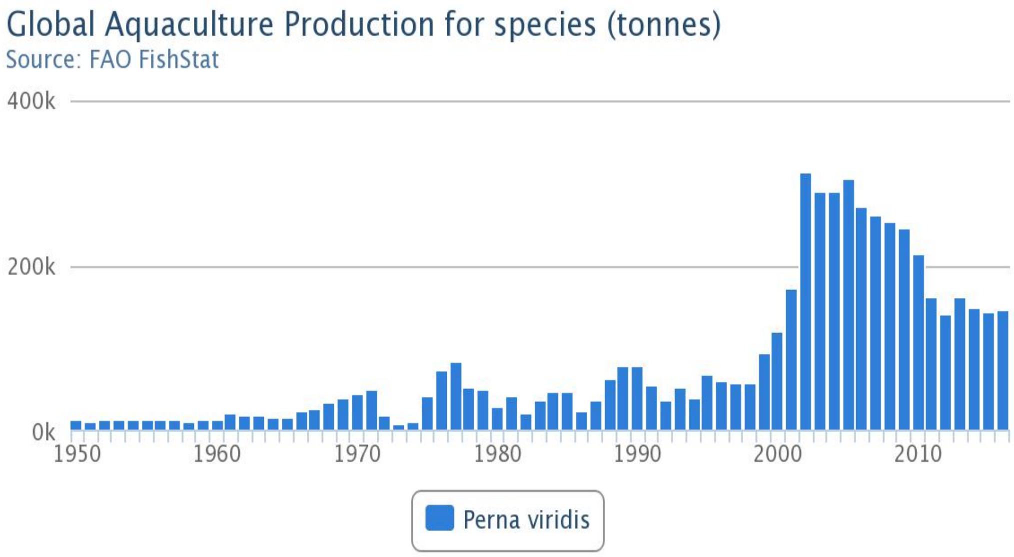

Figure 4. Global Aquaculture Production for species (tonnes)
Source: FAO FishStat

The value of mussel production trend is generally increasing despite the slight slump in 2006 with a production value of PhP 125,806,000 from 138,863,000 in 2005. In 2013, production value again slightly dropped to PhP 252,644,080. In terms of ranking in the production volume for mussel in 2013, Western Visayas ranked first among the four top mussel producing regions in the Philippines in 2013. The top producing regions are Western Visayas, CALABARZON areas, Eastern Visayas, and Central Luzon. These regions posted more than 1000 metric tons of harvested mussels in the year indicated (Figure 5).

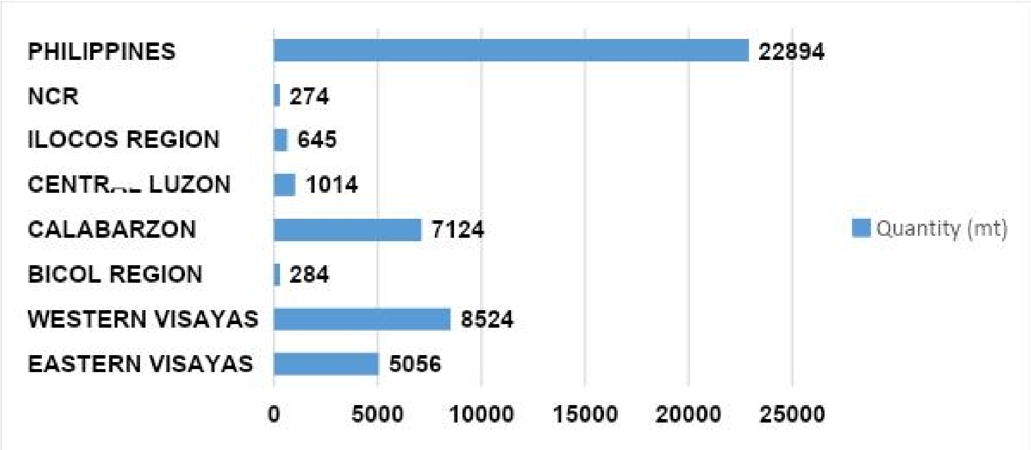

Figure 5. Regional Volume of Production, 2013 (Source: BAS, 2013)

Among the top producing provinces in 2013 are Capiz, Cavite, Samar, and Bataan. The top mussel-producing provinces are Capiz, followed by Cavite, Samar, and Bataan (Figure 6). Philippines rank number 8 in green mussel culture, leading countries like China, New Zealand, and South Korea.

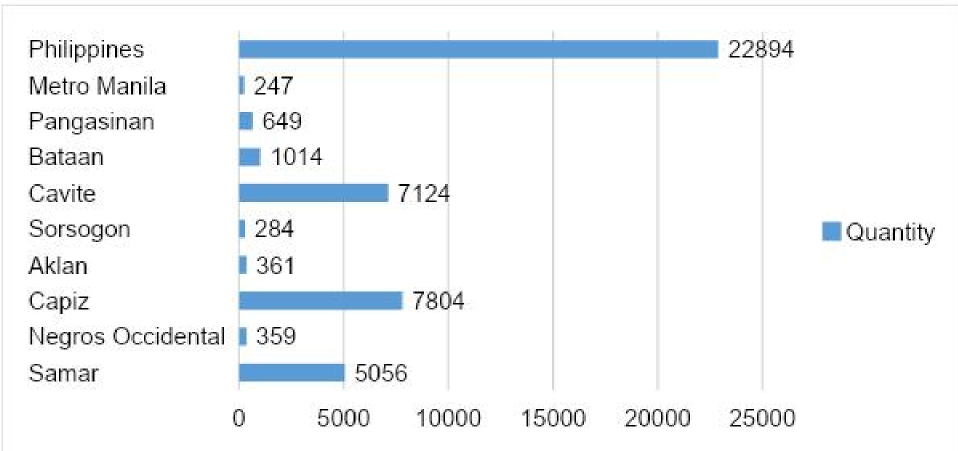

Figure 6. Provincial Volume of Production, 2013 (Source: BAS, 2013)

There are roughly 4,291 fishing households that depend on mussel industry for livelihood. There were more than 2,000 coastal families engaged in mussel farming in Western Visayas recorded more than two decades ago (Samonte, 1992). There are currently more than 1,865 households along Maqueda Bay in the Samar area that depend on the mussel industry for livelihood. There are 426 registered operators of mussel farms in Cavite in 2013. Duncan's (2009) statics indicated that fisher households operate 91% of these mussel farms. This data indicated the number of persons engaged directly or indirectly for employment in the Philippines' mussel industry. While there is scarce data on the actual number of persons employed in the industry, a 2006 data in Jiabong, Samar indicated a total of 279 persons employed in the mussel processing industry in the area out of its 15,397 registered population in 2000.

According to Baylon and Tandang (2015), "stake" method is a traditional method of growing green mussles in the Philippines wherein the mussle"spats" or young mussels freely attached to bamboo poles placed in coastal areas. There is, however, minimal management on this method since the number of mussel spats growing in the bamboo poles is uncontrolled, which results to low-quality mussels, which are typically small in size and contain low meat content. The method is unsustainable as it increases sedimentation in the mussel beds which causes the culture area to become shallow and in time, be no longer suitable for growing mussels.

To address the need for a sustainable method, the longline culture system used by New Zealand was adopted locally with inexpensive materials used. Pinoy "Longline" is implemented by the UP Visayas, SSU and CSU; a project funded by DOST-PCAARRD.

Related Studies

Based on the study conducted by Dr. Carlos C. Baylon, Prof. Renato C. Diocton, and others, under the DOST sponsorship, which later became an operational *Manual on the Longline Culture of Green Mussel* showing the "Cost and Returns" using the longline culture method. Stated hereafter, are things which must be considered:

The length of the longline may vary depending on the size of the culture farm and the mussel farmer's financial capability to construct the lines. It can be 20-m, 50-m, or 100-m long. The cost for the construction of a longline varies depending on its length. The economic indicators for each length of the longline are presented below. Fixed costs for the different lengths of longline only vary with the amount of the materials needed, specifically on the length of ropes (PP and PE), several mussel spats, and several tom weights and plastic containers.

One 20-m longline costs P8,020.00 and three lines would cost P24,060.00. The return on investment (ROI) was 53%, and initial investments will be paid back after almost two years. To achieve a break-even or zero lost and zero income, the harvested mussel must be sold at P9.76/kg. On the other hand, one 50-m longline costs P11,980.00 and three longlines have an initial investment of P35,940.00. The initial investment has a payback period of 0.53 years and an ROI of 187%. Moreover, extending the longline to 100 meters would cost P21,205.00 and the three lines for P63,615.00. ROI and payback period are 243% and 0.41 years, respectively.

