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EFFECTS OF INTENSIVE MARICULTURE OPERATION ON WATER QUALITY AND PRODUCTIVITY IN BOLINAO, PHILIPPINES

by

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Effects of Intensive Mariculture Operation on Water Quality and Productivity in Bolinao, Philippines[1]

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I. Introduction

Aquaculture or cultivating edible fish and other marine species in an artificial system in both freshwater and marine environment has been practiced to meet the growing demand for fish. Historically, aquaculture production followed the traditional extensive method with low-yielding "natural ponds" where harvests are low but sustainable over long period (Hagler, 1997 as provided in www.greenpeace.org). During those times, aquaculture has been considered as a clean and environmentally friendly activity since the operation made use of natural feed production in water bodies (Anderson and de Silva, 1997).

The Philippines has been listed as the world's third largest producer of aquaculture species (Craig, 1999). One of the main aquaculture areas in the country is Lingayen Gulf. The industry started as early as the 1970s on brackishwater fishponds where the semi intensive form of milkfish culture was adopted. Milkfish was given natural food. Supplemental food, in the form of breadcrumbs and commercial feeds, was given only when the natural food got exhausted. This was accelerated in 1980s through the conversion of mangrove areas into fishponds. However, with the prohibition of mangrove conversion into fishpond in the early 1990s, aquaculture operation was expanded through the construction of fishpens and fishcages in the coastal waters and rivers, now popularly known as mariculture.

To regulate mariculture operation, the Lingayen Gulf Coastal Area Management Council (LGCAM) was instituted and the Lingayen Gulf Coastal Area Management Plan (LGCAMP) was formulated in 1992. The LGCAMP identified zones within the Gulf area that are suitable for mariculture. Based on the criteria, the bulk of mariculture activity in the area is concentrated on the coastal and inland waters in five municipalities namely: Bolinao, Anda, Dagupan and Binmaley in Pangasinan and Aringay in La Union. However, the LGCAM did not live long and the Plan was not implemented. As such, in 1995, the Bolinao Local Government Unit (LGU) formulated its own Coastal Development Plan (CDP) to regulate mariculture operation within the municipality. As an implementing guideline of the CDP, the Municipal Fishery Ordinance (MFO) that prescribed the provisions related to fishpen and fishcage operation was passed in 1999. Article VIII Section 41 stipulated that the minimum size of fishpens shall be 1,200 sq m (30 m x 40 m) and the maximum size shall be 4,000 sq m (100 m x 40 m) and the distance must be 30 meters between units. For fishcage, the minimum size shall be 12 meters x 12 meters and the maximum size shall be 18 meters x 18 meters and shall be in cluster of 10 units per cluster with 100 meters distance from each cluster. Among the provisions of the MFO included, number of fishpen/fishcage that an operator can own should not exceed 5 units and the distance of the structure from the shore

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must be at least 300 meters. On the other hand, Section 46 stated that the operator may be allowed to construct and operate a maximum of five (5) units of fishcages/fishpens and that the total number of fishpens and fishcages must not exceed the 544 units (covering 130 hectares) carrying capacity of the area.

Despite the passage of the MFO, fishpens and fishcages have continued to be constructed and operated illegally. In 1999, it was reported that the number of fishpens/fishcages had exceeded carrying capacity of the Caquiputan Channel in Bolinao (Verceles, McManus and Aliño, 2000).

In addition to the high concentration of fishpens/fishcages, the operators have been reported to practice high stocking density and overfeeding. The milkfish fry (3-5 cm) were stocked at 15 to 50 pcs/m^2 of fishpen, which is considered to be highly intensive compared to the recommended stocking density for milkfish of 12 – 15 pcs/m^2.

Accumulation of excess leftover commercial feeds resulted in sedimentation leading to water turbidity. This in turn causes deterioration in health and quality of reefs. As overcrowding due to high stocking density and excess commercial feeds become intense, eutrophication of the water surrounding the rearing pens and the bodies of water or rivers receiving the mariculture effluent may result. In the case of Bolinao, it was reported that the poor water quality reached the adjacent waters of Dewey and Tambac Bay.

Results of the water quality monitoring done by the University of the Philippines Marine Science Institute (UP-MSI) in 1999 showed that dissolved oxygen (DO) of the waters of Caquiputan Channel in Bolinao ranged from 2.9 - 4.5mg/l. These values were below the critical value of DO (5mg/l) for fish survival (Boyd and Lichtkoppler, 1979. Excessively low DO (below 3mg/L) is already detrimental for milkfish growth.

As of the time of the study, sporadic fish kills have been periodically reported in the study area. These occurred in specific fishpens that are usually densely constructed and with high stocking density. Unfortunately, these fish kills are considered minor and are left undocumented to serve as basis for the formulation of policy towards sustainable mariculture (personal communication with Mr. Florante Garcia, CRM officer of Bolinao).

Objectives of the Study

In general, the study aimed to assess the effects of intensive mariculture operation on water quality and milkfish production in Bolinao, Northern Philippines.

Specifically, the study was conducted to:

a. describe the status of the mariculture operation in Bolinao, specifically, at the Caquiputan Channel;

b. assess the water quality of the Caquiputan Channel in terms of DO and TSS;

c. estimate the effects of high stocking density and overfeeding on mariculture production;

d. identify policy options and recommend directions for further research related to mariculture industry.

II. Research Methodology

Place and Scope of the Study

There are five municipalities along the Lingayen Gulf that are involved in mariculture industry. These are the municipalities of Bolinao, Anda, Dagupan and Binmaley in Pangasinan and Aringay in La Union. This study focused only on the municipality of Bolinao due to the intense operation of the industry in seven barangays in the Caquiputan Channel.

Unit of Analysis and Sampling Procedure

From the information obtained from the municipal office in Bolinao in November 2000, there were 120 multi-unit mariculture operators in Bolinao. However, only 34 operators were interviewed during a meeting held by the operators association[4]. For water quality analysis, two sample fish pens per barangay were chosen based on the willingness of the owners to cooperate with the study. On the average, these fishpens are located 279 meters from the shore.

Mariculture Production Analysis

The tool of analysis used in the study is production function analysis. Like agriculture, milkfish production from mariculture is a function of inputs used. In this case, the main inputs are stocks/fry and feeds, and milkfish as output. Since mariculture operation is done in coastal water, the quality water is treated also as a variable that may affect the output. The production function for mariculture is expressed as:

$$Ya = Y(SD, F, WD)$$

Where: Ya = mariculture production (kg per 100 m^2 area)
SD = stocking density (fry per 100 m^2)
F = quantity of feeds per production cycle (50 kg-bags per100 m^2 area)
WD = water quality dummy
1 if DO level inside the pen is $\leq$ 4mg/L
0 if DO level inside the pen is > 4mg/L

To determine the effect of high stocking density and overfeeding on production, square values of SD and F were included in the equation. Several functional forms were used but the linear form gave the best fit based on the coefficient of determination and significance of the coefficients.

