A Typology of Mariculture Production Systems and Their Profitability in Selected Sites in the Philippines

Alice Joan G. Ferrer, Herminia A. Francisco, Canesio D. Predo
Benedict Mark M. Carmelita, and Jinky C. Hopanda

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Front cover photo: Fish cages in Sual, Pangasinan, Philippines.
Photo by Benedict Mark M. Carmelita

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Alice Joan G. Ferrer
Herminia A. Francisco
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Benedict Mark M. Carmelita
Jinky C. Hopanda

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Comments should be sent to: Dr. Alice Joan G. Ferrer
Division of Social Sciences, University of the Philippines Visayas,
5023 Miagao, Iloilo, Philippines
Tel: +63-33-5137012
Email: aj_ferrer2005@yahoo.com; agferrer@upv.edu.ph

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EXECUTIVE SUMMARY

This study assessed the profitability of mariculture operation in seven mariculture areas in the Philippines using data from key informant interviews, focus group discussions, and reports and records review conducted from January to August 2015. Profit levels and profitability indicators varied by mariculture technology, scale, and location. Mariculture production systems were distinguished by the (1) material used for cages/pens (bamboo, galvanized iron [GI] pipes, rope-framed, or high density polyethylene [HDPE]); (2) scale (number and dimensions of grow-out cages/pens); (3) surface shape (circular vs rectangular/square); and (4) structure (fixed or floating). This paper presents a profitability analysis of these various mariculture production systems.

Results showed variations in the yield (in kg/m^3) of mariculture operation. Milkfish farming using smaller and fewer cages had better or similar yield than those with bigger or more cages. Generally, mariculture operations in the LGU and BFAR-led sites (i.e., Balingasag and Lopez Jaena) had higher yield compared to those in the private sector and LGU-led sites or in the private sector and BFAR-led sites. Except for grouper culture inside the assigned mariculture area and milkfish culture outside the assigned mariculture area in Sto. Tomas, the mariculture operations were found to be profitable. There was high variation in profits and in the values of profitability indicators among mariculture operations in the same and across categories of mariculture areas. Generally, the private sector and LGU-led mariculture operations in Sual and Bolinao registered higher annual gross and net profits compared to other mariculture operations in other categories. On a per kilogram basis, green grouper farming in fish pens outside of the designated mariculture park under the private sector and the BFAR-led mariculture areas in Sto. Tomas registered the highest net profit at PHP 618/kg, followed by green grouper farming using fish cages (PHP 77/kg). In contrast, green grouper farming in the designated mariculture area using a rope-framed cage had the biggest net loss (PHP 94,100; PHP 314/kg). The major investment items were the cages or the pens and the nets, while feeds were the most expensive operation input.

Profits can still be improved if the following major issues are resolved: (1) identification of suitable cage farming sites; (2) availability of the required seeds; (3) production and availability of cost effective grow-out feeds; (4) economically viable farming protocols; (5) carrying capacity assessments of mariculture for sustainability; (6) regulation of key aspects of cage farm management; (7) provision of financial assistance, particularly to small-scale operators; (8) enhancing marketing strategies; and (9) developing and enforcing open sea cage farming policies.

1.0 INTRODUCTION

Starting in the early 2000s, the Philippine government has promoted fish farming in the country through the mariculture park program. This program is expected to contribute to employment generation and poverty alleviation in the countryside; promote marine fish culture as an alternative source of livelihood for marginalized and sustenance fishers; develop an area with appropriate equipment and infrastructure that will allow fishers, fish farmers, and investors to operate cost effectively and securely; develop skilled and technically capable fisherfolk to support the mariculture industry; and promote the use of environment-friendly inputs and farm management practices (Rosario 2008).

As practiced in the country, mariculture parks differ from traditional fish farming present in some areas in the country even before the Bureau of Fisheries and Aquatic Resources (BFAR) introduced the mariculture park program. Mariculture parks cultivate high-value fish and marine life in large enclosures (pens, tanks, or cages) in open sea or municipal waters for food and other products. These include milkfish, siganids, groupers, red snappers, seaweeds, aquasilviculture, mussel culture, oyster culture, and sea ranching of lobsters and seahorses in coral reefs and seagrass areas (BFAR 2009). The *Philippine Daily Inquirer* (2 January, 2012) reported that according to the DA, fish farmed using this method have better quality than fish farmed in fish tanks or ponds.

There has been much optimism in the "moneymaking power of mariculture" (PIA 2009). In fact, it was expected that the yield per cropping of one cage could equal the yield of a two-hectare fishpond. The legal mandate for the establishment of mariculture parks can be found in the Fisheries Code of 1998 (Republic Act [RA] No. 8550) as amended by RA 10654,[1] in the Department of Agriculture and Department of Environment and Natural Resources (DA-DENR) Joint Memorandum Order No. 01 (Series of 2000), and in municipal ordinances (Rosario 2008). The Fisheries Code of 1998 requires that aquaculture areas be designated by local governments in municipal waters or by the DA for areas outside municipal waters (Yap 1999). The appropriate government unit is also required to regulate stocking density and feeding based on the carrying capacity of an area. Accordingly, the development of mariculture parks will make it easier to monitor and regulate the cages installed therein (Rosario 2008; Yap 1999). The idea was that the government will regulate the number and sizes of cages (and thus stocking and feeding), and the distance between cages. Fisheries Office Order 317 (s. 2006) provides the Implementing Guidelines and Procedures in the Establishment and Management of Mariculture Zone/Parks.

With mariculture as a centerpiece program, the BFAR provides technical assistance and financial support in the development of mariculture parks. It is also expected to lead in mariculture park research (e.g., developing new mariculture-related technologies, such as better mooring systems against strong wind and wave action, and cage design standardization) and to provide capacity building support through training of fisherfolk involved in mariculture.

Among the critical challenges in the early years of mariculture park establishment is the low participation of the target beneficiaries. Financial constraint was identified as the major problem. Thus, in 2009, the BFAR came up with guidelines on the implementation of the cage-for-rent program to address the problem of non- or low participation of small fishers due to the high investment cost mariculture requires. To attract investors, the BFAR also provides inputs such as fingerlings and nets. However, there is still lower investment in mariculture than expected despite the claim that mariculture is a lucrative business. As of 2016, less than 1% of the target for mariculture development has been achieved, with only 62 mariculture parks and about 2,200 investors after more than a decade of the program's implementation.

This paper then focuses on the questions: *Is mariculture operation profitable? What are the components of the investment and operational cost of the venture and could these pose a constraint to engagement by local fisherfolk as investors?*

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[1] An Act to prevent, deter, and eliminate illegal, unreported, and unregulated fishing, amending RA 8550, otherwise known as the "The Fisheries Code of 1998," and for other purposes.

This paper considered the varying scale of mariculture operation and the technologies adopted by the operators. Specifically, the paper aims to identify the dominant mariculture technologies in seven mariculture sites in the country and to determine the profitability of the various technologies.

2.0 METHODOLOGY

2.1 The Study Sites and the Classification of Mariculture Areas

Seven municipalities in the Philippines, where there are active mariculture operations, were selected for this study (Figure 1). These were (1) Balingasag, Misamis Oriental and (2) Lopez Jaena, Misamis Occidental in Region 10 (Northern Mindanao); (3) Calape and (4) Talibon, Bohol in Region 7 (Central Visayas); (5) Sto. Tomas, La Union; and (6) Bolinao and (7) Sual, Pangasinan in Region 1 (Ilocos Region). These mariculture sites were chosen to represent those sites where

1. there is a strong presence of the BFAR working closely with the local government unit (LGU) (categorized as LGU and BFAR-led);
2. the private sector is working closely with the LGU (categorized as private sector and LGU-led); and
3. most private mariculture operations exist outside of the established mariculture park and, thus, are not subject to BFAR regulations (private sector and BFAR-led) (Table 1).

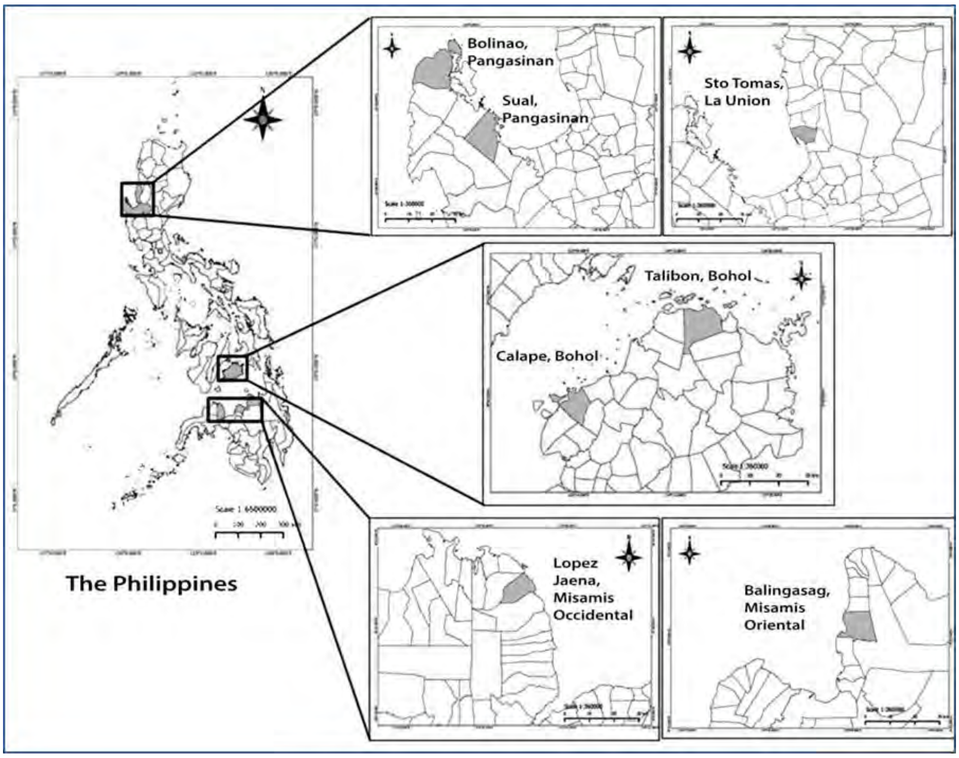

Figure 1. Location of the study sites

Table 1. Categories of mariculture areas selected for the study

Category	Description	Site
LGU and BFAR-led	The area is officially declared as a mariculture park and with an active Executive Management Council chaired by the local chief executive and co-chaired by the BFAR regional director.	Mariculture park in the municipality of Balingasag, Misamis Oriental (Region 10) Mariculture zone in the municipality of Lopez Jaena, Misamis Occidental (Region 10)
Private sector and LGU-led	The LGU has a strong presence in the management and operation of privately-owned fish cages and pens in the identified mariculture zone. The BFAR provides technical support.	Mariculture zone in the municipality of Sual, Pangasinan (Region 1) Mariculture zone in the municipality of Bolinao, Pangasinan (Region 1)
Private sector and BFAR-led	These are officially declared mariculture areas, but most of the privately-owned fish cages and pens are found outside the declared mariculture zone, and their operation is unregulated. The BFAR has demonstration cages in the area, which can be found inside or outside the designated mariculture zone.	Mariculture in the municipality of Calape, Bohol (Region 7) Mariculture in the municipality of Talibon, Bohol (Region 7) Mariculture in the municipality of Sto. Tomas, La Union (Region 1)

Note: *mariculture park; mariculture zone.