Concurrently, models and decision-making processes are being developed to support fisheries management in a multi-objective framework. Ideally, such models would include quantitative relationships for each of the three components, with the outcomes under each objective determined by these relationships and the management scenario modeled. In practice, however, this is not always possible. Difficulties in quantifying some of the relationships, particularly around social objectives, and differences in the quantity and quality of data available on the fisheries have resulted in many different modeling approaches being developed and applied. These range from qualitative approaches based on expert opinion (e.g. Dichmont *et al.*, 2013b) to complex composite models (Dichmont *et al.*, 2013a; Plagányi *et al.*, 2013; Fulton *et al.*, 2014) that have been used to assess management strategies taking into account social, economic, and ecological interactions.

Through the list overlapped, all gave a place of prominence to technological change or more accurately to factors that would later come to be understood as falling under the broad rubric of technological change. In an article (1927) commenting on the productivity studies, Paul Douglas cited three leading causes of the measured productivity increases: increased quantities of capital per worker; the rapid development of American technical methods which includes the moving conveyor as its most notable feature and the internal and external to firms' economies of scale which were made possible by the nation's large internal market in where free trades prevail. Interestingly, Douglas listed the inability of unorganized workers to resist the introduction of new production methods as fourth factor. Douglas pointed to changes in the willingness of managers to seek out and employ new and more productive techniques to explain the reason of productivity growth that had markedly accelerated after the war, through factors he cited had been pre-operative.

Biddle (2012), in his paper "The Cobb-Douglas Regression and the Measurement of Economic Growth and its Causes," used the phrase "Cobb-Douglas Regression" to describe the empirical procedure of regressing a measure of output on measures of inputs under the assumption that the production function takes what is now known as the Cobb-Douglas form. The procedure was introduced in Cobb and Douglas's 1928 paper, "A Theory of Production," which Douglas continued to work with for the next 20 years that produced a stream of studies which applied to both cross-section and time-series data sets. His work with the Cobb-Douglas regression attracted positive and negative comments from his fellow economists. However, before the mid-1940s, few outside of Douglas's research group utilized the regression. Two decades after the war, Cobb-Douglas regression turned into a purposeful research tool for empirical economists who adopted, adapted, and generalized the procedure to explore various questions, both micro and macroeconomic.

Woodlief Thomas thought it evident that the growing use of mass production, increased mechanization and scale economies from industrial consolidation were the leading causes of productivity growth. He was also willing to give credit to improved education and literacy, universities' scientific researches and the businessmen's increasing use of statistics.

Cobb-Douglas Production Function was widely used in economics and productivity studies across many sectors. The function's quantitative modeling of resource inputs and production outputs is appealing to construction management's research domain (Hassani, A. 2012).

Moving to Opportunity (MOT) is the best possibility farmers should take risks as they will choose to use the traditional method or shift to the new technology of mussel farming. Studies of management objectives worldwide have identified three core areas: economic, social, and environmental sustainability (e.g., Mardle *et al.*, 2002; Cheung and Sumaila, 2008; Ward and Kelly, 2009; Cowx and Van Anrooy, 2010; Péreau *et al.*, 2012). Others have considered additional objectives, namely political (Crutchfield, 1973; Hilborn, 2007), food security, and income generation (Charles, 1989).

Chapter 3

METHODOLOGY

This section presents the methods and procedures that were used in this study. It describes the research design, locale of the study, instrumentation, validation of the instrument, sampling procedure, data gathering procedure, and the statistical tools in the data's treatment.

Research Design

The profitability model of traditional (stake and wigwam) and longline culture methods were considered in this study applying the Cobb-Douglas Economic Model and was validated based on data collected in the different pre-identified areas where mussels are grown in the municipalities of Samar, Philippines. Focused-group discussion (FGD), one on one interview, and ethno survey were conducted. This also includes field visits, site observation (Figure 7) and actual measurement of data with regards to water depth, broodstock size, broodstock density and age of broodstock.

Study Site

This study was conducted in the traditional mussel growing areas in the Municipality of Jiabong, Catbalogan City, Villareal and Tarangnan, Samar, Philippines. Fieldwork focused on the selected Mussel Aquaculture Farms in these municipalities (Figure 8).

Figure 7. Mr. Mario Cano Sr. showing his harvested mussels using longline in Tarangnan, Samar (Left and upper right) and wigwam mussel farm in Villareal bay, Villareal, Samar (Lower right)

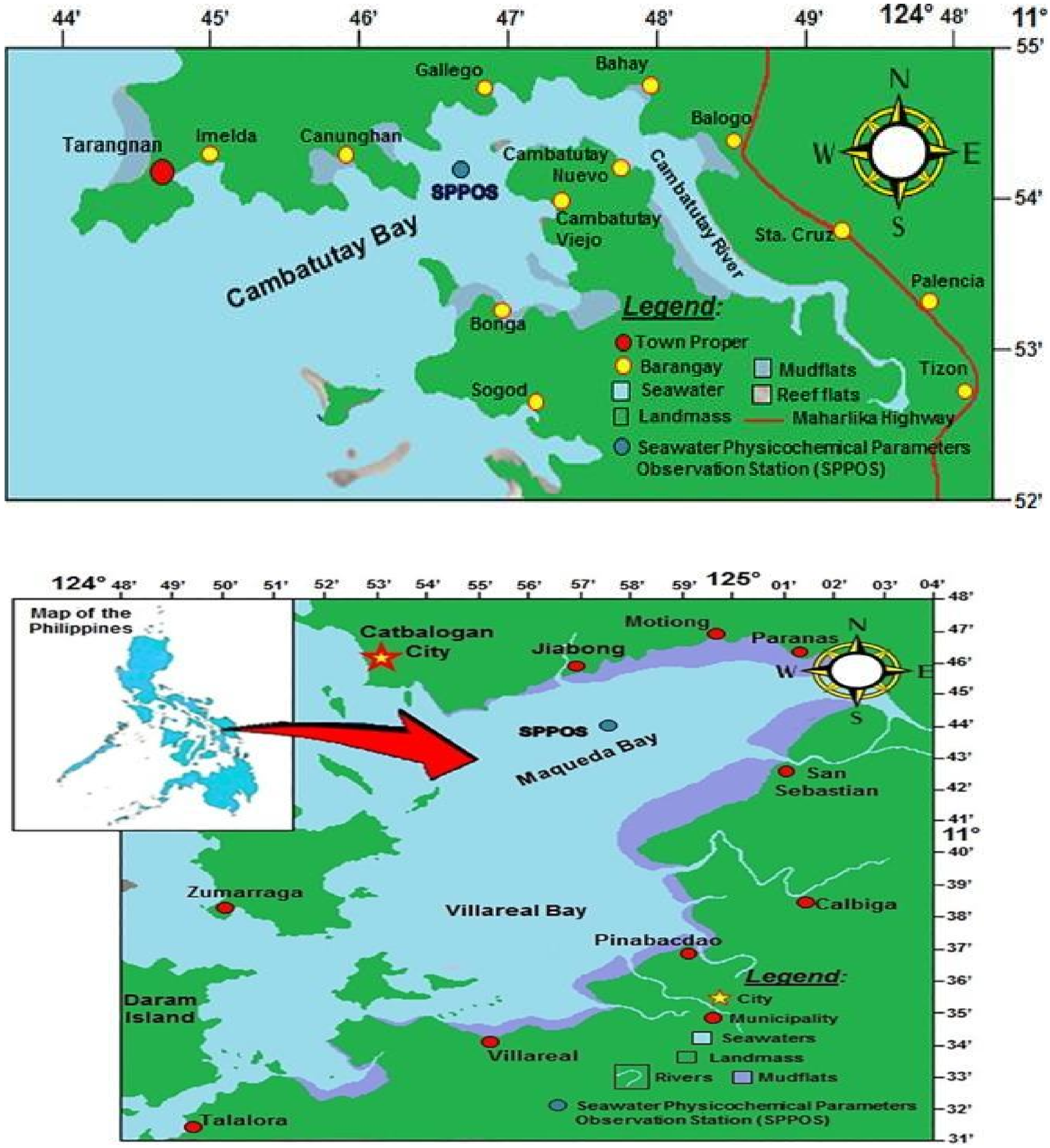

Figure 8. The geographical location of different Mussel Farms in the Municipalities of Samar, Philippines

Sampling Procedure

The research employed purposive sampling wherein available owners and operators of mussel farms were interviewed.

Data Gathering Procedure

Data and information were obtained from one-on-one interview with the operators, and field visits/site observation in collecting data on the selected Mussel Farms in the Municipality of Jiabong, Catbalogan City, Villareal and Tarangnan, Samar, Philippines. A total of 10 interviews were conducted.