Thus, the equation is expressed as:

$$Ya = \alpha + \beta_1 SD - \beta_2 SD^2 + \beta_3 F - \beta_4 F^2 - B_5 WD$$

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4 During the time of survey, most of the operators were out of town. Operators are not necessarily from Bolinao and the addresses of the operators were held confidential.

The negative signs of the coefficients for SD^2 and F^2 were expected since it is hypothesized that there are levels of stocking density and amount of feeds where total production is maximum, beyond which, milkfish production will decrease.

To determine the effect of water quality, dummy variable was included in the equation. It was hypothesized that if the undesirable situation exists, that is, DO level ≤ 4mg/L, milkfish production is likely to decrease and vice versa. As an intercept shifter, if DO =<4 mg/L, the intercept of the production function will be $\alpha - \beta 5WD$.

Water Quality Analysis

Five hundred ml of water samples, following the sampling method discussed by University of the Philippines Marine Science Institute (UP-MSI), were obtained using Niskin sampler from each of the sample fishpen/cage. The samples were analyzed for the dissolved oxygen (DO) and total suspended solids (TSS) values at the University of the Philippines Marine Science Institute (UP-MSI) Laboratory.

III. Results and Discussion

3.1 Description and Status of Mariculture Operation In Bolinao

It was in 1997 when mariculture operation was reported to be already intense in the Bolinao. It was also in this year when the LGU of Bolinao formed the technical committee composed of representatives from the local government, non-government organization (NGO), UP-MSI, fishers and residents to formulate the ten-year (1997 – 2007) Coastal Development Plan (CDP) of Bolinao. In fact, "Bolinao was the first municipality in the Philippines to have formulated a CDP in a community-based and participatory manner" (Jacinto, 2002). The CDP contained the technical considerations for sustainable management of fishpens and fishcages and also designated areas for fishpens and fish cage operations. As an implementing guideline of the CDP, the Municipal Fishery Ordinance (MFO) was passed and finally approved in 1999 (PDI, Feb. 6, 2002).

The MFO classified the waters of Bolinao into four zones namely: eco-tourism (Zone 1); multiple-use zone (Zone II); fishery management (Zone III); and navigational zone (Zone IV). Mariculture is specified under the multiple-use zone covering nine (9) barangays (villages) along the Caquiputan Channel

3.2 Number of Fishpen/Fishcage Structures

Despite the number of fishpens allowed in the MFO, fish pens and fish cages have continued to be constructed and operated both legally and illegally. From 242 fish pen units listed at the Coastal Resource Management (CRM) Office of Bolinao during the start of mariculture operation in 1995, the number of units continuously increased such that in 2001, there were already 1170 structures. In most of the periods, the number of permits issued was way below the actual figure in ocular survey or inspection made, an indication that indeed there were illegally constructed structures (Table 1). Based on the records gathered from the CRM office, the maximum number of structures that an operator registered for 2000 – 2001 was 10 units. This was already beyond the provision in the municipal fishery ordinance of five units per operator.

Table 1. Number of mariculture structures in Bolinao, 1995 – 2001.

YEAR	NUMBER OF STRUCTURE
1995 [a]	242
1997 [a]	1076 (ocular survey); 703 (permits officially issued)
1998 [a]	476 (permits officially issued)
1999 [b]	797 (ocular survey)
2000	993[c] (MFRMP, 2000); 371[d] (permits officially issued)
2001 [b]	1170 (AFMA-DMEQCMA study)
January 2002 [e]	1067 (LGCAMC physical count); 621 (permits officially issued)

[a] Verceles, Macmanus and Aliño, 2000; [b] MFRMP (on going study in 2001)
[c] AFMA-DMEQCMA (on going study in 2001); [d] CRM office, Bolinao; [e] PDI, Feb. 9, 2002.

3.3. Water Quality Analysis

Generally, there are eight parameters used to test water quality. This includes the following: temperature, pH, salinity, turbidity, total suspended solids (TSS), dissolved oxygen (DO), Chlorophyll-a, and fecal coliform bacteria. The parameters that are of interest in this study are DO and TSS due to their importance on the growth of aquatic and marine species.

Four mariculture barangays (Luciente 2, Luna, Tara and Pilar) in Bolinao were chosen to be the sample areas. Barangay Victory, which does not have mariculture structures, served as the control site. In each barangay, designated fish pens or fish cages (2 each), as well as a designated point "outside" (≈200 meters away from the mariculture structures) were monitored for four months. This means three stations for each barangay except for Tara, which has five points (two each for fish pens and fish cages, and an outside station). Corresponding codes were assigned for the sample points (Table 2). Sampling was done three times a day: early morning (5:20 – 9:00 AM); noontime (11:00 AM – 3:00 PM); and late afternoon (3:20 – 7:00 PM).

Water samples were obtained, depending on the station's depth, using a Niskin sampler. About 500 ml of each water sample was filtered through a filter paper aided by a pump to obtain the TSS. Part of the water sample was placed in two DO bottles to determine its DO value. Water samples were analyzed for the DO and TSS values at the UP-MSI Marine Laboratory.

Dissolved Oxygen (DO)

This is a universal and critical indicator of the presence and health of aquatic life in a body of water. A high DO value means that there is no oxygen demanding stresses present, thus, the aquatic life there can be considered of "good health". A low DO value, on the other hand, means that stress-inducing conditions are occurring.

Table 2. Number and station codes for water quality study, by barangay, Bolinao, Pangasinan, 2001.

BARANGAY	STATION CODE		TOTAL
	Fish pen	Outside of (or without) mariculture structure	
Luna	LUN1 LUN2	LUNO	3
Luciente	LCT1 LCT2	LCOT	3
Tara	TAR1 TAR2	TROT	3
Pilar	PLR1 PLR2	PLOT	3
Victory (non- mariculture barangay)		VICT1 VICT2	2
TOTAL	8	6	14

DO by time of sampling and sampling month. Results of the water quality analysis showed varying levels of DO throughout the day and across barangays and stations. On the average, low DO values were observed during the early part of the day, increasing towards the late afternoon (Table 3). This could be due to the fact that at night and early morning, respiration dominates, thus consuming most of the dissolved oxygen present in the water. DO level steadily declines during the night, and is thus lowest just before dawn. All the sampling months showed this trend (except for September), with most of them attaining a value higher than 5mg/L during the late afternoon. According to Boyd and Lichtkoppler (1979), 5 mg/L is the amount of oxygen that is needed by a fish in order to attain normal growth. A value lower than this is already stressful to most vertebrates and causes mortality to some invertebrates. In fact, at a DO value of <1.0mg/L, milkfish already stops feeding and continues only when the DO is maintained at >3.0mg/L (Chiu et al. 1986). By month, DO values on the average were found to be relatively highest during August (Table 3.), and lowest during December (Dec < Sept < July < August).