2.2 Data and Methods of Data Collection

The data used in this paper came from a larger data set of the project "Economic, Social, and Distributional Aspects of Mariculture in the Philippines" funded by the Economy and Environment Program for Southeast Asia. This paper focuses on the profitability of dominant mariculture technologies in selected mariculture study sites. The larger data set was collected using multiple field data collection methods from November 2014 to August 2015. These include focus group discussions (FGDs), household surveys, key informant interviews (KIIs), secondary data collection, and field observation. In this paper, the data were mostly from KIIs, secondary data collection, FGDs, and field observation.

The profiles of 381 mariculture operators were gathered in this research. Numerous key informants were interviewed on mariculture establishment and operations, consisting mainly of stakeholders who were involved in the different stages of mariculture operations: (1) input (suppliers of feeds and fingerlings and cage and net fabricators); (2) grow out (operators, caretaker/watchman/laborer); and (3) marketing (traders and processors). There were also key informants representing the local mariculture area managers and aquaculture experts from the local government and the BFAR.

Data from 48 FGDs (315 participants) conducted in 27 barangays in the seven sites were also utilized. The participants of these FGDs were selected based on two criteria: (1) they have been residents of the *barangay* (village) even before the establishment of the mariculture area and (2) they must be familiar with mariculture operations in the area.

Relevant secondary data were also collected. They came mostly from the BFAR Central Office and regional offices and their official websites, the local government of the study sites, and from other agencies' official websites. Observations were conducted by visiting the designated mariculture parks/zones and observing major activities such as transporting fingerlings and feeds from the shore to mariculture areas/cages, feeding, changing nets, fabricating cages, harvesting, postharvest activities, and trading. Video documentation of some of these activities is available.

Data were analyzed using frequency counts and descriptive statistics. Financial analysis was used to estimate profitability of the mariculture operations.

3.0 RESULTS AND DISCUSSION

3.1 Typology of Mariculture Production Systems: Practices and Investments

The data collected from about 381 operators, from records and reports, and from in-depth interviews with 43 operators in seven mariculture sites in the Philippines enabled the researchers to identify a typology of the dominant mariculture production systems in the various sites.
The identification of dominant systems considered the (1) scale of operations (using number and size of cages/pens); (2) type of materials used (bamboo, high density polyethylene [HDPE], or galvanized iron [GI] pipes), and (3) structure (floating vs fixed). The mariculture production systems were described by type of governance and by site.

3.1.1. LGU and BFAR-led

The mariculture operations in Balingasag and Lopez Jaena were almost similar. These two sites receive technical assistance from the BFAR Regional Office 10. Their production systems are classified as small, medium, and big, and are largely for milkfish production. Small operators use square-shaped, floating type small bamboo cages (about 5 × 5 × 8 meters [m]). The small fish farmers acquired these cages through the BFAR's rent-to-own scheme, which are identified as "livelihood" cages by the BFAR. A medium operation had bigger square bamboo cages (10 × 10 × 8 m) of the floating type. A medium operator usually owned a few of these units. Big operators had even bigger and more numerous cages made of either bamboo or HDPE, which were either square or circular in structure. HDPE is more expensive but lasts 10–15 years, while bamboo has a maximum life span of three years.

Of the 63 mariculture operations in Balingasag, 28 were classified as small, 24 were medium-scale, and 11 were big-scale operators (Table 2). In Lopez Jaena, there were livelihood operators who received financial support from the BFAR, mostly in the form of cages, nets, and free fingerlings for initial stocking. The dimensions of the livelihood cage were 10 × 10 × 4 m. There were 10 conditioning[2], 36 livelihood operators, 23 medium operators, 10 big-scale operators, which comprise the 79 mariculture operators in Lopez Jaena.

3.1.2 Private Sector and LGU-led

The mariculture operations in the private sector-LGU led areas (i.e., Sual and Bolinao) are considered big operations. The cages were made of HDPE, GI pipes, or bamboo. These cages were bigger than the cages used in the other mariculture sites (LGU and BFAR-led and private sector and BFAR led). In Sual, there were 21 operators identified owning 5–100 cages with cages having dimensions of 17 × 17 × 16 m or circular ones with diameter of 20 m and depth of 8 m, made of HDPE. In Bolinao, the size of the cages or pens were almost the same, but the number of units owned was fewer as there were more operators (131 as of May 2015) in the area. In Sual and Bolinao, milkfish was the primary species being farmed.

3.1.3 Private Sector and BFAR-led

The mariculture operations in the private sector and BFAR-led sites are classified based on their locations: cages are inside or outside of designated mariculture zones. There were six operators in Calape: one serving as a demo site in the mariculture zone and all others were located outside. The structure is floating, made of bamboo structure, and with average cage dimension of 8 × 8 × 8 m. In Talibon, the seven operators were also located outside the mariculture zone using bamboo cages that are floating (6 × 6 × 5 m) or fixed (20 × 20 × 5) (Table 2). There were 74 operators in Sto. Tomas, with only three operating inside the mariculture zone. The cages were either floating or fixed and were made up of different materials (bamboo, HDPE, and ropes as framing materials). They farmed groupers or milkfish. Grouper farming conducted outside of the designated mariculture area used bamboo cages or pens. The fish cages inside the designated mariculture area were farming milkfish (private operator) and grouper (with livelihood assistance from BFAR).

The research team felt it was necessary to describe the different systems that dominate in the study sites as it is not easy to talk of one typical production system. The analysis of the initial capital investment, operating costs, production practices, volume of production, and profitability was carried out following these various mariculture production systems.

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[2] Conditioning cages are smaller cages where fingerlings are first acclimatized before they are transferred to grow out cages.

Table 2. Type of mariculture operations by type of governance, 2015

LGU and BFAR-led					
Site	**Balingasag (63)**				
Type of operator	Small	Medium	Big	Big	
Mariculture production systems in terms of scale (number and size), structure, material, crop	1 5×5×8 m Square, floating Bamboo Milkfish	1 10×10× 8 m Square, floating Bamboo Milkfish	24 10×10× 8 m Square, floating Bamboo Milkfish	4 15×8 m Circular, floating HDPE Milkfish	
Site	**Lopez Jaena (79)***				
Type of operator	Livelihood	Medium	Big	Big	
Mariculture production systems in terms of scale (number and size), structure, material, crop	1 10×10×4 m Square, floating Bamboo Milkfish	2 10×10× 6 m Square, floating Bamboo Milkfish	30 10×10×6 m Square, floating Bamboo Milkfish	11 20×6 m Circular, floating HDPE Milkfish	
Private Sector and LGU-led					
Site	**Sual (21)**				
Mariculture production systems in terms of scale (number and size), structure, material, crop	55 18×8 m Circular, floating HDPE Milkfish	75 20×8 m Circular, floating HDPE Milkfish	22 17×17×16 m Square, floating GI pipe Milkfish	18 19×19×16 m Square, floating GI pipe Milkfish	
Site	**Bolinao (131)**				
Mariculture production systems in terms of scale (number and size), structure, material, crop	13 40×100×10 m Square, fixed pens Bamboo Milkfish	6 18×18×16 m Square, floating cages GI pipe Milkfish	5 18×16 m Circular, floating cages HDPE Milkfish		

Table 2 continued

Private Sector and BFAR-led					
Site	**Calape (6)**				
Mariculture production systems in terms of scale (number and size), structure, material, crop	4 8×8×8 m Square, floating cages Bamboo Milkfish				
Site	**Talibon (7)**				
Mariculture production systems in terms of scale (number and size), structure, material, crop	1 6×6×5 m Square, floating cage Bamboo Milkfish	2 20×20×5 m Square, fixed pens Bamboo Milkfish			
Site	**Sto. Tomas (74)**				
Mariculture production systems in terms of scale (number and size), structure, material, crop	4 16×8 m Circular, floating cage HDPE Milkfish (Inside MP)	1 10×10×6 m Square, floating cage Rope-framed Grouper (Inside MP)	1 10×10×2 m Square, floating cage Bamboo Grouper (Outside MP)	1 10×10×2 m Square, fixed pen Bamboo square Grouper (Outside MP)	1 13×13×2 m Square, fixed pen Bamboo Milkfish (Outside MP)

Note: * Includes 10 conditioning ponds

3.2 Capital Investment in Mariculture Operation by Dominant Production Systems

Table 3 shows the investment made by mariculture operators to set up their operations. The major investment items for mariculture production were cages and nets. Materials for cages were provided by the operators to the local fabricators (locally trained individuals or groups), who were paid by the number of cages constructed. The HDPE cages were bought from Manila.

For the LGU and BFAR-led mariculture areas, the small operators in Balingasag and those using livelihood cages in Lopez Jaena received support from the BFAR for cages and nets. Hence, their investment costs were lower, ranging from PHP 6,000 for a small-scale operator in Balingasag and PHP 60,000 for a livelihood cage operator in Lopez Jaena, to several millions for multiple bamboo cage operators and those using HDPE. A big-scale operator having four HDPE cages in Balingasag spent PHP 3.97 million, while one who owned 11 HDPE cages in Lopez Jaena invested PHP 10.46 million. The cage investment accounted for 70%–80% of the initial capital layout. On the average, a circular HDPE cage having a diameter of 15–20 m and depth of 6–8 m cost PHP 700,000–800,000. A cage made of bamboo with a dimension of 10 × 10 × 8 m cost about PHP 90,000–95,000. In terms of life span, an HDPE can be used up to 10 years while bamboo cages can last up to three years.