Since most of the data was gathered through interviews, the researcher asked permission for the Municipal Mayor down to the Municipal Agriculture Officer (MAO) to Brgy. Captain and lastly to the identified mussel farmers and conducted the study through letter and ask for their available time for the meeting and interview process and highly assured confidentiality of the data. Respondents were given a letter signifying that they permit the researcher to conduct an interview, and they will be given a token as appreciation for their participation. These documents are shown in Appendices A to G.

The needed data on the following variables such as: broodstock density, broodstoock size, age of the broodstock, amount of filter plankton, water depth and age of the mussel bed was gathered through actual measurement during field visit. The mentioned variables was measured shown on Figure 9.

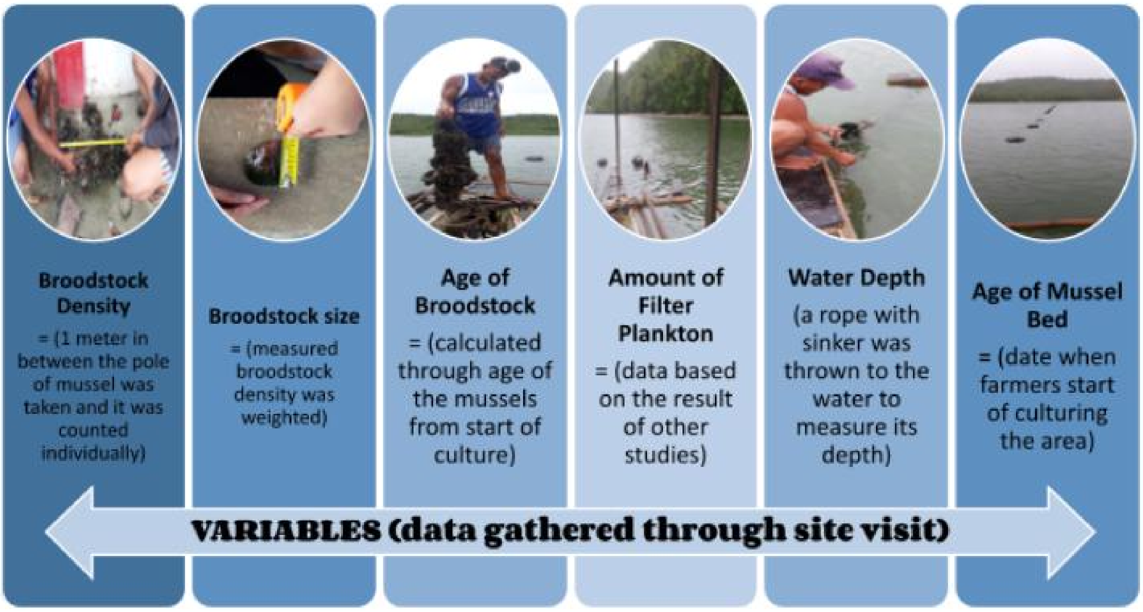

Figure 9. Presentation of Variables (Data Gathering)

Appropriate statistical analysis of the data was used to describe the variables in the study.

Analysis of Production Technology and Efficiency of Input Use. Analytical Framework: The Cobb-Douglas Production Function with the following variables, derived from a survey of green mussel producers in Samar.

$$P(L,K) = bL^{\alpha}K^{\beta} \quad (Eqn.\ 1)$$

where:

- P = total production (the monetary value of all goods produced in a year)
- L = labor input (the total number of person-hours worked in a year)
- K = capital input (the monetary worth of all machinery, equipment, and buildings)
- b = total factor productivity

- α and β are the output elasticities of labor and capital, respectively. These values are constants determined by available technology.

Output elasticity measures the responsiveness of output to a change in levels of either labor or capital used in production, ceteris paribus. For example, if α = 0.15, a 1% increase in capital usage would lead approximately a 0.15% increase in output.

Further, if:

$\alpha + \beta = 1$, the production function has constant returns to scale. If L and K are each increased by 20%, then P increases by 20%.

Return to scale refers to a technical property of production that examines output changes after a proportional change in all inputs (where all inputs increase by a constant factor). If output increases by that exact proportional change, there are constant returns to scale (CRTS), sometimes referred to as a return to scale. If output increases by less than that proportional change, there are decreasing returns to scale (DRS). If output increases by more than that proportion, there are increasing returns to scale (IRS).

However, if

$\alpha + \beta < 1$, return to scale are decreasing, and if

$\alpha + \beta > 1$, returns to scale are increasing. Assuming perfect competition , α and β can be shown to be labor and capital's share of output.

Validation of Instrument

The researcher's drafted instrument was submitted to the adviser for validation, focusing on the instrument's main content. After this, the interview schedule was re-drafted by integrating all the researcher's adviser's suggestions. The research adviser is an expert on longline production as he introduced its use in Samar.

Statistical Treatment of Data

The interview and actual data gathered was organized, tallied, tabulated, analyzed, and interpreted using appropriate statistical measures and procedures. Statistical analysis was made in Minitab® 2018 and R studio and MS Excel spreadsheet.

The Cobb-Douglas Model with the general form presented in Eq'n 1 was used to derive a mussel seed and mussel production function models. This was done by taking the natural logarithms of the model to arrive and apply technology and economic variables that are considered in longline production. Through multiple regression, we can derive the values of α and β which are the coefficient of the constants and the variables respectively. From the studies on longline culture, fourteen explanatory variables were assumed to affect mussel seed production. The basic model was as follows:

$$\ln Y = \ln a + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + \beta_{10} \ln X_{10} + \beta_{11} \ln X_{11} + \beta_{12} \ln X_{12} + \beta_{13} \ln X_{13} + \beta_{14} \ln X_{14} + \varepsilon \quad \textit{(Eqn 2.)}$$

Where:

ln = natural logarithm

Y = dependent variable (number of mussel seeds produced/m^2)

a = intercept

β = the parameters to be estimated

X_i = i^{th} input variable

E = error term

X_1 = broodstock density (number/m^2)

X_2 = broodstock size (grams)

X_3 = age of broodstock (months)

X_4 = broodstock ratio

X_5 = source of broodstock (dummy variable)

X_6 = amount of filter plankton (Liter/hour)

X_7 = labor (mandays)

X_8 = monthly spacing

X_9 = size of farm (ha)

X_{10} = water depth (m)

X_{11} = fish farmer's experience in mussel production

X_{12} = fish farmer's attendance to training (dummy variable)

X_{13} = fish farmer's frequency of farm visit (number/week)

X_{14} = age of mussel bed (years)

For the mussel production function model, eleven explanatory variables were assumed to affect mussel production. The basic model was as follows:

$\ln Y = \ln a + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7$

$+ \beta_8 \ln X_8 + \beta_9 \ln X_9 + \beta_{10} \ln X_{10} + \beta_{11} \ln X_{11} + \varepsilon$ (*Eqn. 3*)

Where the input variables X_is denote the following:

X_1 = stocking rate per mussel sack

X_2 = weight of seed at stocking

X_3 = source of stock

X_4 = labor (mandays)

X_5 = culture period

X_6 = size of farm (ha)

X_7 = water depth (cm)

X_8 = fish farmer's experience in mussel production

X_9 = fish farmer's attendance to training (dummy variable)

X_{10} = fish farmer's frequency of farm visit (number/week)

X_{11} = age of mussel bed (years)

The Cobb-Douglas Economic Model was used to predict the use of multiple linear regression in Minitab 2018 using the raw data gathered from the survey in Appendix H. All values from the surveys were initially used. However, variables that are constant or the same for all respondents are not included in the multiple linear regression. This does not introduce a meaningful correlation or change since it is constant. Also, in modeling, the variance inflation factor (VIF) should be considered. A high VIF (>10) means that there was multicollinearity between independent variables. The variables with high VIF values were summed. This was done in a series of iterations until the resulting VIFs were less than 10. The sum of squares (SS) was first determined for each variable to recover the summed variables. The individual coefficients were then derived using a weighted sum of products. Pearson's r-squared was also generated in Minitab® 2018 to determine the strength of the regression model.

A reduced form of mussel seed production and mussel production were also determined using stepwise regression in R-studio. This software automatically shows the resulting regression equation with the highest r-squared while also considering the lowest number of variables in the equation. Similarly, stepwise regression makes use of Pearson's r-squared to evaluate the strength of the model.

Ethical Considerations

Ethical consideration upon the study's delivery was followed strictly to protect each participant/respondent's rights. Confidentiality of the results was maintained through the use of coding and pseudonyms. In this study, the researcher asked permission from the municipal mayor down to the Municipal Agriculture Officer to gather data on the identified mussel farmer in their municipality. The permit was asked from the Barangay Chairman to assist in visiting mussel farmers in their barangay.