DO by sampling station (inside and outside of the structure, and without mariculture structures). The DO values obtained outside the structures were found to be significantly higher than the values obtained inside the structure. (Table 3 and Figure 1). It appears that wastes from mariculture have minimal or no effect at all outside the structure. This implies that there is "confinement" of the wastes inside the structures and if ever wastes are carried outside these are diluted by the freely and continuously flow of water at the outside station. The average DO value inside the structure did not even reach the critical 5mg/L value for DO throughout the sampling period, indicating the high DO demand of fishes. As for the outside station, DO level was able to reach the critical value of 5mg/L only for the months of July and August. The low DO value during September, may be attributed to the 1-meter decrease in water level during the noontime sampling time in two of the sampling areas. Waters at this level could have high temperatures, decreasing the solubility of oxygen, and thus accounting for low DO. In December, the occurrence of fish kills in some of the stations was evidence of the low DO during this month and could have also influenced the outside stations. This was marked with whitish water and a large number of dead fish (mostly small pufferfish) floating in and out of the pen.

Comparing the DO values inside and outside the structure, with those without mariculture operations showed that the overall average DO value for all sampling months in the latter was higher than those from both the inside and outside stations (Table 3). Moreover, it was found to be beyond the critical value for DO or nearing that value for all the sampling months, an indication that indeed, mariculture operation affects water quality.

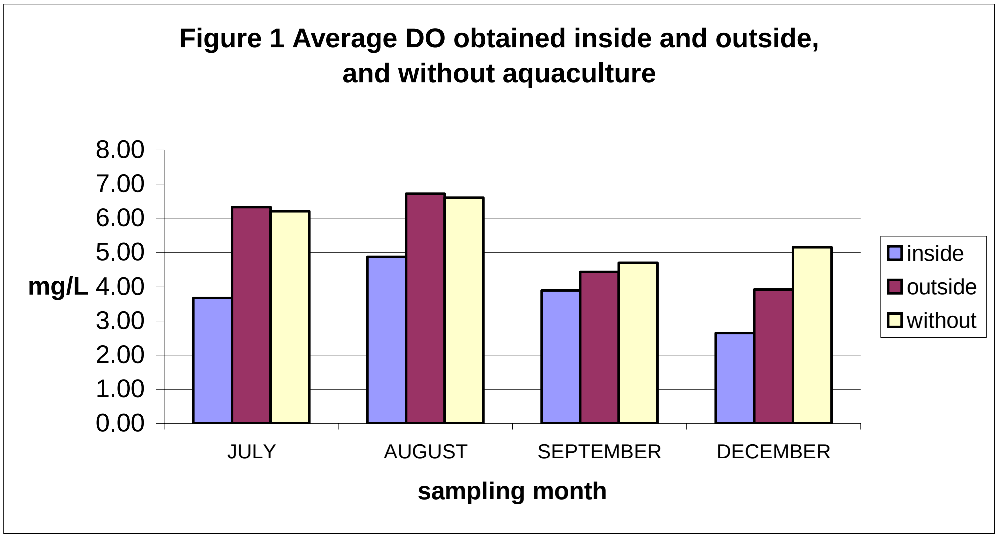
Total Suspended Solids (TSS)

TSS are solids that are found "suspended" in a water column, and can be trapped by a filter. The mineral constituents of these solids can be organic or inorganic by nature, sources of which can be silt brought about by soil erosion, domestic and industrial waste discharge, plankton, excessive algal growth, and decaying plant and animal matter. High presence of TSS in an aquatic ecosystem can cause several problems for both the aquatic environment and its organisms. These suspended solids can clog fish gills, reduce growth rates, decrease resistance to disease, and prevent egg and larval development (possibly through suffocation)

Table 3. Average DO values (mg/L) inside and outside of (or without) structures, by month and time of the day, July, August, September and December 2001.

MONTH/TIME OF SAMPLING	INSIDE THE STRUCTURE	OUTSIDE OF THE STRUCTURE	WITHOUT STRUCTURE	ALL
July				
Early morning	2.99	6.00	5.94	4.11
Noontime	3.73	5.96	5.61	4.14
Late afternoon	4.31	7.03	7.08	5.33
Average	**3.68**	**6.33**	**6.21**	***4.53***
August				
Early morning	3.73	5.31	5.72	4.37
Noontime	5.18	7.47	7.08	5.99
Late afternoon	5.73	7.41	7.05	6.31
Average	**4.88**	**6.73**	**6.61**	***5.56***
September				
Early morning	3.00	2.86	1.34	2.66
Noontime	4.53	5.55	5.97	4.96
Late Afternoon	4.12	4.88	6.80	4.65
Average	**3.88**	**4.43**	**4.70**	***4.09***
December				
Early morning	1.98	2.68	4.43	2.46
Noontime	2.80	4.15	5.28	3.50
Late Afternoon	3.16	4.92	5.75	3.92
Average	**2.65**	**3.92**	**5.15**	***3.29***
For Four Months				
Early morning	2.91	4.30	4.36	3.46
Noontime	3.93	5.78	5.98	4.65
Late afternoon	4.33	6.06	6.67	5.05
Average	**3.72**	**5.38**	**5.67**	***4.39***
Overall Average	3.76	5.36	5.67	4.37

Higher amount of suspended solids can also reduce the feeding activity of fishes. They also block the sunlight, limit plant, algal and plankton growth, and thus reduce the food supply of most fishes.



TSS by time of sampling and sampling month. In general, average TSS values were higher in stations inside mariculture structure than those outside or without mariculture structures except for afternoon sampling in July and December (Table 4 and Figure 2). This may have been due to the leftover feeds and wastes from milkfish culture. It was also observed that TSS increases by time of day. That is, the values were higher during the afternoon sampling, due to the accumulation of wastes from the cultured fish. Among all the months, December was observed to have the highest TSS values and, except for the non-mariculture barangay, exceeded the critical limit of 13 mg/L on the average.