The investment cost for mariculture operation in the private sector and LGU-led mariculture areas in Sual and Bolinao was huge, ranging from PHP 36.65 million to PHP 97.18 million in Sual and PHP 3.13–3.9 million in Bolinao (Table 4). Big-scale operation in Sual was characterized by bigger, numerous cages, and reliance on the more expensive HDPE cages. Note that several of the Sual operators are corporations. Hence, they can invest in storage house for feeds and boats and office space and housing units for workers. These structures cost PHP 30 million per operator.

In the private sector and BFAR-led mariculture areas of Calape, Talibon, and Sto. Tomas, the investment cost was relatively lower than that in the other sites since operations in these areas are smaller in scale (Table 5). Those in Sto. Tomas made an initial investment of PHP 23,000–36,000 per fish pen or cage. One HDPE operator in Sto. Tomas with four cages reported an investment of PHP 2.2 million.

Calape mariculture operators used polystyrene foam (popularly called in the study sites as Styrofoam, a trademark brand of polystyrene foam) rolls instead of plastic drums, and these cost around PHP 400 per piece. About 16 pieces of polystyrene foam are needed to make a cage structure float but polystyrene foam do not last longer than plastic drums. For four cages, the initial investment cost for the Calape operator was estimated at PHP 144,000. In Talibon, the fish pens were built by skilled fish corral makers who were paid on a per day basis. The investment cost was PHP 194,000–PHP 422,000, depending on the number of cages.

Table 3. Initial total capital investment (PHP): LGU and BFAR-led mariculture areas

Site	Balingasag (63)				Lopez Jaena (79)			
Type of operator	**Small**	**Medium**	**Big**	**Big**	**Livelihood**	**Medium**	**Big**	**Big**
Mariculture production systems in terms of scale (number and size), structure, material, crop	1 5×5×8 m Square Floating Bamboo Milkfish	1 10×10×8 m Square Floating Bamboo Milkfish	24 10×10×8 m Square, Floating Bamboo Milkfish	4 15×8 m Circular Floating HDPE Milkfish	1 10×10×4 m Square Floating Bamboo Milkfish	2 10×10×6 m Square Floating Bamboo Milkfish	30 10×10×6 m Square Floating Bamboo Milkfish	11 20×6 m Circular Floating HDPE Milkfish
Cage	BFAR rent-to-own	100,000	2,160,000	2,800,000	c/o BFAR	180,000	2,850,000	8,800,000
Net	Part of cage rental	34,000	816,000	Part of cage cost	c/o BFAR	63,360	950,400	Part of cage cost
Mooring	c/o BFAR	c/o BFAR	89,520	14,920	c/o BFAR	c/o BFAR	111,900	41,030
Floating house	None	13,680	13,680	13,680	None	10,050	38,850	38,850
Small boat	6,000	6,000	70,000	28,000	60,000	16,700	–	183,700
Big boat	–	–	–	–	–	–	160,000	55,000
Storage house	–	–	–	–	–	–	60,000	60,000
Foam boxes	–	–	–	–	–	–	360,000	360,000
Harvest net	–	–	13,000	26,000	–	–	26,000	26,000
Harvest tray	–	–	–	–	–	–	120,000	120,000
Harvest table	–	–	–	–	–	–	25,000	25,000
Fish tank	–	–	12,000	20,000	–	–	16,000	24,000
Floating platform	–	–	219,000	365,000	–	–	110,000	165,000
Truck	–		850,000	700,000	–	–	–	560,000.00
TOTAL	**6,000**	**153,680**	**4,243,200**	**3,967,600**	**60,000**	**270,110**	**4,828,150**	**10,458,580**

Notes: (1) USD 1= PHP 45 (2) *na = not applicable

Table 4. Initial total capital investment (PHP): Private sector and LGU-led mariculture areas

Site	Sual				Bolinao		
Mariculture production systems in terms of scale (number and size), structure, material, crop	55 18×8 m Circular Floating HDPE Milkfish	75 20×8 m Circular Floating HDPE Milkfish	22 17×17×16 m Square Floating GI pipe Milkfish	18 19×19×16 m Square Floating GI pipe Milkfish	13 40×100×10 m Square Fixed pens Bamboo Milkfish	6 18×18×16 m Square Floating cages GI pipe Milkfish	5 18×16 m Circular Floating cages HDPE Milkfish
Cage	27,500,000	60,000,000	3,520,000	3,060,000	1,300,000	1,800,000	2,775,000
Net	3,300,000	4,500,000	1,320,000	1,080,000	2,600,000	1,200,000	1,000,000
Mooring	1,100,000	1,500,000	220,000	180,000	–	60,000	100,000
Floating house	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Small boat	240,000	600,000	250,000	250,000	50,000	50,000	50,000
Big boat	2,100,000	500,000	2,000,000	2,000,000	–	–	–
Storage, housing, and office	30,000,000	30,000,000	30,000,000	30,000,000	–	–	–
Fish buckets	60,000	60,000	60,000	60,000	–	–	–
Total cost	**64,320,000**	**97,180,000**	**7,390,000**	**36,650,000**	**3,970,000**	**3,130,000**	**3,945,000**

Notes: (1) USD 1 = PHP 45

Table 5. Initial capital investment (PHP): Private sector and BFAR-led mariculture areas

Site	Calape	Talibon		Sto. Tomas				
Mariculture production systems in terms of scale (number and size), structure, material, crop	4 8×8×8 m Square Floating cages Bamboo Milkfish	1 6×6×5 m Square Floating cage Bamboo Milkfish	2 20×20×5 m Square Fixed pens Bamboo Milkfish	4 16×8 m Circular Floating cage HDPE Milkfish (Inside MP)	1 10×10×6 m Square Floating cage Rope-framed Grouper (Inside MP)	1 10×10×2 m Square Floating cage Bamboo Grouper (Outside MP)	1 10×10×2 m Square Fixed pen Bamboo Grouper (Outside MP)	1 13×13×2 m Square Fixed pen Bamboo Milkfish (Outside MP)
Cage	Rental	150,000	160,000	2,000,000	c/o BFAR	50,000	21,520	34,370
Net	95,200	238,000	–	100,000	–	–	–	–
Mooring	c/o BFAR	3,590	–	–	–	3,000	–	–
Floating house	30,000	15,000	15,000	30,000	–	–	–	–
Small boat	19,000	15,000	19,000	47,000	47,000	–	–	–
Bamboo raft	–	–	–	30,000	–	1,000	1,700	1,800
Total	**144,200**	**421,590**	**194,000**	**2,207,000**	**47,000**	**54,000**	**23,220**	**36,170**

Note: USD 1 = PHP 45

3.3 Production Practices and Operating Costs of Mariculture Production

The production cycle varies by location. In Balingasag and Lopez Jaena, the rearing period lasts for 4–5 months, which allowed the operators to have two croppings a year. The rearing period in Sual and Bolinao is 6–8 months for milkfish, thus allowing for only one cropping a year. The target size for harvested milkfish, however, was bigger at half a kilo. In Calape, the production period is 5 months but operators adopted only one cropping a year. In Talibon, the production cycle is 4 months, thus, enabling three croppings a year for cage culture. This was made possible due to the smaller cages, year-round availability of fingerlings from the BFAR, and the presence of private growers who sell fry and juveniles.

The operating costs for mariculture was estimated as annual cost to cover expenditures for seeds/fingerlings, feeds, and labor for the various activities, involving full-time and part-time workers. Payments for cage rental, fuel, electricity, ice, and other miscellaneous items were also included (Table 6, 7, and 8).

3.3.1 Fingerlings/Seeds

Stocking density depends on the carrying capacity of the cages and feeding habits of the cultured species. The BFAR recommends a stocking density of 5,000 pieces of fingerlings for a 5 × 5 × 5 m bamboo cage; 15,000 fingerlings for a 10 × 10 × 10 m bamboo cage; and 40,000 fingerlings for a 15-m (diameter) HDPE cage. For milkfish, the general rule is to adopt stocking weight of 50–60 grams (g) or length of 5–6 inches, measured from the tip of the mouth to the tip of the tail.

In Balingasag and Lopez Jaena (LGU and BFAR-led mariculture sites), the stocking densities of milkfish for bamboo cages (5,000–15,000 pieces) and for HDPE cages (45,000–48,000 pieces) were within the recommended stocking density, but the size of fingerlings were lower than the recommended level at 30–50 g or 3–5 inches (Table 6). Fingerlings accounted for close to 20% of total annual operating cost in the two sites with a value of PHP 75,000 for small-scale operators; PHP 120,000 for medium operators; and PHP 2.5–2.7 million for big-scale operators in Balingasag. In Lopez Jaena, livelihood cage operators received free fingerlings from the BFAR; medium-scale operators spent PHP 420,000; and big-scale operators spent PHP 3.7–PHP 5.4 million.

With bigger cages/pens in Sual and Bolinao, the stocking density of milkfish fingerlings was between 35,000–60,000 pieces (Table 7). The size of fingerlings used in stocking was 3–4 “up” (equivalent to the width of 3 to 4 fingers). Although the percentage share of fingerlings was smaller at 4%–8%, their value was staggering at PHP 2.7–9 million for big-scale operators in Sual. For Bolinao operators, the fingerlings were valued at PHP 440,000–1 million per year.

In Calape, the floating bamboo cage was stocked with 8,000 pieces of milkfish fingerlings, while in Talibon the smaller bamboo cage was stocked with 20,000 milkfish fingerlings at about 3 inches in length. The milkfish HDPE cage inside the mariculture zone in Sto. Tomas was stocked with 40,000 fingerlings, while fish pens outside of the mariculture zone had lower stocking density of 7,000 pieces (Table 8). Grouper cages inside the mariculture zone were stocked with 6,000 fingerlings at 3–4 “up” size. The floating bamboo cage outside of the mariculture zone, which was three times smaller in dimension, was stocked with only 300 “extra-large” (more than 5 fingers in width) fingerlings. The cost of seeds was placed at 18% of total annual operating cost in Calape (or PHP 80,000) and 16%–19% in Talibon (PHP 162,000–280,000).