The interview asked questions about mussel farming, culture method, cost per cycle, capital cost, maintenance cost, transportation cost, and mussel production. The letters state that saying yes or no to being in the study would not change any benefits farmers would get in the future. Their help in the study is voluntary but is also helpful to the success of the study. For considering our request for their help, they have received a token to appreciate their effort and time.

Chapter 4

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

This chapter presents the collected data, the corresponding results of the analysis that was undertaken, and the interpretation of findings.

Mussel Seed Production Function

The raw data gathered from the survey that was conducted are shown in Appendix I. Before applying the Cobb-Douglas Production Model, the values of the surveyed variables of mussel seed production were examined. The Cobb-Douglas Production Model's coefficients were estimated using multiple regression or ordinary least squares method (OLS) using the surveyed data in Appendix I. Initial evaluation of the data showed that since the values for brood-stock ratio (x_{4a}) were the same for all farms as well as the amount of filter plankton (x_{6a}) and monthly spacing (x_{8a}), they were removed from the model. A regression model requires that independent variables affect the dependent variable, or an effect can be observed. However, it is not the case for these variables as they remain constant even in the areas that were considered. Moreover, the data should be incorporated in the constant term of the linear model. The model was run using Minitab® 2018.

The pre-runs multiple regression model showed multicollinearity of variables for two data groups. Multicollinearity of variables was identified the high variance inflation factors (VIF) that were greater than 10. A VIF greater than 10 means there is multicollinearity between the variables. When two or more variables are multicollinear, they are correlated or one independent variable can be predicted by another independent variable. This should be prevented by multiple regression models as it undermines the statistical significance of the affected variables. A method to manage multicollinearity is to group or sum the independent variables and post-process the resulting model equation. For this case, labor (x_{7a}) and water depth (x_{10a}) were first grouped. While, the second grouped variables were brood-stock density (x_{1a}), source of brood-stock (x_{5a}), farmer's attendance to training(x_{12a}), and frequency of farm visit (x_{13a}). The multiple linear regression equations' iterations aim to reduce the VIF to an acceptable value are shown in Appendix J.1. Post-processing of data was applied to retrieve the coefficient of the variables in the full regression model. The characteristics of the Mussel Seed Production Model are summarized in Table 1.

The regression equation for the values in Table 1 can be expressed as:

$$\ln y_a = 31.9 + 0.1329x_{1a} - 4.59x_{2a} + 1.90x_{3a} + 0.0186x_{5a} + 0.1032x_{7a} + 0.7363x_{9a} + 0.0928x_{10a} + 0.66x_{11a} + 0.0114x_{12a} + 0.0207x_{13a} - 0.569x_{14a}$$

or in the original form,

$$ya = 31.9x_{1a}^{0.1329}x_{2a}^{-4.59}x_{3a}^{1.90}x_{5a}^{0.0186}x_{7a}^{0.1032}x_{9a}^{0.7363}x_{10a}^{0.0928}x_{11a}^{0.66}x_{12a}^{0.0114}x_{13a}^{0.0207}x_{14a}^{-0.569}$$

The multiple regression equation implies that increasing most factors would result in a higher mussel seed production apart from the broodstock size and the mussel bed's age. Further increasing such positively correlated variables and decreasing negatively correlated variables by one unit will increase production by 50.49 times. Of the variables considered, the broodstock's age has the highest positive correlation to mussel seed production. The production, however, is least correlated to the farmer's attendance at training.

Table 1

Full Regression Model for Mussel Seed Production of Longline Cultures in Samar

Variable	Parameter	Coefficient	SE
Constant	A	31.9	21.2
Broodstock density	β_{1a}	0.1329	0.0402
Broodstock size	β_{2a}	-4.59	3.13
Age of Broodstock	β_{3a}	1.90	1.32
Broodstock ratio	β_{4a}	-	-
Source of broodstock	β_{5a}	0.0186	0.0056
Amount of filter plankton	β_{6a}	-	-
Labor	β_{7a}	0.1032	0.0842
Monthly Spacing	β_{8a}	-	-
Size of farm	β_{9a}	0.7363	0.0869
Water depth	β_{10a}	0.0928	0.0758
Fish farmer's experience in mussel production	β_{11a}	0.6600	0.371
Fish farmer's attendance to training	β_{12a}	0.0114	0.0034
Fish farmer's frequency of farm visit	β_{13a}	0.0207	0.0063
Age of mussel bed	β_{14a}	-0.569	0.316

Coefficient of determination (r^2) = 0.9972

Returns to scale ($\Sigma\beta$'s) = 5.2317

F-value = 50.49

The coefficient of determination is 99.72 percent which suggests that the model development is highly reliable. Further, the F-value of 50.49 means that the model's variables are significant at a 95.00 percent confidence level.

A reduced model for mussel seed production using stepwise regression was also performed. The most appropriate stepwise regression model showed the correlation of the size of farm (x_{9a}) alone is the highest correlated reduced model to mussel seed production. Using the same data in the multiple regression model in Minitab 2018, a stepwise regression was carried out using R Studio software. The result of the stepwise regression displays a regression equation:

$$\ln y_a = 2.974 + 0.9807x_{9a}$$

However, the coefficient of this reduced model is 0.9471, which is lower than the whole model. This implies that the entire model is a more appropriate form to be adapted.

Mussel Production Function Model

Following the mussel seed production data, since the values of the weight of seed at stocking (x_{2b}) were similar in all interviews, it was removed from the analysis. Also, initial runs of multiple regression showed very high VIF between two data groups, as shown in Appendix J.2. The first group consists of the sum of stocking rate per mussel sack (x_{1b}), labor (x_{4b}), and fish farmer's attendance to training (x_{9b}). The second group includes the sum of a source of stock (x_{3b}), water depth (x_{7b}), and frequency of farm visit (x_{10b}). These were done to decrease the VIF, similar to what was discussed in the mussel seed production function. The iterations of the regression modeling are illustrated in Appendix J.2. Summation of values was made to remove multicollinearity and were post-processed to regain the said variables' values for an equation involving all the variables identified as shown in Appendix J.2. The result of the Mussel Seed Production Model is summarized in Table 2.

Table 2

The Full Model for Mussel Production for Longline Cultures in Samar

Variable	Parameter	Coefficient	SE
Constant	α	-4.93	4.08
Stocking rate per mussel sack	β_1	0.1310	0.146
Weight of seed at stocking	β_2	-	-
Source of stock	β_3	0.0348	0.0131
Labor	β_4	0.0467	0.052
Culture period	β_5	4.1000	2.09
Size of farm	β_6	0.7340	0.128
Water depth	β_7	0.0686	0.0258
Fish farmer's experience in mussel production	β_8	0.6480	0.362
Fish farmer's attendance to training	β_9	0.0117	0.013
Fish farmer's frequency of farm visit	β_{10}	0.0309	0.0116
Age of mussel bed	β_{11}	-0.4840	0.203

Coefficient of determination (r^2) = 0.9928

Returns to scale (Σβ's) = 30.49

F-value = 46.28

The regression equation for the values in Table 2 can be expressed as:

$$\ln y_b = -4.93 + 0.1310x_{1b} + 0.0348x_{3b} + 0.0467x_{4b} + 4.10x_{5b} + 0.7340x_{6b}$$
$$+ 0.0686x_{7b} + 0.0648x_{8b} + 0.0117x_{8b} + 0.0309x_{10b} - 0.480x_{11b}$$

or in the original form,

yb= -4.93x1b0.1310 x3b0.0348x4b0.0467 x5b4.10x6b0.7340 x7b0.0686x 8b0.0648 x9b0.0117x10b0.0309x11b-0.480

The above equation implies that increasing one unit of all the variables except the mussel bed's age will increase production by 5.23 times, which is very significant. The determination coefficient was computed as 99.28 percent, which means that the combination of the variables is very highly correlated to mussels' production in the data gathered. Analysis of variance revealed that fitting all the model variables significantly correlates to the yield (kg) of mussel production.

Stepwise regression was also used in R-studio to find a reduced model; however, the results yield a production model with only the farm's size as the single variable. This can be presented through the equation:

$$\ln y_b = 4.024 + 0.9807x_{6b}$$

Also, the coefficient of determination reduces to 0.9471, which is lower than the full model.

From the results of modeling longline culture, it can be concluded that the Cobb-Douglas Model can be used to derive an economic model for longline culture in Samar. The results show that a multiple linear regression model can be derived with an r-squared of 0.9972 for mussel seed production and 0.9928 for mussel production. Using actual data from longline mussel production in Samar, as shown in Table 3, the following values were considered using the coefficients in Table 2.