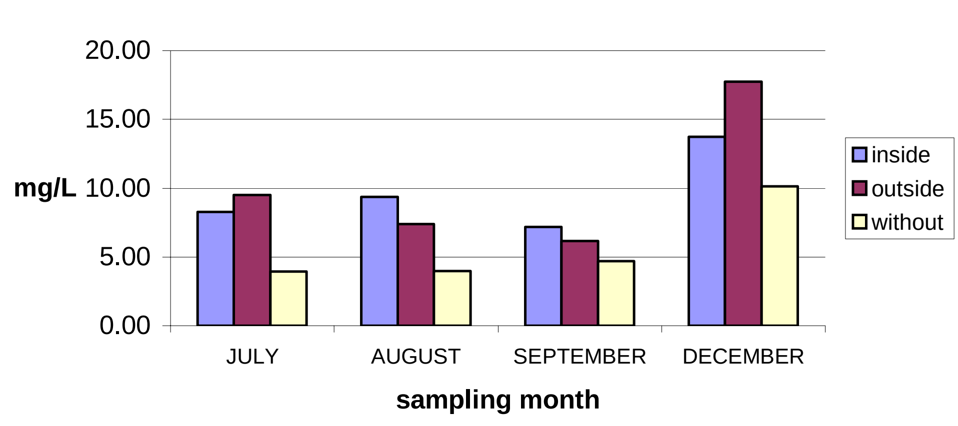
TSS values by sampling station. Average TSS values were found to be higher inside the mariculture structure than outside or 200 meters away from it during the months of August and September (Figure 2). This may be due to the feeds and wastes that could have accumulated inside the structure, building up the amount of suspended solids in the water column. Weather condition could also have some effect on the TSS value. Rain that occurred during most of the sampling time in August could have resulted in high siltation that was manifested by flood-like water and could have influenced the TSS value.

Table 4. Average TSS values (mg/L) inside and outside of (or without) structure, Bolinao, Pangasinan, July, August, September and December 2001

MONTH/TIME OF SAMPLING	INSIDE THE STRUCTURE	OUTSIDE THE STRUCTURE	WITHOUT STRUCTURE	ALL
July				
Early morning	5.58	6.40	2.20	5.25
Noontime	10.57	5.30	4.95	8.55
Late afternoon	8.64	16.88	4.65	10.20
Average	**8.26**	**9.53**	**3.93**	**8.00**
August				
Early morning	9.17	7.15	3.80	7.99
Noontime	6.50	7.35	3.55	6.34
Late afternoon	12.45	7.73	4.60	10.29
Average	**9.37**	**7.41**	**3.98**	**8.21**
September				
Early morning	4.90	3.67	3.55	4.32
Noontime	7.17	7.00	3.45	6.66
Late afternoon	9.45	7.78	7.15	8.74
Average	**7.17**	**6.15**	**4.72**	**6.57**
December				
Early morning	7.64	8.55	3.70	7.38
Noontime	18.78	21.13	2.80	17.37
Late Afternoon	14.83	23.60	23.85	18.15
Average	**13.75**	**17.76**	**10.12**	**14.30**
For Four Months				
Early morning	6.38	6.64	3.31	6.01
Noontime	10.76	10.19	3.69	9.73
Late Afternoon	11.34	13.99	10.06	11.85
Average	**9.49**	**10.28**	**5.69**	**9.20**
Overall Average	**9.61**	**10.22**	5.69	**9.26**

TSS values obtained during the month of December were the highest among all the sampling months. This may have possibly contributed to fish kills, and influenced not only the water quality inside the mariculture structure but outside the structure as well. In fact, some of the stations outside the mariculture structures had TSS values greater than 13mg/L during this month. As for the non-mariculture barangay, average TSS values obtained during the sampling months were significantly lower than those with mariculture structures (Figure 2).

Figure 2. Average TSS obtained inside and outside, and without aquaculture



3.4 Water quality and number of mariculture structures

Based on the records at the CRM office of Bolinao, there were about 70 mariculture structures in Luciente 2, 36 units in Tara, 23 units in Luna, and 22 units in Pilar for the year 2000-2001. It is hypothesized that the greater the number of structures in an area, the lower the DO value (and possibly the higher TSS) since it is more congested, thus more structures contributing more wastes and lowering the water quality of that area. In addition, congestion restricts the flow of water thus, limiting the inflow of new oxygen-rich water. Luciente 2 is considered as an area that is highly impacted by mariculture activities. Reports in light of the February 2002 fish kill event revealed that there were around 353 units in Luciente 2 where the massive fish kill started.

For TSS, sampling points in Tara recorded to have the highest values 10.96 mg/L. This was followed by Pilar (9.90 mg/L), Luna (9.51mg/L), then Luciente 2 (7.97 mg/L). Tara obtained the highest TSS value primarily because of its location where flushing rate and current flow is strong. High turbidity is often observed in these areas, especially where substantial inputs of silt and fine-grained particles from erosion-prone areas exist (Maaliw et al., 1989). It was surprising though, that sampling points from barangay Pilar got higher average TSS value than Luna and Luciente 2 given that it was low impacted by mariculture activities. This may be due to the rains that occurred during most of the sampling time, causing heavy siltation. All of the mariculture stations however, obtained an average TSS value below the critical limit of 13 mg/L.

3.5 Stocking Density and Water Quality

Another factor that affect water quality is stocking density. Too many fishes occupying a given confined area, like fish pen and fish cage, lessen the movement of fish thereby resulting in low oxygen. Overcrowding due to high stocking density also result in excessive excretion of fish wastes including ammonia, nitrate and nitrite, the last binding with hemoglobin in the blood and probably causing fish kills.

The stocking density recommended by INTAQ (2000) for a 4000 m^2 fish pen ranges from 50,000 – 60,000 fry or 1,250 – 1,500 fry per 100 m^2. In the water quality sampling areas, the sizes of fish pens varied in size hence, stocking density. However, except for the sampling points in Pilar, the stocking densities in the sample fish pen structures were above the recommended values by 25% to 50%. Highest stocking densities were recorded for both the sample fish pens in Luna. One of the sample structures in this barangay even practiced double stocking, that is, at the 4^{th} month of the first stock (74,000 fry in a 4000 m^2 fish pen) new stock of 75,000 were added. As a result, 25,000 of the new stock died.

Result of the correlation analysis showed negative relationship between stocking density and DO level. This was manifested by correlation value of –0.81 indicating high and negative relationship between the two variables. This means that as stocking density increases DO level decreases. In Pilar, both the sample fish pen structures followed the recommended stocking density and had relatively higher DO levels compared with the other sample sites (Table 5). Nevertheless, the DO levels in both sampling points were below the critical value of 5mg/L. The fish cage samples in Tara were also within the recommended stocking density and were recorded to have higher DO levels, with one exceeding the critical limit. This may be attributed to the low stocking density and location of fish cages wherein the structures are situated in deeper water, hence wastes are diluted by water flows. It was also evident that the values were still below 5mg/L. although the DO levels in sampling points 200 meters away from the fish pen structures were higher than those samples taken inside the mariculture structures. The trend showed positive correlation between the DO values inside the mariculture structures and the DO values outside the structure. This implies that if the DO levels inside the mariculture structures decline further; the water body closer to it will also suffer from low DO level.

For the non-mariculture barangay, the DO levels were higher compared with those in the mariculture barangays. This suggests that the presence of mariculture operation in the area affected the DO level and, consequently, coastal water quality.

From the foregoing discussions, it appears that there are indications of deteriorating water quality due to mismanaged mariculture operation, specifically overstocking. Although poor water quality are normally confined within the mariculture structures, if the situation gets worse, adjacent water bodies would also suffer from water quality deterioration.