Table 6. Production practices and cost: LGU and BFAR-led mariculture areas

Site	Balingasag				Lopez Jaena			
Type of Operator	**Small**	**Medium**	**Big**	**Big**	**Livelihood**	**Medium**	**Big**	**Big**
No. of cages in the sample	1	1	24	4	1	2	30	11
Cage structure	Floating Bamboo Square	Floating Bamboo Square	Floating Bamboo Square	Floating HDPE Circular	Floating Bamboo Square	Floating Bamboo Square	Floating Bamboo Square	Floating HDPE Circular
Dimension of cage	5×5×8 m	10×10×8 m	10×10×8 m	15 m (dia.) × 8 m	10×10×4 m	10×10×6 m	10×10×6 m	20m (dia.) ×6 m
Volume (m^3)	200	800	800	1,414	400	600	600	1,885
Primary species cultured	Milkfish	Milkfish	Milkfish	Milkfish	Milkfish	Milkfish	Milkfish	Milkfish
Production practices								
Stocking density (pcs) per cage	5,000	15,000	15,000	45,000	7,300	15,000	15,000	48,000
Size per piece (inches)	4–5	3	4	4–5	6	4–5	3–4	4.5
Average weight at stocking (grams)	40–50	40	30–40	30–35	30–40	–	30	–
Culture months (per cropping)	4	5	5	5	4	5	5	5
Average weight at harvest (grams)	333	333	333	333	500	500	500	500
Croppings/year	2	1	1	2	2	2	2	1
Fish food consumed/ cage/cropping (sacks)	200	650	700	1,750	258	500	600	1,800

Table 6 continued

Site	Balingasag				Lopez Jaena			
Type of Operator	**Small**	**Medium**	**Big**	**Big**	**Livelihood**	**Medium**	**Big**	**Big**
Production cost (PHP) and share to total (%)								
Seed stock (PHP and %)	75,000 (20.67)	120,000 (18.58)	2,700,000 (17.23)	2,520,000 (19.55)	c/o BFAR	420,000 (20.85)	5,400,000 (16.66)	3,696,000 (19.07)
Feed (PHP and %)	280,000 (77.17)	455,000 (70.46)	11,760,000 (75.04)	9,800,000 (76.04)	386,484 (87.39)	1,498,000 (74.37)	26,064,000 (80.39)	15,147,000 (78.15)
Labor (PHP and %)	1,500 (0.41)	66,480 (10.29)	1,205,322 (7.69)	554,091 (4.3)	51,744 (11.70)	93,000 (4.62)	908,490 (2.80)	505,670 (2.61)
Other variable inputs* (PHP and %)	6,330 (1.74)	4,315 (0.67)	7,331 (0.05)	14,674 (0.11)	4,000 (0.90)	3,300 (0.16)	49,600 (0.15)	34,249 (0.18)
Annual operating cost (PHP)	362,830	645,795	15,672,653	12,888,765	442,228	2,014,300	32,422,090	19,382,919
Annual cost per cage (PHP)	362,830	645,795	653,027	3,222,191	442,228	1,007,150	1,080,736	1,762,084
Annual cost per kg (PHP)	90.71	64.58	81.63	89.50	73.58	91.56	77.20	87.14

Note: * refers to rentals, fuel, ice, electricity, consignment share

Table 7. Production practices and costs: Private sector and LGU-led mariculture areas

Site	Sual				Bolinao		
Level of Operation							
No. of cages/pens in the sample	55	75	22	18	13	6	5
StructurE	Floating HDPE Circular	Floating HDPE Circular	Floating GI pipe Square	Floating GI pipe Square	Fish pen (fixed) Bamboo Square	Fish cage (floating) GI pipe square	Fish cage (floating) HDPE Circular
Dimension of cage/pen	18 m (dia.) × 8 m	20 m (dia.) × 8 m	17×17×16 m	19×19×16 m	40×100×10 m	18×18×16 m	18 m (dia.) ×16 m
Volume (m^3)	2,036	2,513	1,734	2,166	40,000	5,184	4,072
Primary species cultured	Milkfish	Milkfish	Milkfish	Milkfish	Milkfish	Milkfish	Milkfish
Production Practices							
Stocking density (pcs) per cage	50,000	60,000	45,000	50,000	35,000	40,000	40,000
Size per piece* (inches)	3–4 up	3–4 up	4 up	4 up	3–4 up	3–4 up	3–4 up
Average weight at stocking (grams)	n.d.	8–10; 11–15	n.d.	n.d.	n.d.	n.d.	n.d.
Culture months (per cropping)	8	8	6	6	7	7	7
Average weight at harvest (grams)	500	500	500	500	500	500	500
Croppings/year	1	1	1	1	1	1	1
Feed consumed per cage/cropping (sacks)	3,000	4,800	2,300	2,600	1,500	1,800	1,800

Table 7 continued

Site	Sual				Bolinao		
Production costs (PHP) and share to total (%)							
Seed stock	5,500,000 (3.93)	9,000,000 (4.23)	2,970,000 (7.77)	2,700,000 (7.56)	1,001,000 (6.31)	528,000 (5.97)	440,000 (5.95)
Feed	123,750,000 (88.44)	180,000,000 (84.54)	25,300,000 (66.22)	23,400,000 (65.52)	13,650,000 (86.04)	7,560,000 (85.48)	6,300,000 (85.21)
Labor	2,638,279 (1.89)	10,216,570 (4.8)	6,666,470 (17.45)	6,396,219 (17.91)	102,526 (0.65)	124,221 (1.40)	120,721 (1.63)
Other variable inputs**	8,030,000 (5.74)	13,699,440 (6.43)	3,270,360 (8.56)	3,215,360 (9.00)	1,110,500 (7.00)	632,000 (7.15)	533,000 (7.21)
Annual operating cost	139,918,279	212,916,010	38,206,830	35,711,579	15,864,026	8,844,221	7,393,721
Annual cost per cage	2,543,969	2,838,880	1,736,674.	1,983,977	1,220,310	1,474,037	1,478,744
Annual cost per kg per cage	84.80	94.63	69.47	66.13	81.35	81.89	82.15

Notes: (1) USD 1 = PHP 45, (2) n.d. = no data (3) * up means using the width of one's fingers to estimate the width of the fish, 1 up is equivalent to one finger, (4) ** refers to rentals, fuel, ice, electricity, consignment share

Table 8. Production practices and costs: Private sector and BFAR-led mariculture areas

Site	Calape	Talibon		Sto. Tomas				
Level of Operation								
No. of cages/pens in the sample	4 cages	1 cage	2 fish pens	4 cages	1 cage	1 cage	1 fish pen	1 cage
Cage structure	Floating Bamboo Square	Floating Bamboo Square	Fixed Bamboo Square	Floating HDPE Circular	Sinking Rope-frame Square	Floating Bamboo Square	Fixed Bamboo Square	Fixed Bamboo Square
Dimension of cage/pen	8×8×8 m	6×6×5 m	20×20×5 m	16 m (dia.) ×8 m	10×10×6 m	10×10×2 m	10×10×2 m	13×13×2 m
Volume (m^3)	512	180	2,000	1,609	600	200	200	338
Primary species cultured	Milkfish	Milkfish	Milkfish	Milkfish	Green Grouper	Green Grouper	Green Grouper	Milkfish
Production practices								
Stocking density (pcs) per cage	8,000	20,000	20,000	40,000	6,000	300	2,000	7,000
Size per piece (inches)	3–4 in	3 in	3.5 in	3.5–4 in	3–4 up	2 up-XL	1–3 in	3 up
Average weight at stocking (grams)	10	n.d.	n.d.	15	n.d.	n.d.	n.d.	n.d.
Culture months (per cropping)	5	4	5	5	9	9	5	8
Average weight at harvest (grams)	333	250	250	333	1000	500	500	333
Cropping/year	1	3	2	2	1	1	1	1
Fish food consumed/ cage/cropping	110 sacks	320 sacks	352 sacks	1,200 sacks	504 kg	1,080 kg	1,440 kg	25 sacks

Table 8 continued

Site	Calape	Talibon		Sto. Tomas				
Production costs (PHP) and as share to total cost (%)								
Seed stock	80,000 (17.82)	162,000 (16.41)	280,000 (18.81)	768,000 (8.49)	240,000 (94.34)	8,750 (34.57)	21,000 (42.00)	17,500 (48.21)
Fish food	330,000 (73.50)	710,400 (71.94)	1,126,400 (75.68)	7,776,000 (85.92)	12,600 (4.95)	16,200 (64.00)	28,800 (57.60)	18,500 (50.96)
Labor	30,500 (6.79)	77,616 (7.86)	62,780 (4.22)	396,363 (4.38)	1,800 (0.70)	–	–	300 (0.83)
Other variable inputs*	8,500 (1.89)	37,464 (3.79)	19,200 (1.29)	110,000 (1.22)	–	360 (1.00)	200 (0.40)	–
Annual operating cost	449,000	987,480	1,488,380	9,050,363.	254,400	25,310	50,000	36,300
Annual cost per cage	112,250	987,480	744,190	2,262,591	254,400	25,310	50,000	36,300
Annual cost per kg per cage	74.83	82.29	93.02	87.47	848.00	253.10	41.67	145.20

Note: (1) * refers to rentals, fuel, ice, electricity, consignment share. (2) Sacks is for feeds and kilograms is for trash fish.

3.3.2 Feeds

Overfeeding is a major source of water pollution in aquaculture or mariculture operations. Hence, the BFAR requires caretakers to undergo a mandatory training on cage culture and feeding management. The prescribed feeding is 5–6 times during daytime only, with feeding times lasting 30–60 minutes. The amount of slow-sinking feeds given differs with the age of the farmed fish, with bigger amounts and more frequent feeding prescribed after 21 days of fish rearing. Feed cost accounts for the biggest share of the variable costs of mariculture operations.