Though the predicted value is lower than the actual value at 1.48%, it can still be said that the Cobb-Douglas concept is applicable in creating a model for longline culture in Samar.

Table 3

Data for Comparison of Actual vs. Predicted Mussel Production

Variables	**Actual**
Stocking rate per mussel sack	250
Weight of seed at stocking	35
Source of stock	4
Labor	5
Culture period	7
Size of farm	1000
Water depth	5
Fish farmer's experience in mussel production	25
Fish farmer's attendance to training	10
Fish farmer's frequency of farm visit	1
Age of mussel bed	25
Actual Yield	**15,450**
Predicted Yield	**15,222**
%Error	**1.48%**

Profitability Analysis

The lifetime of longline technology used in Samar is five years. Mussel culture methods that use the stake method average a lifetime of two years. In order to create an equal comparison, profitability analysis was extended for ten years. A single cycle for both methods is typically nine months. Hence, in simple analysis, one cycle per year is assumed.

Further, an analysis was made using the same selling price (PhP 12.00 per kg) and interest rate (14.00 percent). Production was also scaled to one hectare. Project economic characteristics are summarized in the table below. Initial capital investment for the longline method was amortized for five years while stake method for two years.

Table 4

Project Costs and Income of Longline and Stake Methods of Mussel Farming in Samar

Item	**Unit**	**Culture Method**	
		Long-line	Stake/Wigwam
Capital Cost	PhP $ha^{-1}yr^{-1}$	226,071.43	142,597.22
Operating Cost	PhP $ha^{-1}yr^{-1}$	23,571.43	126,305.56
Interest	PhP $ha^{-1}yr^{-1}$	20,636.60	15,299.22
Total Expenses	PhP $ha^{-1}yr^{-1}$	270,279.46	284,201.99
Net Income	PhP $ha^{-1}yr^{-1}$	122,849.11	87,580.00
Net Present Value	PhP $ha^{-1}yr^{-1}$	451,503.94	365,070.00

The table compares the two culture methods in terms of capital cost, operating cost, interest, total expenses, net income, and net present value.

The graph above shows that the Net Present Value (NPV) for the longline culture method is higher than the stake method, which means it is a more profitable project to be considered. While capital costs for longline are higher than stake method, these are offset by the latter's higher operating costs. The higher lifetime of longline makes it more economical and practical labor-wise over a longer-term.

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions, and recommendations.

Summary of Findings

The following statement presents the summary of findings based on the result of the study.

Mussel Seed Production Function

1. The multiple regression equation implies that increasing most factors would result in a higher mussed seed production apart from the brood-stock size and the mussel bed's age. Further increasing such positively correlated variables and decreasing negatively correlated variables by one unit will increase production by 50.49 times.
2. The broodstock's age has the highest positive correlation to the mussel seed production of the variables considered. The production, however, is least correlated to the farmer's attendance at training.
3. The coefficient of determination is 99.72 percent which suggests that the model development is highly reliable. Further, the F-value of 50.49 means that the model's variables are significant at a 95.0 percent confidence level.

Mussel Production Function Model

4. The equation implies that increasing one unit of all the variables except the mussel bed's age will increase production by 5.23 times, which is very significant. The coefficient of determination was computed as 99.28 percent, which means that the combination of the variables is very highly correlated to mussels' production in the data gathered. Analysis of variance revealed that fitting all the model variables produces a significant correlation to the yield (kg) of mussel production.

Profitability Analysis

5. The Net Present Value (NPV) for longline culture method is higher than the stake method, which means it is a more profitable project to be considered. While capital costs for longline are higher than the stake method, these are offset by the latter's higher operating costs. The higher lifetime of longline makes it more economical and practical labor-wise over a longer-term.

Conclusions

The following are the statement concluded based on the result of the study.

1. The Cobb-Douglas model is applicable in describing longline culture for mussel production in Samar, Philippines.
2. The longline culture method has a higher NPV than the stake/wigwam method.

3. With the longline culture system, the country need not worry that coastal areas will become shallow and cause the loss of culture sites – threats posed by the old stake method.

Recommendations

The following recommendations were made based on the study conducted:

1. Mussel farmers using the traditional culture method must realize the economic value in shifting to the longline method, giving them a higher return on investment.
2. Strengthen LGU interventions to support sustainable longline mussel farming.
3. A longline culture system is expected to modernize the mussel industry.
4. More hydro-dynamic modeling should be done to advance mussel culture using longline, especially in non-traditional areas or offshore.

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APPENDICES

Appendix A

Letter Asking Permit to Conduct the Study

February ___, 2020

The Honorable
MARILOU R. LATORRE
Municipal Mayor
Municipality of Villareal
Villareal, Samar

Dear Mayor Latorre:

Greetings!

The undersigned is currently conducting a study entitled, **Applicability of Cobb-Douglas Economic Model of Longline Culture of Mussel *Perna viridis* (Linneaus, 1758) in Samar, Philippines**, which aims to come up an economic model for farmers to shift from traditional farming into new technology, in line to my thesis program in Master in Fisheries Technology (MFT) at Samar State University, Catbalogan City, Samar.

Relative to this, I would like to ask for your approval for I need to conduct my study with your mussel farmers in the municipality of Villareal, Samar.

I greatly assure you that any information derived from the study will be treated with utmost confidentiality.

Hoping for your favorable response.

Thank You.

Respectfully yours,

NOEME D. PAJARILLO
Researcher

APPROVED:

HON. MARILOU R. LATORRE
Municipal Mayor

Appendix B

Letter Asking Permit to Conduct the Study

February ___, 2020

The Honorable
DEXTER UY
City Mayor
Catbalogan City

Dear Mayor Uy:

Greetings!

The undersigned is currently conducting a study entitled, **Applicability of Cobb-Douglas Economic Model of Longline Culture of Mussel *Perna viridis* (Linneaus, 1758) in Samar, Philippines**, which aims to come up an economic model for farmers to shift from traditional farming into new technology, in line to my thesis program in Master in Fisheries Technology (MFT) at Samar State University, Catbalogan City, Samar.

Relative to this, I would like to ask for your approval for I need to conduct my study with your mussel farmers in Catbalogan City, Samar.

I greatly assure you that any information derived from the study will be treated with utmost confidentiality.

Hoping for your favorable response.

Thank You.

Respectfully yours,

NOEME D. PAJARILLO
Researcher

APPROVED:

HON. DEXTER M. UY
City Mayor

Appendix C

Letter Asking Permit to Conduct the Study

February ___, 2020

The Honorable
DR. JULIE UY. CERENO
Municipal Mayor
Municipality of Jiabong
Jiabong, Samar

Dear Mayor Sereno:

Greetings!

The undersigned is currently conducting a study entitled, **Applicability of Cobb-Douglas Economic Model of Longline Culture on Mussel *Perna viridis* (Linneaus, 1758) in Samar, Philippines**, which aims to come up an economic model for farmers to shift from traditional farming into new technology, in line to my thesis program in Master in Fisheries Technology (MFT) at Samar State University, Catbalogan City, Samar.

Relative to this, I would like to ask for your approval for I need to conduct my study with your mussel farmers in the municipality of Jiabong, Samar.

I greatly assure you that any information derived from the study will be treated with utmost confidentiality.

Hoping for your favorable response.

Thank You.

Respectfully yours,

NOEME D. PAJARILLO
Researcher

APPROVED:

HON. JULIE UY. CERENO, Ph.D.
Municipal Mayor

Appendix D

Letter Asking Permit to Conduct the Study

February ___, 2020

The Honorable
ENGR. ARNEL R. TAN
Municipal Mayor
Municipality of Tarangnan
Tarangnan, Samar

Dear Mayor Tan:

Greetings!

The undersigned is currently conducting a study entitled, **Applicability of Cobb-Douglas Economic Model of Longline Culture on Mussel *Perna viridis* (Linneaus, 1758) in Samar, Philippines**, which aims to come up an economic model for farmers to shift from traditional farming into new technology, in line to my thesis program in Master in Fisheries Technology (MFT) at Samar State University, Catbalogan City, Samar.

Relative to this, I would like to ask for your approval for I need to conduct my study with your mussel farmers in the municipality of Tarangnan, Samar.

I greatly assure you that any information derived from the study will be treated with utmost confidentiality.

Hoping for your favorable response.

Thank You.

Respectfully yours,

NOEME D. PAJARILLO
Researcher

APPROVED:

HON. ARNEL R. TAN
Municipal Mayor

Appendix E

Letter Asking Permit to Conduct the Study

February ___, 2020

The Honorable

____

Brgy. Chairman

____

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Dear Brgy. Chairman:

Greetings!