3.6 The Mariculture Operators

Socio-Economic Characteristics of the Respondent-Operators

A total of 34 fish pen operators were surveyed on information related to mariculture operation. More could have been interviewed but most of the operators/ owners were not from Bolinao and names could not be obtained from the CRM office in Bolinao. There were also informal reports that there are dummy operators hence, it was difficult to locate the real owners. For those whose names were listed, only 34 cooperated with the study. Table 6 summarizes the socio-economic information of the sampled fishpen/fishcage operators.

Table 5. Stocking density and DO levels in different sampling points, mariculture and non-mariculture areas, Bolinao, Pangasinan, 2001

SAMPLING POINT	AREA (m^2)	STOCKING DENSITY ($pc/100m^2$)*	DO LEVEL (mg/L)				
			July	Aug.	Sept.	Dec.	Ave.
LCT1	1,600	1563	3.51	4.84	3.15	2.46	3.49
LCT2	2,800	1786	4.69	4.57	2.89	2.09	3.56
LCTOT	**	**	6.71	6.58	3.35	2.66	4.83
LUN1	4,000	1850	2.88	4.47	3.51	1.71	3.14
LUN2	2,000	2250	2.98	2.58	3.03	1.53	2.53
LUNO	**	**	6.87	6.46	3.07	2.75	4.79
PLR1	2,800	1250	4.03	5.77	4.12	3.74	4.41
PLR2	4,000	1500	3.44	6.02	4.84	3.61	4.48
PLOT	**	**	5.68	6.92	5.68	5.31	5.90
TAR1	1,200	1667	2.99	5.02	4.54	2.68	3.81
TAR2	1,600	2188	1.06	4.02	4.22	2.05	2.84
	**	**	6.05			4.95	6.24
TROT	non mariculture	non mariculture	6.46	6.96	7.0	5.39	5.82
VICT1	barangay	barangay	5.95	6.51	4.91	4.91	5.52
VICT2				6.71	4.50		
Correlation r between stocking density and average DO level was -0.81.							

Note:

* Recommended stocking density for fish pen is 1250 – 1500 pc/100 m^2

** Sampling point in each mariculture barangay 200 m away from the mariculture structure

Physical Information About Mariculture Operation

On the average, each operator owned two units of fish pen.. However, there were those who owned 11 units (Table 7) that is a clear violation of the municipal ordinance, which specifies that an operator can own only five units at the maximum. The average size of fish pen is 3,208 m^2 although the range was 1,200 – 6,000 m^2. As indicated in the MFO, the minimum size of fish pen should be 1,200 but should not exceed 4,000 m^2. Hence, in terms of minimum size the ordinance had been followed but not when it comes to maximum size. This maybe explained by the fixed license fee of PhP 5,000 per unit of structure per cropping such that the operator tried to maximize his/her return from the fixed license cost. Average depth of the structure is four meter from the water surface although this varied from 0.60 m to nine m, the deepest being in Luciente 2 and Luna. The average distance of the structure from the shore is 279.50 m that is below that required by the ordinance of at least 300 m. However, by specific operator, there were those whose structures were located just four meters away from the shore. Luciente 2 and Luna had average distance of only 137.50 m and 101.25 m, respectively, while Pilar and Tara had structures located within the provision of the ordinance. Mariculture structures in Tara had average distance of 541 m while Pilar had 377.50 m on the average (Table 7). The relatively closer distance to the shore of the structures in Luciente 2 and Luna may be explained by the desire of the operators from these barangays to minimize the cost of operation. However, this has some implications on water quality that were discussed earlier. Fish pens are usually situated in shallower water since the nets and structures are anchored at the bottom.

Reported mortality during the study period was 16% which was relatively higher compared to the mortality of 14% experienced in 1998 and earlier. Operators in Pilar whose fish pens were hit by fish kill and oil spill that occurred in January 2000 reported highest mortality. Accordingly, they experienced huge losses in their operation prior the study (Table 7). These operators were also among those who reported 50% mortality rate in 1998.

Given optimum stocking and proper management, potential yield of a 4000 m^2 pen could be from 22,000 – 30,000 kg of fish (at an average of 2 pc per kg). (INTAQ, 2000). Based on the responses given by the operators, they were able to produce 29,967 kg of fish on the average for a 4000m^2 fish pen that was within the potential yield (Table 7). There are even those who were able to harvest more than 56,000 kg. Thus, it may appear that the operators were operating efficiently. However, there were also those whose harvest was only 9,000 kg, a figure far below the potential yield. These were the operators from Luna who suffered 60% mortality in their recent operation. Compared to 1998, the operators were able to produce more in 2001. This maybe attributed to the fish kill that hit the area in 1998 due to proliferation of excessive number of structures.

Another important information gathered from the respondents was the longer grow out period in the recent years compared to that of 1998. Accordingly, the average grow out period (from stocking of fry to harvest) lately was 5.17 mo (21 wks) compared to 4.6 mo (18.5 wk) in 1998 (Table 7). This longer grow out period was attributed by the operators to the deteriorating water quality.

Management Practices

Management practices related to mariculture operation include stocking density, feeding practices, use of pest and disease control, use of air compressor or aerator, and to a certain extent water quality testing.

Stocking Density. This refers to the number of fry placed per unit area of the fish pen. For fish pen, the recommended stocking density for a 4,000m^2 fish pen was 50,000 – 60,000 per unit (INTAQ, 2000). This translates to stocking density of 1,250 – 1,500 fry per 100m^2. Since the size of fish pens varied, the stocking density based on per 100 m^2 was used to compare operators with different fish pens areas and determine if there was high stocking density.

For the sample operators, the average stocking density during the time of the study was 1,119 fry per 100 m^2 and was a bit short of the recommended number. A closer look at the individual operators, however, revealed that the average masked the true situation in the area. There were those who had relatively low stocking density of only 625 fry per 100 m^2. The reason given was the limited capital to buy the milkfish fry. However, there were also those whose stocking density reached up 2,971 fry per 100 m^2, which was twice that of the recommended rate. Results of the survey showed that in all sample areas, there were operators who practiced high stocking density. Lowest average stocking density of 988 fry per 100 m^2 was computed for operators from Luciente while the higher average stocking of 1,242 fry per 100 m^2 was recorded for Tara. (Table 7).