In Balingasag and Lopez Jaena, the feeds (in 25-kilogram sacks) used per cage for the entire cropping was 200–258 sacks for the small/livelihood bamboo cages, 500–650 sacks for medium bamboo cages, 600–700 sacks for big bamboo cages, and 1,750–1,899 sacks for big and circular HDPE cages (Table 6). Feed cost accounts for about 77% of total annual operating cost, worth PHP 280,000 for small operators, PHP 455,000 for medium operators, and PHP 9.8–11.76 million for big-scale operators in Balingasag. The feed cost for Lopez Jaena was about 80% of total annual operating cost valued at PHP 386,000 for livelihood cage producers, PHP 1.5 million for medium operators, and a huge PHP 15–26 million for big-scale operators. This is a big cost that no small-time community fisherfolk can afford.

The amount of feeds used for Sual and Bolinao cages was even higher, particularly since operators practice continuous feeding from 6 a.m. to 6 p.m. This is not the recommended practice, and is most likely the reason for the increased incidence of fish kills in these study sites. The estimated feed consumption in terms of sacks per cage ranged from 2,300 to 4,800 in Sual and from 1,500 to 1,800 in Bolinao (Table 7). Translating these feed quantities to value—the feed cost was valued at PHP 23.4 million annually for 18 units of GI-pipe floating square cages and PHP 180 million for 75 units of HDPE floating circular cages. The expenditure of Bolinao operators on feeds was relatively lower at PHP 528,000 for six units GI-pipe floating circular cages, PHP 1.0 million for 13 units fixed bamboo square cages, and PHP 6.3 million for five units of HDPE, circular cages.

The fish farmer in Calape used about 110 sacks of feeds per cropping while fish farmers in Talibon used 320 sacks of feeds in their fish cages (Table 8). For fish pens, a total of 1,200 sacks of feeds were used in one cropping. The investment on feeds was estimated at PHP 330,000 for four floating bamboo cages, amounting to about 73% of total operating costs. In Talibon, expenditure on feeds was placed at PHP 710,000–PHP 1.13 million for the bamboo floating cages with 2–3 croppings per year. It was observed that feeding practices in Calape and Talibon differed from other mariculture sites. Feeding was done 3–5 times a day and used "grower" feeds during the second month and "finisher" feeds on the third to fifth months. In Sto. Tomas, the feeding of milkfish was carried out two or three times a day (7–8 a.m., 11:30 a.m.–12:00 p.m., and 3–4 p.m.).

For Sto. Tomas operators growing groupers, they used trash fish (small "sapsap" and tilapia) as feeds. Feeding depended on the availability of trash fish. Feeding can be twice weekly, or four times a week when there was an abundant supply of trash fish and depending on the budget of the operators. Feeds were usually given in the morning and during high tide. Every feeding used up 5–7 kg, 6 kg, 7–8 kg, or 10 kg of trash fishes, depending on the size of fish. Feed cost was thus much lower at 5% of total annual operating cost or PHP 12,600 per year. The milkfish farmed inside the mariculture zone in Sto. Tomas used 1,200 sacks per cage per cropping and with four HDPE floating circular cages, the cost of feeds was huge at PHP 7.77 million, representing 86% of total annual operating cost. Milkfish growers outside of the mariculture zone used 25 sacks in one cropping and incurred an annual cost of PHP 18,500, which amounted to 51% of total annual operating cost.

Overall, the cost of feeds indeed represents a big component of the cost of mariculture operations and continues to be the limiting factor for engaging community fishers in mariculture park investment. It is no wonder that this venture generally attract only big-scale rich investors.

3.3.3 Labor operations required

In the LGU and BFAR-led sites of Balingasag and Lopez Jaena, labor requirements included a caretaker, manager, watcher, harvester, and net changers. The work of the caretaker included feeding the fish, mending nets, and guarding the cages during the day. The manager supervised the caretakers and reported to the operator. Harvesters were on call during harvest time; their work included scooping fish from the cages to the boat, transporting fish from the cage area to the landing site, classifying or sizing the fish, and loading them to the delivery truck. The net changers changed the nets of cages. The watcher guarded the cages during the night.

Labor cost accounted for less than 1%–10% of the total annual operating cost, ranging from PHP 1,500 (excluding owner-operator labor) to PHP 1.2 million for big-scale operators in Balingasag. In Lopez Jaena, the livelihood cages incurred an operating cost of PHP 51,700 per year, amounting to 12% of the total operating cost, while big-scale operators spent PHP 908,500 on labor annually (Table 6).

In the private sector and LGU-led sites, Sual had the highest labor requirement because of the big scale of their operation. They needed more workforce as feeder, maintenance workers, harvesters, security workers, manager, technician, supervisor, secretary, boat driver, boat helper, truck driver, and truck helper. Altogether, their labor costs range from PHP 2.64 million to PHP 10.2 million per year, which represents 2%–18% of total operating cost (Table 7). Bolinao operators' expenditure on labor cost represented 1%–2% of their total annual operating cost amounting to PHP 102,000–124,000 per year.

In Calape and Talibon, the caretaker was the main labor hired, and harvesters were hired only during harvest time. Hence, labor cost was only PHP 30,500 or 7% of total operating cost. In Sto. Tomas, particularly in fish cages and pens outside of the mariculture zone, the operator was also the caretaker who did all the work needed. In grouper farming outside of the mariculture zone in Sto. Tomas, the scale of operation was small, with the owner doing all the work. Labor costs of owner-operators were not valued in the calculation shown in Table 8. In grouper farming inside the mariculture zone, the members of the association that own the operation helped each other in maintaining the operation.

Table 9 shows the wages for hired labor in the mariculture sites. In general, the wages are below the minimum wage rate, and few received employment benefits such as health insurance and social security. Those employed by big-scale operators in Sual and Bolinao get better pay and even a share in the profit. In other study sites, the workers were also provided one sack of rice as monthly food subsidy.

Table 9. Compensation of hired labor

LGU and BFAR-led	
Balingasag	**Lopez Jaena**
Caretaker: PHP 200/day; 1 sack of rice/month; SSS + PhilHealth Watchman: PHP 150/day; 1 sack of rice/month Manager: PHP 250/day; 1 sack of rice/month Harvester: PHP 0.60/kg Net changer: PHP 250/net (small players); PHP 800/net (medium and big players)	Caretaker: PHP 150–200/day; 1/2–1 sack of rice/month; SSS + PhilHealth; harvest incentive at PHP 1/kg Manager: PHP 200/day; 1 sack of rice/month; SSS + PhilHealth; harvest incentive at PHP 1/kg. Harvester: PHP 0.60/kg, PHP 150/person, PHP 250/cage Net changer: PHP 500–600/net
Private Sector and LGU-led	
Sual	**Bolinao**
Feeder: PHP 166.67– 200/day; rice allowance of 25 kg/month, 10% of net profit, SSS + PhilHealth Maintenance worker/Net changer: PHP 300–500/net Harvester: PHP 600/ton/harvest Security: PHP 200/day Manager: PHP 50,000/month; 10% commission during harvest Technician: PHP 500/day; PHP 250/truck during harvest Supervisor: PHP 20,000/month; 5% commission, PHP 250/truck during harvest Secretary: PHP 300/day; PHP 250/truck during harvest Boat Driver: PHP 4,000/month; food and accommodation; PHP 300/trip during harvest Boat Helper: PHP 4,000/month; food and accommodation; PHP 250/trip during harvest Truck Driver: PHP 1,000–2,000/trip Truck Helper: PHP 500–600/trip	Feeder: PHP 60–PHP 133.33/day. Incentive: 6%–10% of net income during harvest; rice allowance; SSS + PhilHealth Net changers: PHP 250/net Harvest laborers Taga-saklit: PHP 4,500/saklit Classifier: PHP 3,800/harvest Laborer: PHP 300/person Pawis: PHP 120/banyera Byahero: PHP 1,200

Table 9 continued

Private Sector and BFAR-led		
Calape	**Talibon**	**Sto. Tomas**
Caretaker: PHP 100/day; PHP 2,000 weekly allowance Net changer: PHP 200/net Harvester: PHP 150/person	Caretaker: PHP 133.33/day; 1 sack of rice/month Net changer: PHP 200/net Harvester: PHP 150/person	Feeder: PHP 150–200/day; 2 cavans of rice; 6% of net income divided by number of laborers; SSS + PhilHealth Technician: PHP 250/day Supervisor: PHP 14,000/month Diver: PHP 150/day; 2 cavans of rice, 6% of net income divided by number of laborers; SSS + PhilHealth Net mender: PHP 150/day; 2 cavans of rice; 6% of net income divided by number of laborers; SSS + PhilHealth Harvester: PHP 100/person; PHP 300/harvest Net changer: PHP 200/ net

Note: USD 1 = PHP 45

3.3.4 Annual operating cost per cage and per kilogram of fish

To sum up, the annual operating cost per cage and per kilogram of fish of Balingasag operators was PHP 362,830 per cage made up of bamboo and with a dimension of 5 × 5 × 8 m. Considering the volume of harvest, this translates to PHP 91/kg of milkfish. For bigger cages of 10 × 10 × 8 m made of the same material, the operating cost was PHP 645,795 per cage or PHP 65/kg. The big operators (having more cages) incurred almost the same operating cost per cage of PHP 653,027, but are not necessarily more efficient as cost per kilogram was higher at PHP 82. HDPE cage costs PHP 3.22 million or PHP 89.50/kg.

In Lopez Jaena, even the livelihood cage operators receiving some support from the BFAR had to spend PHP 442,228 per cage or PHP 73.58/kg. Medium- and big-scale operators needed a big annual operating cost of a million pesos per cage that translates to PHP 77–92/kg.

The operating cost per year in Sual mariculture farms was estimated at PHP 1.98–2.84 million per cage or PHP 66–95/kg for big cages using either GI pipe or HDPE. The annual operating cost for Bolinao operators did not vary much at PHP 1.22–1.47 million per cage or PHP 82/kg of milkfish.

In Calape, the total annual operating cost was PHP 449,000 or PHP 112,250 per cage, which translates to PHP 74.83/kg given the level of production. For Talibon operators of a unit of floating bamboo cage, the annual cost was PHP 987,480 per cage or PHP 82.29/kg. In the fixed bamboo cage, the annual cost was PHP 744,190 per cage or PHP 93.02/kg.