The undersigned is currently conducting a study entitled, **Applicability of Cobb-Douglas Economic Model of Longline Culture on Mussel *Perna viridis* (Linneaus, 1758) in Samar, Philippines**, which aims to come up an economic model for farmers to shift from traditional farming into new technology, in line to my thesis program in Master in Fisheries Technology (MFT) at Samar State University, Catbalogan City, Samar.

Relative to this, I would like to ask for your approval for I need to conduct my study with your mussel farmers in your Barangay.

I greatly assure you that any information derived from the study will be treated with utmost confidentiality.

Hoping for your favorable response.

Thank You.

Respectfully yours,

NOEME D. PAJARILLO
Researcher

Appendix F

Letter to the Respondents

____

Dear Respondents:

Greetings!

The undersigned is currently conducting a Master's Degree thesis under the College of Graduate Studies (CGS) in Samar State University (SSU) taken up the Program Master in Fisheries Technology (MFT) major in Aquaculture. The title of the study is "Applicability of Cobb-Douglas Economic Model of Longline Culture on Mussel *Perna viridis* (Linnaeus, 1758) in Samar, Philippines".

In this regard, I am asking for your precious time and effort to answer the questions in the questionnaire that are important and helpful for the completion of the study. The interview asks questions about mussel farming, culture method, cost per cycle including capital cost, maintenance cost, transportation cost, and mussel production.

Saying yes or no to being in the study will not change any benefits you will get in the future. Your help in this study is voluntary but is also helpful to the success of the study. For considering our request for your help, you will receive a token of our appreciation.

Rest assured that all data gathered from you will be kept in the highest level of confidentiality and purely for academic purpose.

Your positive response in this request will be valuable contribution for the success of the study and will highly appreciate.

Thank you very much for your cooperation.

Respectfully Yours,

NOEME DIOCTON-PAJARILLO
Researcher

Appendix G

Respondent's Permit to Conduct the Interview

AGREEMENT TO CONDUCT INTERVIEW

This is to certify that I, ________________________________ (respondent),
(Name: Last Name, First Name, MI)
a mussel farmer of Brgy. __________________________, hereby
(Address)
agree to participate in the research study of **NOEME D. PAJARILLO**, of Samar State University (SSU) in her thesis entitled: "APPLICABILITY OF COBB-DOUGLAS ECONOMIC MODEL OF LONGLINE CULTURE ON MUSSEL *Perna viridis* (Linnaeus, 1758) IN SAMAR PHILIPPINES".

I concur and agree to give my personal data and other data in relation to mussel farming, culture method, cost per cycle including capital cost, maintenance cost, transportation cost, and mussel production needed by the researcher that are important and helpful for the completion of the study.

____
Participants' Signature over Printed Name

Contact No.: ____________________________

Date: ___________________________________

Appendix H

Survey Questionnaire

____

Dear Respondents:

The undersigned is currently conducting a Master's Degree thesis under the College of Graduate Studies (CGS) in Samar State University (SSU) under the Program Master in Fisheries Technology (MFT) major in Aquaculture. The title of the study is "Applicability of Cobb-Douglas Economic Model of Longline Culture on Mussel *Perna viridis* (Linnaeus, 1758) in Samar, Philippines". The purpose of conducting the study is to come up an economic model for mussel farmers to shift from traditional farming form into new technology. We ask for your help to realize this study by providing answers to the following questions in the survey questionnaire. The data and information obtained with this interview will be assured secured and kept confidentially.

Thank you.

NOEME DIOCTON-PAJARILLO
Researcher

Appendix I
SURVEY QUESTIONNAIRE

Name of Respondents: (Optional) ______________________________

Address: ______________________________________

Type of mussel culture: Longline method Wigwam method Staking method

No. of years of mussel farming: ________________ **Date started mussel farming:** __________

A. Source of information		Ownership	
Owner		2. Owner engaged on mussel farming	Yes No
Partner		3. Owner's sole occupation engagement in mussel farming	Yes No
		4. If NO to (3), is mussel farming the main source of income for the owner	Yes No
Variable group		**Variable**	**Unit**
Commercial (destination of the first sale)		5. Wholesaler	
		6. Auction	
		7. Exporter	
		8. Processing industry	
		9. Fishmonger	
		10. Direct selling to the final customer	
		11. Direct Selling to the restaurant	
		12. Self-consumption	
Variable group		**Variable**	**Unit**
Farmers Experience and Training		Mussel farmer's experience in mussel production:	
		Mussel farmer's attendance to training:	
		Mussel farmer's frequency of farm visit:	

B. For Economic Data:

1. Breakdown of Cost per Cycle

Variable Group	**Variable**	**Unit**
Capital Costs of Construction	Materials	
	Labor	
	Others: (Please specify)	
Variable Group	**Variable**	**Unit**
Recurring Operating Expenses	Materials	
	Labor	
	Fuel	
	Others: (Please specify)	
Variable Group	**Variable**	**Unit**
Lifetime of the material: (Longline, Wigwam,Staking)	How long will it be used?	
	Is it constructed every cycle?	

2. Maintenance Cost

Variable Group	**Variable**	**Unit**
Costs	Materials	
	Labor	
	Others: (Please specify)	

3. Transportation Cost

Variable Group	**Variable**	**Unit**
Costs	Fuel	
	Boat/Vessel	
	Others: (Please specify)	

4. Mussel Production

Variable Group	**Variable**	**Unit**
Production	Cycle per year	
	Production (kg or tons) per cycle	
	Selling price of mussels (per kilo or sack)	

C. Mussel Seed Production and Mussel Production Model	Unit
1. Size of farm (ha):	
2. Age of mussel bed (in years):	
3. Broodstock density :	
4. Broodstock size (grams) :	
5. Age of broodstock (months) :	
6. Broodstock ratio :	
7. Source of Broodstock :	
8. Culture period (months) :	
9. Labor (rate per day) :	
10. Monthly Spacing	
11. Water Depth	
12. Stacking rate per mussel sack	
13. Weight of seed at stacking	
14. Amount of filter	

oOo Thank you! oOo

Appendix J

Summary of Survey Result on Longline Mussel Culture

Table I.1. Summary of production data for mussel seed.

Location			Villareal		Jiabong			Catbalogan		Tarangnan	
y	=	Production (kg)	20000	12500	35000	6000	40000	5000	4500	5500	45000
x1	=	broodstock density (number/m^2)	300	300	300	300	300	250	250	300	250
x2	=	broodstock size (grams)	35	35	35	35	35	35	35	35	35
x3	=	age of broodstock (months)	1	1	2	2	2	3	3	4	4
x4	=	broodstock ratio	16	16	15	15	30	3	3	3	3
x5	=	source of broodstock (dummy variable)	7.5	7	7	7	7.5	7.5	7.5	7	7
x6	=	amount of filter plankton (Liter/hour)	400	400	600	100	600	100	100	100	1000
x7	=	labor (mandays)	6.5	6	5	5	6	5	5	5	5
x8	=	monthly spacing	27	15	37	24	20	15	15	10	25
x9	=	size of farm (ha)	1	1	2.2	1	1	2.2	2.2	1	10
x10	=	water depth (cm)	0.1429	0.0667	0.2857	0.2857	0.4286	1	1	1	1
x11	=	fish farmer's experience in mussel production	27	15	37	24	20	45	45	10	25
x12	=	fish farmer's attendance to training (dummy variable)	301	301	302.2	301	301	252.2	252.2	301	260

x13	=	fish farmer's frequency of farm visit (number/week)	1.1	1.1	2.3	2.3	2.4	4.0	4.0	5.0	5.0
x14	=	age of mussel bed (years)	1.4	1.2	1.6	1.4	1.3	1.7	1.7	1.0	1.4

Table I.2. Summary of production data for production.

Location			Villareal		Jiabong			Catbalogan		Tarangnan	
y	=	Production (kg)	20000	12500	35000	6000	40000	5000	4500	5500	45000
x1	=	stocking rate per mussel sack	300	300	300	300	300	250	250	300	250
x2	=	weight of seed at stocking (35 kg/sack)	35	35	35	35	35	35	35	35	35
x3	=	source of stock (Jiabong & Tarangnan)	1	1	2	2	2	3	3	4	4
x4	=	labor (mandays)	16	16	15	15	30	3	3	3	3
x5	=	culture period (120 days)	7.5	7	7	7	7.5	7.5	7.5	7	7
x6	=	size of farm (ha)	400	400	600	100	600	100	100	100	1000
x7	=	water depth (cm)	6.5	6	5	5	6	5	5	5	5
x8	=	fish farmer's experience in mussel production	27	15	37	24	20	15	15	10	25
x9	=	fish farmer's attendance to training (dummy variable)	1	1	2.2	1	1	2.2	2.2	1	10
x10	=	fish farmer's frequency of farm visit (number/week)	0.1429	0.0667	0.2857	0.2857	0.4286	1	1	1	1

x1 1	=	age of mussel bed (years)	27	15	37	24	20	45	45	10	25

Table I.3. Economic data for wigwam and longline production in Tarangnan.