Table 6. Socio-economic characteristics of the respondent-operators, by barangay, Bolinao, Pangasinan, 2001 (except for n and age, numbers below indicate percentages)

CHARACTERISTIC	BARANGAY				ALL
	Luciente 2	Luna	Pilar	Tara	BARANGAYS
	n=8	n=9	N=8	n=9	n=34
Average age(in yr)	43	47	51	44	44
Gender					
Male (% of respondents)	88	56	75	100	82
Civil Status					
Married (% of respondents)	88	78	100	89	85
Educational Attainment					
Elementary (% or respondents)	12.5	11	50	0	12
Secondary (% of respondents)	25	11	25	44	29
College (% of respondents)	25	33	25	33	29
Vocational (% of respondents)	12.5	11	0	11	12
No Answer (% of respondents)	25	33	0	11	18
Average Household Size	5	6	5	4	5
Membership in Organization (%)	75	67	50	89	74
Type of Organizational					
Membership (%)					
Civic	25	11	0	0	12
Fishery	50	56	25	67	53
Environmental	0	0	25	0	3
Others	0	0	0	22	6
None	25	33	50	11	24
Type of Operation (%)					
Part time	62	67	25	67	62
Full time	38	33	75	33	38
Years Operating in Bolinao (%)					
< 4 years	38	33	25	44	35
> 4 years	62	67	75	56	65

Feeding Practices. The information related to feeding practices included the following: kind of feeds; quantity of feeds given and frequency of feeding. Different types/kinds of commercial feeds were given to milkfish at different stages of growth. For the sample operators, production cycle of milkfish lasted for five months and in extreme cases up to seven months. During the 1st month of the growing cycle, the most common type of feeds given consisted of fry mash and starter/crumble. Fry mash was used by all the respondents from Luna and Pilar and by 62 % of the respondent operators from Luciente 2. In Tara, the most common feeds given were starter mash or crumble. For the 2nd month, the most common feed was starter except for Tara where the fish were fed with grower up to the 4th

month of growth. During the 5th month, all the operators used finisher. This were given continuously especially in cases where the growth cycle extended until the 6th or 7th month.

The frequency of feeding affects the capacity of the fish to absorb/ingest the feeds given. Cultured species can absorb/take in only so much feed at a time such that if feeds are given in bulk and less frequent most of the feeds will just go to waste. Frequency of feeding varies by stage of growth. In Luciente, the feeds were given four times a day from the 1st to the 3rd month and five times from the 4th month onwards. In Luna, feeds were given less frequent during the same stages of growth. In Pilar, the feeds were given continuously but smaller quantities from the 4th month onwards while in Tara, the operators practiced smaller but more frequent (more than eight time a day) feeding from the 2nd month onwards. However, it is difficult to say whether the operators are over feeding the milkfish. The recommended feeding rate was based on the weight and not on the age of fish. For example, the feeding rate for fish weighing 1 – 5 g should be 15 – 20% of body weight while for bigger fish weighing 500 g, the feeding rate is 3% of body weight. However, overfeeding maybe implied since the caretakers were reportedly feeding the fish frequently especially from the 3rd month of fish growth. This practice is very inefficient and may lead to wastes especially during cold weather when the fish culture requires less feed. As suggested by INTAQ, 2000, it is better to underfeed than overfeed the fish since the latter may only contribute to poor water quality.

Water Quality Testing. Another important management practice in mariculture industry is water quality testing. This is necessary to monitor the DO levels so that appropriate measures can be done in case of low DO. Only 25% of the respondents said they performed water quality testing. No one of the operators from Luciente 2 and Pilar did water quality testing. Highest percentage (75%) from Luna and some 22% from Tara did the activity through the help of the UP-MSI. These operators were among those trained on water quality testing by UP-MSI as part of their participatory approach to mariculture management program. However, during the interview, the operators mentioned that the laboratory part is to technical, laborious and expensive and unless UP-MSI provides for funds and assistance, they could not do the water quality testing continuously.

Net Income from Mariculture Operation[5]

Net income is the difference between total revenue and total costs from the operation. Total Revenue (TR) is obtained by multiplying the quantity harvested with the average price of milkfish received by the operators. Total Cost (TC) consisted of all the costs incurred in production. This included the Total Fixed Costs (TFC) and Total Variable Costs (TVC).

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[5] For this section, only the information from the fish pen operators was used for analysis. There were some inconsistencies on the data from the fish cages that may render unreliable estimates. Since the operators had varying sizes of fishpens the analysis was carried out for a 4000m^2 fishpen.

Table 7. Information related to fish pen/cage operation by barangay and selected variables, Bolinao, Pangasinan, 2001

VARIABLE	BARANGAY				ALL
	Luciente 2	Luna	Pilar	Tara	BARANGAY
Average number of fish pen units	1	4	2	2	2
Range	*(1 - 2)*	*(1 – 11)*	*(1 - 3)*	*(1 - 3)*	*(1 - 11)*
Average area of fish pen unit (m^2)	3556	3400	3280	2822	3301
Range (m^2)	*(2,000 – 6,000)*	*(1,200 - 4,000)*	*(1,200 - 4,800)*	*(1,200 - 4,000)*	*(1,200 – 6,000)*
Average depth of net from the surface (m)	4	4.5	4.75	3.8	4
Range (m)	*(1.83 - 9)*	*(2.6 – 8)*	*(4 - 6)*	*(0.60 - 7)*	*(0.60 - 9)*
Average stocking density (pcs/100 m^2)	988	1,187	1,035	1,242	1,119
Range (pcs/100 m2)	*(625 - 2,000)*	*(875 – 1,416)*	*(375 - 2,174)*	*(750 - 2,971)*	*(625 – 2,971)*
Average number of structure near the operator's	7	4	13	3	6
Range	*(2 - 30)*	*(1 – 10)*	*(4 - 20)*	*(1 - 10)*	*(1 - 30)*
Average distance of structure from the shore (m)	137.5	101.25	377.5	541.13	279.5
Range (m)	*(40 - 500)*	*(17.5 - 400)*	*(30 - 1,000)*	*(4 - 4,000)*	*(4 - 4,000)*
Average mortality 2001 (% of stocking density)	7	18	22	21	16
Range(% of stocking density)	*(12 - 18)*	*(4 – 60)*	*(7 - 24)*	*(0.33 - 34)*	*(0.33 - 60)*
Average mortality 1998 (% of stocking density)	8	18	50	8	14
Range (% of stocking density)	*(1 - 20)*	*(4 – 43)*	*(1 - 50)*	*(0.17 - 30)*	*(0.17 - 50)*
Average Production (kgs/4000 m^2) 2001	17,454	19,293	18,607	17,208	17,930
Range (kgs/4000 m2)	*(10,000 – 39,850)*	*(9,000 – 24,072)*	*(13,825 – 34,783)*	*(10,974 – 56,667)*	*(9,000 – 56,667)*
Average Production (kgs/4000 m^2) 1998	13,516	12,869	6,157	17,992	14,293
Range (kgs/4000 m2)	*(7,167 - 26,667)*	*(9,524 - 16,000)*	*(3,356 - 7,517)*	*(9,333 - 38,502)*	*(3,356 - 38,502)*
Average grow out period (mo/cropping) 2001	5.38	5.14	6	5.22	5.17
Range (mo/cropping)	*(5 - 6)*	*(4 - 6)*	*(5 - 7)*	*(3.5 - 7)*	*(3.5 - 7)*
Average grow out period (mo/cropping) 1998	4.64	5.07	4.17	4.21	4.6
Range (mo/cropping)	*(4 - 6)*	*(4 - 6)*	*(4 - 4.5)*	*(3.5 - 6)*	*(3.5 - 6)*
Average price paid for fingerlings/fry (PhP/pc)	2.61	2.61	2.69	2.4	2.46
Range (PhP/pc)	*(2.4 - 3.1)*	*(2.3 – 3)*	*(2.5 - 2.9)*	*(1.5 - 2.75)*	*(1.5 - 3.1)*
Average price received by the operators (PhP/kg)	51	57	59	58	56
Range (PhP/kg)	*(50 - 56)*	*(50 - 60)*	*(45 – 78)*	*(55 - 65)*	*(45 – 78)*

Price of milkfish received by the individual operator varied depending on size of fish with average values of PhP51.00 – PhP59.00 per kg. Since the operators reported varied sizes of fish pens, net income was expressed in terms of a 4000m^2 fish pen area for uniformity.