The cost incurred by Sto. Tomas operators for the HDPE cages for milkfish production inside the mariculture zone was also high at PHP 2.26 million or PHP 87.47/kg. For rope-framed cages having a size of 10 × 10 × 6 m, this was the operator's first attempt to grow grouper; and he incurred an annual operating cost per cage of PHP 254,400 (94% of which was the cost of seeds). Unfortunately, his operation suffered a setback, which he attributed to the fish blasting practice of nearby fishers that resulted in high mortality of the groupers (5,000 out of 6,000 fingerlings died). The cost per kilogram, thus, was higher at PHP 848.00. The grouper farmer outside of the mariculture zone had a lower cost of PHP 253/kg from his floating bamboo cage, but the fixed cage bamboo had an even lower cost of PHP 42/kg due to higher yield from the fixed cage. It seems that grouper farming is a riskier investment in the site.

3.4 Harvesting and Marketing Practices

In Balingasag, complete harvesting of a cage was practiced. Sorting or "sizing" was done soon after harvest using the following grouping: small at 250–349 g, medium at 350–399 g, large at 400 g and up. The harvest was scheduled and done by caretakers and a few hired help. Each received a payment of PHP 0.60/kg harvested. The fish were transported to the market by big traders. The ice was bought in the nearby city and brought to the site by the truck that picked up the harvest. Fifteen blocks of ice (at PHP 215 per block) were used for a three-ton harvest. The fish were sold in the local market in Cagayan de Oro City (Westbound Market in Bulua, Cogon, Carmen, Agora, Bugo, Puerto, and Gusa). But the fish could reach as far as Iligan City, other municipalities (e.g., Jasaan, Tagoloan), and even Cebu, Negros Island, and Manila.

In Lopez Jaena, the buyer of the harvest was also the supplier of feeds and fingerlings. The cost of feeds was usually deducted during the harvest. The fish were also sorted according to size, similar to Balingasag. The landing site was a barangay waiting shed. The harvesters were also the caretakers who were paid PHP 0.60/kg of harvest. Local fish traders also bought about 50–100 kg of the harvest. The three big buyers (two from the LGU and one from outside) provided the transport vehicles for the harvest. The two local big buyers bought ice in Oroquieta City at PHP 280/block using up five blocks per ton of harvest. Meanwhile, farmers would increase the price by PHP 10–20, if they were to sell the harvest in the local market. However, selling was difficult when there was a glut in the market. The harvest was sold within the LGU and Dapitan City, and even as far as the cities of Iligan, Cebu, Dumaguete, Bacolod, and Tacloban.

In Sual, maintenance workers and hired labor also served as harvesters. Harvesting involved three stages: (1) scooping of fish from the cage, (2) classifying the fish by size, and (3) loading the fish in the truck. The rates were PHP 10/banyera or tub, PHP 600/ton, or PHP 3,000/truck. The target harvest was two pieces per kilogram or the fish having an average body weight of 500 g per piece. An auxiliary fee paid was at PHP 5.00/banyera. Local fish vendors and direct buyers from Tarlac and Zambales bought around 300–1,000 kg of the harvest, when allowed by the operator. The price used was the prevailing price in the consignment areas. The broker received a 4%–5% share of the income.

The farmers transported their harvests using their own or a rented truck, which costs around PHP 50,000 per trip. Truck services started in Alaminos City where the ice is loaded and brought to the mariculture sites. Similar harvest practices were found in Bolinao because some of the operators originally came from there.

In Bolinao, a number of laborers are involved during the harvest. The harvester (*taga-saklit*) scooped the fish from the cage, the laborer counted and carried the fish, the classifier did the sizing, and the *ilador* put ice on the fish. There were also the paws, who provided transport from the pen/cage to the fish port. The *byahero* accompanied the driver and the helpers at the consignment area to do the transaction and recorded/witnessed the selling of the harvest. The two local fish traders in the area bought around 100–400 kg of harvested fish, which they sold at the local market. They said that species from capture fisheries sell faster because tourists often search for these, while milkfish can be bought in Manila. It was difficult to sell fish from cages because of high competition. The price of farmed fish during the low season was PHP 114/kg and sold for PHP 120/kg; during high season, farmed fish were bought for PHP 118/kg and sold for PHP 130/kg. The rental cost for a 10-wheeler truck with ice was about PHP 38,000/trip. The ice used was around 85 blocks for 360 *banyeras*, which were bought in Bolinao, Alaminos, and Sual.

The fish were sold in the local market and in fish ports in Dagupan City. If the size of harvested fish was more than two pieces per kilogram (about 500 g per fish), then the fish were sold in Manila, particularly in Navotas and Malabon. If the size of harvested fish was three pieces per kilogram, then the fish was sold in Dagupan. There were four consignment operators identified in Malabon and Navotas fish ports and seven consignment operators in Dagupan fish port.

In Calape, local traders bought harvests from cages and contacted the wholesaler. The local fish traders bought up to 50 kg, and sold it for around PHP 100–120/kg or an increase of PHP 20/kg from the farm gate price. Ice and transport cost were covered by the buyer.

In Talibon, a harvester from the local area was hired to assist, or the buyer brought a team of harvesters. A boat was rented to transport the harvest to Cebu (deducts 5% from total sales), and there was also a local buyer who sold the fish in the local market. The target harvest size was, at the minimum, 250 g per fish. Complete and partial harvest was practiced depending on the buyer. The fish was in demand during November, December, and January because of the holidays. The buyer shouldered the transport cost of fish sold in the local market using ice from an ice plant in Tagbilaran City. The market destinations included the local market, Calape, Ubay, Tagbilaran City, and Cebu.

In Sto. Tomas, the milkfish harvesters were also the caretakers/feeders. Operators hired one or two people to assist in the harvest, whose compensation was 6% of the net income from the harvest. From the usual four direct buyers, operators chose the buyer who paid them in cash. The buyers identified their suppliers by doing a canvass (going to operators to ask if they have stocks ready for harvest) or contacting the operators through short messaging system or phone call. The target marketable size was around 420 g or higher per piece, with prices higher during December to April. Transport was done by the operator (who operates a fishpond in Dagupan). The groupers were harvested live and picked up by the buyers from the cage area. No ice was used.

3.5 Profitability of Mariculture Operation

Results show large variations in the yield (kilograms per cubic meter [kg/m^3]) of mariculture operation. Milkfish farming using smaller and few cages had a better or similar yield than those with bigger or more cages. The milkfish cage operator in Talibon using a small floating bamboo cage had the highest yield of 67 kg/m^3.

Generally, mariculture operations in the LGU and BFAR-led sites of Balingasag and Lopez Jaena had higher harvest compared to operations in the private sector and LGU-led sites or in the private sector and BFAR-led sites (except for the milkfish cage operator in Talibon mentioned earlier). The harvests in Balingasag and Lopez Jaena were comparable. The most efficient operator was the big player in Balingasag using HDPE cages to farm milkfish with a yield of 25.45 kg/m^3 (Table 10).

In Sual, the different operators had a comparable level of production per cubic meter regardless of the type of cages used. In general, the yield in Sual was higher compared with that in Bolinao. When compared to the other cage and fish pen operations of milkfish in other study sites, Bolinao had the lowest production (Table 11).

In Sto. Tomas, the farmers of groupers were less productive than milkfish farmers. The most efficient operator was operating inside the mariculture area using HDPE cages. The least efficient were the grouper operators regardless of their location (Table 12).

Tables 10, 11, and 12 also show the level of gross and net profits and other profitability indicators per type of operation in the mariculture sites. Except for grouper culture inside the assigned mariculture area and milkfish culture outside the assigned mariculture area in Sto. Tomas, the mariculture operations were found to be profitable. There was high variation in profits and in the values of profitability indicators among mariculture operations in the same category and across categories.

The private sector and LGU-led mariculture operations in Sual and Bolinao registered higher annual gross and net profits compared to other mariculture operations in other categories. In particular, the different mariculture operations in Sual registered the highest annual gross profit (between PHP 22 million and PHP 57 million) and net profit (ranged between PHP 20 million and PHP 50 million). The mariculture operations in Bolinao followed, with the gross profit ranging between PHP 2.5 million and PHP 5.6 million and net profit between PHP 2.4 million and PHP 4.3 million (Table 11).

Table 10. Profitability of mariculture operation: LGU and BFAR-led mariculture areas

Mariculture Production Systems	LGU and BFAR-led							
	Balingasag				**Lopez Jaena**			
	Small Player	Medium Player	Big Player 1	Big Player 2	Livelihood recipient	Medium Player	Big Player 1	Big Player 2
	1 unit, Bamboo, Floating, Square, 5x5x8 m, Milkfish	1 unit, Bamboo, Floating, Square, 10x10x8 m, Milkfish	24 units, Bamboo, Floating, Square, 10x10x8 m, Milkfish	4 units, HDPE, Floating, Circular, 15x8 m (dia.), Milkfish	1 unit, Bamboo, Floating, Square, 10x10x4 m, Milkfish	2 units, Bamboo, Floating, Square, 10x10x6 m, Milkfish	30 units, Bamboo, Floating, Square, 10x10x6 m, Milkfish	11 units, HDPE, Floating, Circular, 20x6 m (dia.), Milkfish
Total annual harvest (kg)	4,000	10,000	192,000	144,000	6,010	22,000	420,000	222,431
Annual harvest per cage/cropping (kg)	2,000	10,000	8,000	18,000	3,005	5,500	7,000	20,221
Annual harvest per kg/m^3	20.00	12.50	10.00	25.45	15.00	18.33	23.33	10.73
Average farm gate price (PHP/kg)	96.00	96.00	95.00	98.00	93.00	95.00	95.00	96.00
Annual revenue (PHP)	384,000	960,000	18,240,000	14,112,000	558,930	2,090,000	39,900,000	21,353,376
Annual operating cost (PHP)	362,830	645,795	15,672,653	12,888,765	442,228	2,014,300	32,422,090	19,382,919
Gross profit (PHP)	21,170	314,205	2,567,347	1,223,235	116,702	75,700.	7,477,910	1,970,457
Net profit (PHP)	18,770	246,798	1,160,974	649,913	112,702	17,528	6,578,145	852,657
Gross profit/kg	5.29	31.42	13.37	8.49	19.42	3.44	17.80	8.86
Net profit/kg	4.69	24.68	6.05	4.51	18.75	0.80	15.66	3.83
Rate of return on operating cost (%)	0.06	0.44	0.15	0.09	0.26	0.04	0.22	0.10
Payback period	0.28	0.49	1.65	3.24	0.51	3.57	0.65	5.31
ROI	3.13	1.61	0.27	0.16	1.88	0.06	1.36	0.08
Breakeven price	91.31	71.32	88.95	93.49	74.25	94.20	79.34	92.17