1. Breakdown of Cost per Cycle		
a. Capital Cost for longline Construction	7,000.00 (staking) 100 poles = 50.00/pole	200,000.00 (estimated cost)
b. Recurring Operating Expenses (Labor, Materials, Fuel, etc.)	0	0
c. Lifetime of the longline (How long will it be used? Is a new longline constructed every cycle?)	pole = once only (They used a low qaulity bamboo)	5 years durability of rope (based on farmer's experienced - 2014 start of construction up to now 2020)
2. Cycles per year	1 cycle only	1 cycle only
3. Maintenance cost	500.00	0 (container last only up to 2 cycles.) Damaged due to weather.
4. Transportation Costs	included in capital cost	included in capital cost
5. Selling Price of Mussels (Per Kilo or Sack)	150.00 per pail (14-15 kls per pail) 500.00 per sack (NFA size. 3 pails = 1 sack)	1200/sack
6. Production (Kg or tons) per cycle.	55 sacks (Note: Estimated weight 1sack = 100 kls.)	3 tons (Note: Estimated weight 1sack = 100 kls.)

Appendix K

Multiple Linear Regression of Mussel Seed and Mussel Production Functions

1. Mussel Seed Production Function Derivation

a. First Iteration

Regression Analysis: y versus x1, x2, x3, x5, x7, x9, x10, x11, x12, x13, x14

The following terms cannot be estimated and were removed:
x12, x13, x14

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	8	7.34823	0.91853	*	*
x1	1	0.02669	0.02669	*	*
x2	1	0.02614	0.02615	*	*
x3	1	0.02618	0.02618	*	*
x5	1	0.02272	0.02272	*	*
x7	1	0	1E-06	*	*
x9	1	0.44093	0.44093	*	*
x10	1	0.00007	6.6E-05	*	*
x11	1	0.02918	0.02918	*	*
Error	0	0	*		
Total	8	7.34823			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
*	100.00%	*	*

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	10.92	*	*	*	
x1	3.001	*	*	*	15.75
x2	-4.079	*	*	*	8.37
x3	1.776	*	*	*	7.62
x5	0.4252	*	*	*	17.33
x7	0.0013	*	*	*	20.65
x9	1.036	*	*	*	17.62
x10	-0.1155	*	*	*	18.42
x11	0.3156	*	*	*	4.35

Regression Equation

y	=	10.92 + 3.001 x1 - 4.079 x2 + 1.776 x3 + 0.4252 x5 + 0.001301 x7 + 1.036 x9 - 0.1155 x10 + 0.3156 x11

b. Second Iteration

Regression Analysis: y versus x1, x2, x3, x5, x9, x11, x12, x13, x14, x15

The following terms cannot be estimated and were removed: x14, x15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	8	7.34823	0.91853	*	*
x1	1	0.00252	0.00252	*	*
x2	1	0.00213	0.00213	*	*
x3	1	0.00366	0.00366	*	*
x5	1	0.00956	0.00956	*	*
x9	1	0.79354	0.79354	*	*
x11	1	0.00792	0.00792	*	*
x12	1	0	1E-06	*	*
x13	1	0.00003	2.6E-05	*	*
Error	0	0	*		
Total	8	7.34823			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
*	100.00%	*	*

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	11.43	*	*	*	
x1	3.02	*	*	*	168.98
x2	-4.207	*	*	*	109.16
x3	1.812	*	*	*	56.74
x5	0.4817	*	*	*	52.88
x9	1.027	*	*	*	9.63
x11	0.3281	*	*	*	17.32
x12	0.00682	*	*	*	324.85
x13	-0.0237	*	*	*	168.38

Regression Equation

y	=	11.43 + 3.020 x1 - 4.207 x2 + 1.812 x3 + 0.4817 x5 + 1.027 x9 + 0.3281 x11 + 0.006817 x12 - 0.02367 x13

c. Third Iteration

Regression Analysis: y versus x2, x3, x5, x9, x11, x14, x15, x16

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	8	7.34823	0.91853	*	*
x2	1	0.05878	0.05878	*	*
x3	1	0.06708	0.06708	*	*
x5	1	0.01374	0.01374	*	*
x9	1	0.08863	0.08863	*	*
x11	1	0.0778	0.0778	*	*
x14	1	0.05881	0.05881	*	*
x15	1	0.03019	0.03019	*	*
x16	1	0.04268	0.04268	*	*
Error	0	0	*		
Total	8	7.34823			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
*	100.00%	*	*

Coefficients

Term	Coef	SE COEF	T-Value	P-Value	VIF
Constant	60.99	*	*	*	
x2	-8.717	*	*	*	17
x3	2.859	*	*	*	7.71
x5	-0.8105	*	*	*	104.12
x9	0.507	*	*	*	20.98
x11	1.066	*	*	*	18.62
x14	-1.223	*	*	*	50.91
x15	0.1926	*	*	*	10.48
x16	0.5937	*	*	*	148.82

Regression Equation

y	=	60.99 - 8.717 x2 + 2.859 x3 - 0.8105 x5 + 0.5070 x9 + 1.066 x11 - 1.223 x14 + 0.1926 x15 + + 0.5937 x16

d. Fourth Iteration

Regression Analysis: y versus x2, x3, x9, x11, x14, x15, x17

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	7.32749	1.04678	50.49	0.108
x2	1	0.04466	0.04466	2.15	0.381
x3	1	0.04635	0.04635	2.24	0.375
x9	1	1.4901	1.4901	71.87	0.075
x11	1	0.06555	0.06555	3.16	0.326
x14	1	0.06729	0.06729	3.25	0.323
x15	1	0.03126	0.03126	1.51	0.435
x17	1	0.22599	0.22599	10.9	0.187
Error	1	0.02073	0.02073		
Total	8	7.34823			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.144	99.72%	97.74%	0.00%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	31.9	21.2	1.5	0.374	
x2	-4.59	3.13	-1.47	0.381	6.21
x3	1.97	1.32	1.5	0.375	5.3
x9	0.7363	0.0869	8.48	0.075	2.63
x11	0.66	0.371	1.78	0.326	8.46
x14	-0.569	0.316	-1.8	0.323	9.64
x15	0.196	0.16	1.23	0.435	9.48
x17	0.1836	0.0556	3.3	0.187	4.71

Regression Equation

y = 31.9 - 4.59 x2 + 1.97 x3 + 0.7363 x9 + 0.660 x11 - 0.569 x14 + 0.196 x15 + 0.1836 x17

e. Recovery of Original Variables for Mussel Seed Production Function

Derived Equation

Variable	SE	SS
x2	3.1300	0.0447
x3	1.3200	0.0464
x9	0.0869	1.4901
x11	0.3710	0.0656
x14	0.3160	0.0673
x15	0.0313	0.0313
x17	0.2260	0.2260

Calculated Sum of Squares from the equation SS= i=1n(xi-x)

Variable	Sum of Squares	Variable	Sum of Squares
x1	0.1636	x8	-
x2	0.0447	x9	0.9063
x3	0.0464	x10	0.0234
x4	-	x11	0.0656
x5	0.0229	x12	0.0140
x6	-	x13	0.0255
x7	0.0165	x14	0.0673

Calculated COEFF = %SS x $COEFF_{combined}$

From X15 where β_{15} = 0.196 we get the following

Variable	SS	%SS	β_n
x7	0.0165	41.26	0.1032
x10	0.0234	58.74	0.0928

From X15 where β_{15} = 0.1836 we get the following

Variable	SS	%SS	βn
x1	0.1636	72.39	0.1329
x5	0.0229	10.13	0.0186
x12	0.0140	6.21	0.0114
x13	0.0255	11.27	0.0207

2. Mussel Production Function Derivation

a. First Iteration

Regression Analysis: y versus x1, x3, x4, x5, x6, x7, x8, x9, x10, x11

The following terms cannot be estimated and were removed:

x10, x11, x4

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	7.34268	1.04895	188.99	0.056
x1	1	0.00161	0.00161	0.29	0.686
x3	1	0.04706	0.04706	8.48	0.211
x5	1	0.00038	0.00038	0.07	0.837
x6	1	0.44217	0.44217	79.66	0.071
x7	1	0.00449	0.00449	0.81	0.534
x8	1	0.03489	0.03489	6.29	0.242
x9	1	0.00967	0.00967	1.74	0.413
Error	1	0.00555	0.00555		
Total	8	7.34823			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.074501	99.92%	97.40%	*