Costs incurred by an operator. On the average, TC incurred by the operators for a 4000m^2 fish pen amounted to PhP 694,129 per cropping cycle. TFC consisted of license fee, permit to operate, depreciation of bamboo poles and nets, and interest on borrowed capital. TVC included expenses for fry, feeds, labor of the caretaker, and other material inputs. TFC per cropping amounted to PhP 50,940 and contributed only seven percent of the TC. It appeared that TVC amounting to PhP 643,189 per cropping dominated the cost of milkfish operation (Table 8). Among the variable inputs, feeds accounted for the majority (72%) of the TVC while fry contributed 18 percent.

Net Income from a 4000 m^2 fish pen. TR from fish pen operation was obtained by multiplying total production by the price of per kg of milkfish received by the operators. TR during the 1st operation cycle in year 2001 ranged from PhP 500,000 – PhP 3,116,667 with an average of Php1,004,098. The operators from Luna realized highest average TR of PhP 1,093,274. This maybe attributed to the high average production per pen. For an individual operator, highest TR of PhP 3,116,667 was estimated for an operator from Tara where highest production of 56,667 kg was also reported (Table 9).

TC ranged from PhP 220,775 – Php2,037,202 with an average of PhP 694,129 (Table 9). Highest total costs of PhP 810,466 were estimated for the operators from Tara where highest costs and lowest TCs by an individual operator were also recorded. The lowest total cost per barangay was that of Pilar.

On the average, net income from a 4000m^2 fish pen was PhP 309,969 (Table 9). On per site basis, highest average net income of PhP 534,840 was computed for Pilar and the lowest of PhP 227,104 was in Luciente. The relatively lower net income in Luciente compared to the other barangays maybe attributed to lower production, lower price per kg of fish and high production costs. These net income values, however, were within the range of the computations of PhP 217,824 - PhP 355,798 done by INTAQ, 2000 for different prices of milkfish.

Form the results of the study it appeared that continuous expansion and construction of more fish cages and fish pens were driven by profit motive. That is, milkfish culture is a lucrative business and the operators, in general, are earning fairly well in mariculture operation. This profitability, coupled with weak governance system led to overcrowding that resulted in massive fish kill event on February 2002. As such, when the fishkill struck the area in February 2002, almost all the operators in Luciente were not able to cover the cost of production. As whole, total losses during the fishkill was valued at P600 M.

Table 8. Details of costs incurred by a fish pen operator for a 4000 m^2 fishpen per cropping, 2001

TYPE	AMOUNT (PHP)
Fixed Costs	
License fee*	5,000
Permit	75
Depreciation of Bamboo**	15,000
Depreciation of Net**	20,540
Raft	1,500
Interest on borrowed capital	8,825
Total Fixed Costs	**50,940**
Variable Costs	
Changing/washing of net	2,768
Rope/nylon cord	2,190
Miscellaneous	4,500
Fry	120,895
Feeds	491,664
Labor (including value of family labor)	21,172
Total Variable Costs	**643,189**
Total Cost	**694,129**

* License fee is P10,000 per unit per year and the operator has two cropping per year

** Bamboo poles and nets are used for two cropping seasons.

Note: US$ 1.00 = PhP 54.00

Table 9. Average Costs and Returns from a 4000 m^2 fish pen operation per cycle, by barangay, Bolinao, Pangasinan, 2001

ITEM	BARANGAY				ALL
	Luciente 2	Luna	Pilar	Tara	BARANGAY
Total Revenue (TR)					
Qty Harvested (kg per 4000 m^2 area)	17,454	19,293	18,607	17,218	17,930
Range (kg/4000 m^2 pen)	*(10,000 – 39,850)*	*(9,000 – 24,072)*	*(13,825 – 34,783))*	*(10,974 – 56,667)*	*(9,000 – 56,667)*
Ave price of Fish (PhP/ kg)	51	56	53	58	52.5
Range	*(50 - 56)*	*(55 - 60)*	*(45 - 57)*	*(55 - 60)*	*(45 - 60)*
Total Revenue (TR) in PhP	**894,519**	**1,093,274**	**1,088,528**	**996,738**	**1,004,098**
(Range)	*(500,000-2,072,200)*	*(522,000 – 1,440,000)*	*(697,500 – 1,913,043)*	*(636,463 – 3,116,667)*	*(500,000 - 3,116,667)*
Total Costs (TC) in PhP	**735,054**	**595,442**	**633,349**	**810,466**	**694,129**
(Range)	*(422,040-1,556,835)*	*(340,155-1,045,575)*	*(432,992-1,050,945)*	*(220,775 – 2,037,202)*	*(220,775 – 2,037,202)*
Net Income (TR less TC) in PhP	**227,104**	**509,015**	**534,840**	**344,386**	**309,969**
(Range)	*(77,960 – 518,875)*	*(36,495 – 805,941)*	*(220,055 – 862,099)*	*(59,428 – 1,079,465)*	*(36,495 – 1,079,465)*

3.7 Mariculture Production Analysis

Effects of mariculture industry can be evaluated based on the following: a) socio-economic aspect; b) environmental aspect and c) ecological aspect For this study the socio-economic effect was evaluated based on income from mariculture production, which was discussed in the previous section. Environmental aspect was captured on the water quality analysis portion. In this section, the focused will be on the analysis of the effects of intensive mariculture operation on the sampled mariculture fishpens

Technically, and in the short run, mariculture production is a function of variable inputs used to produce the fish. For this study, stocking density and feeds were considered as important factors that affect production. This is so because, high stocking density and overfeeding are claimed to contribute to water quality that caused fish kills and eventually reduced yields. In addition, these two inputs accounted for the high production costs, feeds and fry accounted for 72% and 18% of the total production costs, respectively. To determine whether water quality (which is perceived to be caused by mariculture operation) affects yield, water quality dummy using DO values was included in the fish production equation.