Table 11. Profitability of mariculture operation: Private sector and LGU-led mariculture areas

	Private Sector-LGU Led						
	Sual				Bolinao		
	Operator 1	Operator 2	Operator 3	Operator 4	Operator 1	Operator 2	Operator 3
Mariculture Production Systems	55 units, HDPE, Floating, Circular, 18×8 m (dia.), Milkfish	75 units, HDPE, Floating, Circular, 20×8 (dia.), Milkfish	22 units, GI pipe, Floating, Square, 17×17×16 m, Milkfish	18 units, GI Pipe, Floating, Square, 19×19×16 m, Milkfish	13 units, Bamboo, Fixed, Square, 40×100×10 m, Milkfish	6 units, GI pipe, Floating, Square, 18×18×16 m, Milkfish	5 units, HDPE, Floating, Circular, 18×16 m (dia.), Milkfish
Total annual harvest (kg)	1,650,000	2,250,000	550,000	540,000	195,000	108,000	90,000
Annual harvest per cage/cropping (kg)	30,000	30,000	25,000	30,000	15,000	18,000	18,000
Annual harvest per kg/m^3	14.54	11.94	14.42	13.85	0.38	3.47	4.42
Average farm gate price per kg	118.00	120.00	110.00	110.00	110.00	110.00	110.00
Annual revenue (PHP)	194,700,000	270,000,000	60,500,000	59,400,000	21,450,000	11,880,000	9,900,000
Annual operating cost	139,918,279	212,916,010	38,206,830	35,711,579	15,864,026	8,844,221	7,393,721
Gross profit (PHP)	54,781,721	57,083,990	22,293,170	23,688,421	5,585,974	3,035,779	2,506,279
Net profit (PHP)	50,157,054	49,022,445	20,165,939	21,695,588	4,390,824	2,406,296	1,994,462
Gross profit/kg	33.20	25.37	40.53	43.87	28.65	28.11	27.85
Net profit/kg	30.40	21.79	36.67	40.18	22.52	22.28	22.16
Rate of return on operating cost (%)	0.379	0.258	0.553	0.628	0.327	0.320	0.317
Payback period	1.17	1.70	1.68	1.55	0.71	1.03	1.57
ROI	0.78	0.50	0.54	0.59	1.11	0.77	0.51
Breakeven price	87.60	98.21	73.33	69.82	87.48	87.72	87.84

Note: USD 1 = PHP 45

Table 12. Profitability of mariculture operation: Private sector and BFAR-led mariculture areas

	Private Sector-BFAR Led							
	Calape	Talibon		Santo Tomas				
				Inside Assigned Mariculture Area		Outside Assigned Mariculture Area		
		Operator 1	Operator 2	Operator 1	Operator 2	Operator 1	Operator 2	Operator 3
Mariculture Production Systems	4 units, Bamboo, Floating, Square, 8×8×8 m, Milkfish	1 unit, Bamboo, Floating, Square, 6×6×5 m, Milkfish	2 units, Fish pens, Bamboo, Fixed, Square, 20×20×5 m, Milkfish	4 units, HDPE, Floating, Circular, 16x8 m (dia.), Milkfish	1 unit, Rope-framed, Submerged, Square, 10×10×6 m, Green Grouper	1 unit, Fish cage, Bamboo, Floating, Square, 10×10×2 m, Green Grouper	1 unit, Fish pen, Bamboo, Fixed, Square, 10×10×2 m, Green Grouper	1 unit, Fish pen, Bamboo, Fixed, Square, 13×13×2 m, Milkfish
Total annual harvest (kg)	6,000	12,000	16,000	103,464	300	100	1,200	250
Annual harvest per cage/cropping (kg)	1,500	4,000	4,000	12,933	300	100	1,200	250
Annual harvest per kg/m^3	2.93	66.67	8.00	16.08	0.5	0.5	6	0.74
Average farm gate price per kg	105.00	95.00	100.00	100.00	550.00	600.00	670.00	100.0
Annual revenue (PHP)	630,000	1,140,000	1,600,000	10,346,400	165,000	60,000	804,000	25,000
Annual operating cost	449,000	987,480	1,488,380	9,050,363	254,400	25,310	50,000	36,300
Gross profit (PHP)	181,000	152,520	111,620	1,296,037	(89,400)	34,690	754,000	(11,300)
Net profit (PHP)	147,022	24,851	59,009	1,013,670	(94,100)	7,690	741,540	(30,285)
Gross profit/kg	30.17	12.71	6.98	12.53	–298.00	346.90	628.33	–45.20
Net profit/kg	24.50	2.07	1.19	9.80	–313.67	76.90	617.95	–121.14
Rate of return on operating cost (%)	0.375	0.137	0.071	0.139	–0.345	0.663	12.072	–0.204
Payback period	0.80	2.76	1.74	1.70	–0.53	1.56	0.03	–3.20
ROI	1.02	0.06	0.30	0.46	–2.00	0.13	31.94	–0.84
Breakeven price	80.50	92.93	96.31	90.20	863.67	523.10	52.05	221.14

Note: USD 1= PHP 45

On a per kilogram basis, green grouper farming under the private sector and the BFAR-led mariculture areas outside of the designated mariculture park registered the highest net profit (Table 12). Specifically, green grouper farming using fish pens registered the highest (PHP 618/kg), followed by green grouper farming using fish cages (PHP 77/kg). In contrast, green grouper farming in the designated mariculture area using a rope-framed cage had the biggest net loss (PHP 94,100; PHP 314/kg).

The range of gross profit per kilogram and net profit per kilogram in Sual were PHP 25–PHP 44 and PHP 22–PHP 40, respectively (Table 11). In Bolinao, the gross profit per kilogram (PHP 28.65, PHP 28.11, and PHP 27.85) and the net profit per kilogram (PHP 22.52, PHP 22.28, and PHP 22.16) among the different mariculture operations were similar.

Among the mariculture operations in the LGU and BFAR-led mariculture areas, big operators registered higher annual gross and net profits (Table 10). On a per kilogram basis, the medium operators in Balingasag registered the highest (PHP 24.68/kg), while the net profit of the small and big players was almost the same (PHP 4.69, PHP 4.51, PHP 6.05). It was the opposite in Lopez Jaena; the medium player earned the least profit (PHP 0.80/kg) while the livelihood recipient earned the highest net profit (PHP 18.75/kg).

In terms of returns on investment (ROI) and payback period, green grouper farming fish pens registered the highest ROI (31.94), shortest payback period (0.03), and highest return on operating cost (PHP 12.07) (Table 12). This was followed by the small milkfish operation in Balingasag with an ROI of 3.13 and payback period of 0.28 year (Table 10). As expected, the big operators, with their big investment had the longest payback period.

The average farm gate price for milkfish was lowest in Balingasag and Lopez Jaena at PHP 93–98/kg (Table 10) and highest in Sual and Bolinao at PHP 110–120/kg (Table 11). The price in Calape, Talibon, and Sto. Tomas was PHP 100–105/kg (Table 12). As expected, given the higher price and the higher production in Sual and Bolinao, the total revenue was highest in these mariculture sites. Meanwhile, the price of grouper was six times higher than milkfish at PHP 550–670/kg. Grouper from Sto. Tomas were sold to institutional buyers (restaurant, hotels) in Manila or in Baguio.

3.6 Key Observations

3.6.1 There is a lack of diversity in the species farmed

There was a lack of diversity in species farmed in the seven mariculture sites. Milkfish was the primary species farmed in all sites. Milkfish is suited to the exposed condition, but its price is low and has little international market. There were pompano and siganids in Balingasag and Lopez Jaena, but in small numbers.

Among the seven sites, only in Sto. Tomas was grouper farming found. The production was low, but the price was six times higher than that in milkfish production, as grouper farming catered to the live-fish restaurant trade. This finding supported earlier studies on grouper culture, which found it to be highly profitable (Baliao et al. 1998; Baliao et al. 2000; Pomeroy et al. 2004). However, if farm management is poor, survival rate will be low, resulting in losses. This happened to green grouper farming inside the mariculture zone in Sto. Tomas.

3.6.2 Availability of seeds/fingerlings is a constraint

The availability of seeds is a major constraint in the study sites. Although others were sourcing from hatcheries, there was still heavy reliance on capture of wild fry/fingerlings/sub-adults for stocking milkfish, grouper, or other species. The seeds from the wild fishery sources is dwindling or getting more expensive to obtain.

With the scarcity of seed and the dwindling stocks, hatcheries must be the norm. Thus, successful partnership between hatcheries and backyard nurseries and grow-out farmers should be encouraged. There is an urgent need to focus research and development efforts on the development and standardization of commercially viable seed production technologies. The seed production of the species for which technology is available (milkfish) is being done mostly by the BFAR. Nevertheless, consistent and adequate seed availability is a major constraint for prospective cage farmers.

The development of hatcheries will increase the availability of fingerlings. This will encourage competition among hatcheries and will drive the price of seed down. Since seed cost is a major component of production, the lower fingerling cost would reduce the grow-out production cost. These two factors will likely increase mariculture production.

3.6.3 Excessive feed usage leads to high cost and pollution

Commercial pelleted feeds are the most expensive operation input in the mariculture production of milkfish. The different research sites had different feeding practices:

1. Balingasag and Lopez Jaena had scheduled feeding of 5–6 times a day;
2. In Bolinao and Sual, feeding was continuous between 6 a.m. to 6 p.m. or until the fish stop eating;
3. In Calape and Talibon, feeding was 3–5 times a day; and
4. In Sto. Tomas feeding was 2–3 times a day.

For groupers, feeding schedule was dependent on the availability of trash fish. Small-scale fishers do not have access to the financial resources necessary to invest in the purchase of pelleted diets, and thus have low participation in mariculture operations.

There are few feeding companies in the mariculture sites, which would have encouraged competition to lower the price. Also, the distribution channels for pelleted feed are not widely available in rural areas, which limit access to the feed. These two factors increase the cost of the feed. Thus, there is a need for a price ceiling on feeds and also to encourage more feeding companies or more distributors.