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	6.7	23.9	0.28	0.827	
x1	-1.8	3.34	-0.54	0.686	133.81
x3	0.845	0.29	2.91	0.211	33.06
x5	-1.07	4.1	-0.26	0.837	31.98
x6	1.061	0.119	8.93	0.071	18.42
x7	1.15	1.28	0.9	0.534	27.09
x8	0.769	0.307	2.51	0.242	21.57
x9	-0.596	0.452	-1.32	0.413	174.63

Regression Equation

y = 6.7 - 1.80 x1 + 0.845 x3 - 1.07 x5 + 1.061 x6 + 1.15 x7 + 0.769 x8 - 0.596 x9

b. Second Iteration

Regression Analysis: y versus x3, x4, x5, x6, x7, x8, x10, x11, X12
The following terms cannot be estimated and were removed:
x4, X12

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	7.34268	1.04895	188.99	0.056
x3	1	0.00149	0.00149	0.27	0.696
x5	1	0.06156	0.06156	11.09	0.186
x6	1	0.24276	0.24276	43.74	0.096
x7	1	0.03085	0.03085	5.56	0.255
x8	1	0.08086	0.08086	14.57	0.163
x10	1	0.0003	0.0003	0.05	0.854
x11	1	0.09151	0.09151	16.49	0.154
Error	1	0.00555	0.00555		
Total	8	7.34823			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.074501	99.92%	99.40%	*

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-19.7	14.4	-1.37	0.401	
x3	-1.1	2.12	-0.52	0.696	1757.13
x5	17.47	5.25	3.33	0.186	52.45
x6	1.095	0.166	6.61	0.096	35.72
x7	-7.9	3.35	-2.36	0.255	185.6
x8	0.893	0.234	3.82	0.163	12.58
x10	0.217	0.93	0.23	0.854	1224.96
x11	-1.35	0.333	-4.06	0.154	39.89

Regression Equation

y = -19.7 - 1.10 x3 + 17.47 x5 + 1.095 x6 - 7.90 x7 + 0.893 x8 + 0.217 x10 - 1.350 x11

c. Third Iteration

Regression Analysis: y versus x4, x5, x6, x8, x11, x12, x13

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	7.34268	1.04895	188.99	0.056
x4	1	0.0024	0.0024	0.43	0.629
x5	1	0.00001	0.00001	0	0.972
x6	1	0.46527	0.46527	83.83	0.069
x8	1	0.05881	0.05881	10.59	0.19
x11	1	0.00158	0.00158	0.28	0.688
x12	1	0.01333	0.01333	2.4	0.365
x13	1	0.18686	0.18686	33.67	0.109
Error	1	0.00555	0.00555		
Total	8	7.34823			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.074501	99.92%	99.40%	*

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-0.87	3.52	-0.25	0.846	
x4	0.069	0.106	0.66	0.629	14.74
x5	0.07	1.68	0.04	0.972	5.39
x6	1.003	0.11	9.16	0.069	15.66
x8	0.558	0.171	3.25	0.19	6.74
x11	-0.088	0.165	-0.53	0.688	9.78
x12	-0.301	0.194	-1.55	0.365	27.01
x13	0.2241	0.0386	5.8	0.109	4.32

Regression Equation

y = -0.87 + 0.069 x4 + 0.07 x5 + 1.003 x6 + 0.558 x8 - 0.088 x11 - 0.301 x12 + 0.2241 x13

d. Fourth Iteration

Regression Analysis: y versus x5, x6, x8, x11, x13, x14

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	6	7.29559	1.21593	46.2	0.021
x5	1	0.10127	0.10127	3.85	0.189
x6	1	0.86312	0.86312	32.8	0.029
x8	1	0.09221	0.09221	3.5	0.202
x11	1	0.1499	0.1499	5.7	0.14
x13	1	0.18524	0.18524	7.04	0.118
x14	1	0.021	0.021	0.8	0.466
Error	2	0.05264	0.02632		
Lack-of-Fit	1	0.04709	0.04709	8.48	0.211
Pure Error	1	0.00555	0.00555		
Total	8	7.34823			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.162228	99.28%	97.13%	0.00%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-9.54	4.08	-2.34	0.144	
x5	4.1	2.09	1.96	0.189	1.75
x6	0.734	0.128	5.73	0.029	4.52
x8	0.678	0.362	1.87	0.202	6.35
x11	-0.484	0.203	-2.39	0.14	3.12
x13	0.1343	0.0506	2.65	0.118	1.57
x14	0.189	0.212	0.89	0.466	9.75

Regression Equation

$$y = -9.54 + 4.10\ x5 + 0.734\ x6 + 0.678\ x8 - 0.484\ x11 + 0.1343\ x13 + 0.189\ x14$$

e. Recovery of Original Variables for Mussel Production Function

Derived Equation

Variable	Coeff	SE	SS
x5	4.1	2.09	0.10127
x6	0.734	0.128	0.86312
x8	0.678	0.362	0.09221
x11	-0.484	0.203	0.1499
x13	0.1343	0.0506	0.18524
x14	0.189	0.212	0.021

Calculated Sum of Squares from the equation SS= i=1n(xi-x)

Variable	Sum of Squares
x1	0.1281
x2	-
x3	0.0054
x4	0.0052
x5	0.1013
x6	0.8631
x7	0.0107
x8	0.0922
x9	0.0114
x10	0.0048
x11	0.1499

Calculated COEFF = %SS x COEFF$_{combined}$

From X13 where β_{13} = 0.1343 we get the following

Variable	SS	%SS	β_n
x1	0.1281	0.6917	0.1310
x4	0.0052	0.2466	0.0467
x9	0.0114	0.0618	0.0117

From X14 where β_{13} = 0.189 we get the following

Variable	SS	%SS	βn
x3	0.0054	0.2591	0.0348
x7	0.0107	0.5108	0.0686
x10	0.0048	0.2301	0.0309

DOCUMENTATION

Mussel farmers cleaning their harvested mussels. (Brgy. Lamingao, Villareal Samar)

Farm site survey going to Brgy. Lamingao, Banquel, and Guintarcan, Villareal Samar

The researcher conducting interview to the respondent - wife of the Ex-Brgy. Chairman computing the cost of constructing staking method of mussel farming. (Brgy. Lamingao, Villareal Samar)

Passing-by a mussel farm in the municipality of Villareal Samar

The researcher conducting interview to the respondents - wife of mussel farmer (owner) (Jiabong,Samar)

The researcher conducting interview to the respondent - wife of mussel farmer (owner) (Jiabong, Samar)

The researcher conducting interview to the respondent - of mussel farmer (Brgy. Bunu-anan Catbalogan, Samar)

Sacking of mussels for delivery from Jiabong, Samar to Cebu City

The process of breeding the mussels in shallow part of water.

The researcher conducting interview.
(Brgy. Bahay Tarangnan, Samar)

Mr. Cano demonstrating the use of oyster shell as substitute to coconut shell in longline method of mussel farming.

Mussel farm survey in Brgy. Bahay, Tarangnan, Samar

Mr. Cano showing their cultured oyster and mussel.

Mr. Cano showing his harvested 8 month old mussels.

Mr. Cano's mussel farm.

CURRICULUM VITAE

CURRICULUM VITAE

Name	: **NOEME DIOCTON-PAJARILLO**
Birthdate	: October 8, 1992
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Eligibility	: Licensed Professional Teacher
Civil Status	: Married
Name of Spouse	: Ramel F. Pajarillo
Occupation	: Principal I
Department/Office	: DepEd – Samar Division (Villareal NHS)
Office Address	: Villareal, Samar

EDUCATIONAL BACKGROUND

Graduate Studies	: Samar State University
Course	: Master in Fisheries Technology (MFT) Major in Aquaculure
Year Graduated	:
College	: Samar State University – Mercedes Campus
Course	: Bachelor of Secondary Education (BSEd) Major in Fishery Education
Year Graduated	: 2013
Secondary	: Silanga National High School (SNHS)
Year Graduated	: 2009
Elementary	: Pupua Elementary School
Year Graduated	: 2005

WORK EXPERIENCE

Position	: Instructor 1
Department/Office	: SSU-Mercedes Campus
Office Address	: Mercedes, Catbalogan City, Samar
Inclusive Dates	: May 29, 2017 - present
Position	: Secondary School Teacher 1
Department/Office	: DepEd – Samar Division (Plaridel NHS)
Office Address	: Plaridel, Villareal, Samar
Inclusive Dates	: August 04, 2014 – May 28, 2017

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