Results of the multiple linear regression run for mariculture production are as follows:

$$Ya = 141.29^{**} + 2.542SD^{*} - 0.00075SD^{2**} + 2.999F^{ns} - 0.0205F^{2ns} - 40.78WD^{***}$$

$R^2 = 0.93$ F = significant at 0.01

*** significant at 0.01 level; ** significant at 0.05 level
* significant at 0.10 level; ns = not significant at 0.10 level

Where:

Ya = milkfish production of operators (kg/100 m^2 area)
SD = stocking density/100 m^2 area
F = quantity of feeds used for the whole operation in bags
WD = water quality dummy
1 if DO level in the sampling fishpens in the area is equal to or less than 4mg/L
0 if DO level in the sampling fishpens in the area is greater than 4mg/L

The water quality dummy is interpreted as an intercept shifter. It implies that, holding other factors constant, if the undesirable condition, that is water quality deterioration, exists, productivity will decrease thus, shifting the production function downward.

The 4mg/L cut off value for DO was based on the study on DO and marine life conducted by the US Environmental Protection Agency's Environmental Research Laboratory (US-EPAERL) in Rhode Islands. Results of the study showed that if DO level is 4mg/L, survival rate of planktonic larvae of crabs may be reduced by 30% and growth of summer flounder by 25%. This study was used as basis in the absence of available information on the relationship between different DO levels and mortality or milkfish survival in the Philippines.

The signs of the variable inputs coefficients conformed to a priori economic expectation. For the stocking density, as stocks increases so will yield up to a certain level, beyond, which, yield, will start to decline. However, the coefficient of the feed variable appeared to have no significant effect on production. This non-significance of feeds on production may imply that there is no significant variation in feed level used by the operators such that yield differences do not depend on quantity of feeds.

Results for the stocking density show that yield increases as stocks increases but up to a certain extent. There is a maximum stocking density beyond which, production will start to decrease. This is exactly what a short run production analysis tells us. That is, because of the law of diminishing productivity, further increases in the variable input will cause production to decrease. For the mariculture production, this maybe explained also by the nature of the fish as a resource, that is, as more stocks are put in a given space, overcrowding occur, which result in the competition for space and eventually lead to slow growth, if not mortality. In addition, overcrowding also lessen the movement of fish thereby reducing the oxygen level that result in low DO. Moreover, if stocks were beyond the optimum, fish excreta and wastes became excessive that may result in fish kill. .From the equation above, if stocking density per 100 m^2 of fish pen area exceeded 1,693 fry, production will start to decline. The negative sign of the coefficient of the squared stocking density manifests this. This result is quite close to the recommended stocking density of 1,250 - 1,500 fry/100 m^2 fish pen area that was identified by INTAQ (2000).

The coefficient of the water quality dummy is – 40.78. This means that holding other factors constant, if the DO level within the fish pen area fell below 4mg/L, the intercept of the milkfish production function will decrease by 40.78 units and the production frontier will shift downward. Using the results of the regression, this implies that on the average, the intercept would decrease to 83.51.or if all the variables are held constant, production of a 400-m^2 fishpen would only be 83.5 kgs. This could be interpreted to mean that those mariculture structures with DO levels less than 4mg/L are likely to suffer from lower productivity compared to those structures with DO levels higher than 4mg/L. Data on water quality analysis in the sample barangays showed that there were variations in DO levels in specific sampling points; with some points having DO values greater than 4mg/L.

IV. Conclusions and Policy Implications

4.1 Conclusions

From the results above the following conclusions can be drawn:

a. The MFO guidelines were not followed. This was manifested by increasing number of structures that went way above the carrying capacity of the area. The inconsistencies between the actual number of structures and those listed or recorded at the CRM office of Bolinao indicated that most of the structures were illegally constructed. In addition, the number of structures that an operator can own also manifests the ineffectiveness of the ordinances if not inefficiencies of the administrators in implementing the guidelines.

b. Mariculture operation is a lucrative business and the operators are earning fairly well from the operation.

c. The mariculture industry in Bolinao can be classified as intensive. Although the average stocking density fell within the optimal value, there were operators whose stocking densities were more than double that of the optimum.

d. Results of the water quality analysis showed that mariculture indeed affect the water quality in the area. The high and negative correlation between stocking density and DO values in the sampling areas implies that overstocking contributed to water quality deterioration. Despite the fluctuations in DO levels within the day, the average value in areas with mariculture structures fell below the 5 mg/l critical limit for fish growth. TSS values were also high in most of the sampling sites. However, no definite link between mariculture operation and TSS values was established.

e. Results of the mariculture production analysis showed that stocking density had negative effects on production. Beyond a certain level, further increases in stocks would result in decreasing productivity. Water quality dummy also indicate that production is likely to decrease if DO level fell below 4mg/L.

e. Too many structures over the carrying capacity of the area and high stocking density may have led to fish kills and other associated damages that are detrimental not only to the mariculture industry itself but the community as well.

4.2 Policy Implications and Suggestions for Further Research

From the results of the study, several policy implications can be forwarded as follows:

a. As a lucrative business, there must be a need for strict implementation of the ordinance related to mariculture operation. The problems associated with mismanaged mariculture, imply that strict enforcement of the MFO should be in place. Penalty that should be high enough compared to the gains from violation of the ordinances may be considered. Incentives for compliance to the ordinance such as tax holiday, technical assistance, etc may be considered by the LGU.

b. Since coastal mariculture has been operating in other coastal areas of the country, legislative actions aim to regulate the industry may be called for.

c. Since mariculture is contributory to water quality deterioration, LGUs may consider the provision, out of the revenue from the industry, of resources for activities towards sustainable mariculture. Periodic monitoring of the number of structures may be done to make sure that the carrying capacity of the area is met.

d. Polluters-pay-principle may be applicable to the mariculture sites. This will serve as incentive for the operators to practice effective and efficient mariculture operation.

For further research, the following can be considered:

Technical inputs are important in any economic analysis. Based on the above results the following are among the priority activities for research:

a. Studies on the technical relationship between growth of fishes, both captured and aquaculture species, and varied levels of DO. The technical coefficients on this aspect would be useful for valuation studies on the effect of water quality and fish growth.

b. Further study on the optimal stocking density for mariculture shall be considered.

c. Longitudinal or time series study on water quality, hydrologic characteristics, weather condition and fish growth would also be very useful.

d. Technical study on the effects of mariculture wastes on water quality, coral reefs and spawning grounds of captured fish species to determine the survival of fish larvae and juveniles would also provide valuable input especially in assessing the effect of mariculture on captured species.

e. Lastly, comparative study on the socio economic and environmental effects of different types of aquaculture operations (fishpond, freshwater aquaculture, coastal and inland mariculture, concrete tanks, etc) can give important information about mariculture management.

The above studies would be very useful for valuation and assessment studies related to mariculture or culturing fish in coastal water.

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