There is a need to ensure that operators adopt the "best or better management practices," including efficient feed formulation and feeding technique and practices. Wrong feeding practices can result in considerable wastage. The stocking densities and cage numbers should also be within the carrying capacity of the local environment. Proper siting of the area should be observed, where there is adequate water depth below cages and sufficient water movement to disperse wastes. Except for the big operators, most operators did not have appropriate storage facilities for their feeds. This can result in degradation of the pellets, particularly vitamin content, resulting in poor growth and diseases in fed fish.

The lack of affordable and accessible pelleted feeds is a major constraint in grouper mariculture production. Since groupers feed on trash or low-value fish, the availability of trash fish affects grouper farming operations. The use of trash fish has ecological and localized environmental impacts and requires long hours of feeding. The dependence on trash fish should, therefore, be reduced. Appropriate cost-effective pelleted feds have to be formulated, and commercial feed production is needed to expand grouper cage farming practice. The grouper fish farmers also did not have access to refrigeration, finding it easier to collect trash fish themselves, or in small amounts when financial resources or trash fish are available.

3.6.4 Poor location of mariculture parks

In areas declared as mariculture parks or zones, site selection is done by the BFAR. However, three sites—Calape, Talibon, and Sto. Tomas—had few cages in the designated area but had many in nearby areas. It was reported that the sites are either far, have strong currents that bamboo cages cannot withstand for a long time, or water depth is shallow. This needs to be investigated, and the site selection protocol may need to be reviewed.

Bamboo cages are cheap structures that are not built to withstand strong currents and big waves. However, fish farmers that use these structures have lower start-up capital requirement and lower operational costs compared to those who use more durable offshore cages. Thus, operations that use the former kind of structure are affordable to small, cooperative-/family-run, and medium-scale enterprises.

Cages located farther from shore also make the security of the crop a major concern, and this requires living facilities to be built into the cage system. The same problem constrains farmers from moving to open waters. If they do, a more complicated logistical arrangement than they are currently following would have to be devised.

3.6.5 High capital requirements of mariculture production

Cage farming in the seven sites was capital intensive. Fisherfolk, who are supposed to be the main players, were missing as operators. Unless given support by the BFAR (e.g., operators in Balingasag, Lopez Jaena, and Sto. Tomas), fishers are not able to participate as operators in mariculture. Without the assistance of the BFAR through the rent-to-own scheme, small operators cannot engage in cage culture because the initial outlay for mariculture operation is beyond the capacity of the fisherfolk. The major production inputs in mariculture operation are fingerlings, feeds, labor, and cages and nets. Also, the small cages with bamboo frames that the small fishers are operating may not be suitable in typhoon-prone areas. Clusters of small cages may be encouraged in the future. There is, therefore, a need for further research and development in this aspect.

3.6.6 Limited financial and marketing support

More intervention by the government or by the BFAR or government banks (i.e., Landbank, Development Bank of the Philippines) in financing the sector is needed to enhance popularization and the establishment of cage farming in the country. A vital aspect is to develop market chains, especially for domestic marketing, to vertically integrate the different sectors and to bring about more efficacy and cost effectiveness.

3.6.7 Lack of on-farm research

A number of on-farm researches are needed to address the technological challenges involved. The study revealed the need for standardization of many techniques in relation to cage farming operations. The major aspects include stocking density, feeding, farm management biofouling (or biological fouling, which is the accumulation of microorganisms, barnacles, and algae on submerged structures) of net cages, regulation of fish growth and production, grading, health management, water quality, pollution, and the carrying capacity assessment of the farm site.

3.6.8 Weak policies on certain aspects of mariculture operations

Currently, there is no uniform leasing policy for cage sites and regulatory measures for farming. Leasing policies have to be formulated for the development and expansion of cage farming. Regulatory measures are also needed to prevent the use of available inshore sites beyond their carrying capacities. A uniform definition for a small, medium, and large operation is also lacking—each site had its own definition. Moreover, the absence of uniform compensation for the laborers hired was also found.

4.0 CONCLUSION

The government promoted mariculture to contribute to food security and economic growth in the rural areas. This study assessed the profitability of mariculture operation in seven mariculture areas in the country using data from key informant interviews conducted from January to August 2015. Production, profit levels, and profitability indicators varied by mariculture technology, scale, and location. The mariculture production systems were distinguished by (1) the material used for cages/pens (bamboo, GI pipes, rope-framed, or HDPE); (2) scale (dimensions and number of grow-out cages/pens); (4) surface shape (circular vs rectangular/square); and (3) structure (fixed or floating). Production practices (stocking, feeding, rearing period, labor requirements), harvesting, and marketing practices also highly varied.

Cages and nets are the major initial investment items, while feeds are the most expensive operation input. In general, mariculture operation is profitable. However, profits can still be further improved. The following strategies are the major steps forward toward improving the profitability of mariculture in the Philippines: (1) identification of suitable cage farming sites; (2) availability of required seeds; (3) production and availability of cost-effective grow-out feeds; (4) economically viable farming protocols; (5) carrying capacity assessments of mariculture for sustainability; (6) regulation of key aspects of cage farm management; (7) provision of financial assistance, particularly to small-scale operators; (8) enhancing marketing strategies, and (9) development and enforcement of sea cage farming policies.

LITERATURE CITED

Baliao, D.D.; M.A. De los Santos; E.M. Rodriguez; and R.B. Ticar. 1998. Grouper culture in brackishwater ponds. Aquaculture Extension Manual No. 24. Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC), Tigbauan, Iloilo, Philippines.

Baliao, D.D.; M.A. De los Santos; N.M. Franco; N.R.S. Jamon. 2000. Grouper culture in floating net cages. Aquaculture Department, SEAFDEC, Tigbauan, Iloilo, Philippines.

BFAR (Bureau of Fisheries and Aquatic Resources, Department of Agriculture). 2009. Mariculture. http://mariculture.bfar.da.gov.ph/ (Retrieved 4 August, 2014).

PIA (Philippine Information Agency). 2009. Mariculture park opens in Masbate City in Philippines. http://www.panoramaacuicola.com/noticias/2009/10/29/mariculture_park_opens_in_masbate_city_in_philippines_.html (Retrieved 4 August, 2014).

Pomeroy, R.S.; R. Agbayani; M. Duray; J. Toledo; and G. Quinitio. 2004. The financial feasibility of small-scale grouper aquaculture in the Philippines. Aquaculture Economics and Management. 8 (1–2): 61–83.

Rosario, W.R. 2008. The Philippines. A. Lovatelli, M.J. Phillips, J.R. Arthur, and K. Yamamoto (eds.) *In* Proceedings of the FAO/NACA Regional Workshop on the Future of Mariculture: A Regional Approach for Responsible Development in the Asia-Pacific, Guangzhou, China, 7–11, March 2006. Food and Agriculture Organization, Rome, Italy. , 225–240.

Yap, W.G. 1999. Rural aquaculture in the Philippines. Regional Office for Asia and the Pacific, Food and Agriculture Organization, Bangkok, Thailand.

APPENDIX

Appendix A1. Mariculture cage/pen technologies existing in study sites, 2015

Site	Area	Scale of Operation	Structure	Material	Shape of Surface	Dimension	Volume (m)	No. of Key Informants interviewed
Balingasag Total: 63 (as of Jan 2014) Distribution: 28 small, 24 medium, 11 big	195.7 ha (19.5 ha for fish cage, 2 ha for small player, 6 ha for medium, 11.5 ha for big player)	Small	Floating	Bamboo	Square	5×5×8 m	200	4
		Medium	Floating	Bamboo	Square	10×10×8 m	800	2
		Big	Floating	Bamboo	Square	10×10×8 m	800	2
		Big	Floating	HDPE	Circular	15 (diameter) × 8 m	1,414	1
Lopez Jaena Total: 79 (as of 2014) Distribution: 36 livelihood, 23 medium, 10 big, 10 conditioning	313.26 ha (31.2 ha for fish cages); 4 ha for small player, 16 ha for medium player, 8 ha for big player, 1 ha for R&D, 2 ha for conditioning cage)	Livelihood	Floating	Bamboo	Square	10×10×4 m	400	3
		Medium	Floating	Bamboo	Square	10×10×6 m	600	2
		Big	Floating	Bamboo	Square	10×10×6 m	600	1
		Big	Floating	HDPE	Circular	20 (diameter) × 6 m	1,885	1
Calape Total: 6 (as of Feb 2015) (inclusive of the BFAR demo cage)	220 ha (22 ha available for fish cage)	Fish cage	Floating	Bamboo	Square	8×8×8 m	512	6
Talibon Total: 7 (as of Nov 2013) Distribution: 3 fish cages, 4 fish pens	250.28 ha (25.28 ha available for fish cage)	Fish cage	Floating	Bamboo	Square	6×6×5 m	180	1
		Fish pen	Fixed	Bamboo	Square	20×20×5 m	2,000	1

Appendix A1 continued

Site	Area	Scale of Operation	Structure	Material	Shape of Surface	Dimension	Volume (m)	No. of Key Informants interviewed
Santo Tomas Total: 74 (as of May 2015) Distribution: 3 inside mariculture zone (inclusive of BFAR demo cage), 71 outside mariculture zone	10 ha	Inside mariculture zone	Floating	HDPE	Circular	16 (diameter) × 8 m	1,609	1
		Inside mariculture zone	Floating	Rope-framed	Square	10×10×6 m	600	1
		Outside mariculture zone (fish cage)	Floating	Bamboo	Square	10×10×2 m	200	5
		Outside mariculture zone (fish pen)	Fixed	Bamboo	Square	10×10×2 m	200	3
		Outside mariculture zone (fish pen)	Fixed	Bamboo	Square	13×13×2 m	338	1
Sual Total: 21 (as of May 2015)	169 ha		Floating	HDPE	Circular	18 (diameter) × 8 m	2,036	1
			Floating	HDPE	Circular	20 (diameter) × 8 m	2,513	2
			Floating	GI Pipe	Square	17×17×16 m	1,734	1
			Floating	GI Pipe	Square	19×19×16 m	2,166	1
Bolinao Total: (as of Mar 2015) Distribution: 80 fish cages, 51 fish pens	279.9 ha	Fish pen	Fixed	Bamboo	Square	40×100×10 m	40,000	1
		Fish cage	Floating	GI Pipe	Square	18×18×16 m	5,184	1
		Fish cage	Floating	HDPE	Circular	18 (diameter) ×16 m	4,072	1

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