

## The Status of the Land-Based and Offshore Aquaculture Systems in Cebu, Philippines

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### ABSTRACT

Development of aquaculture systems are growing due to increasing human population and its demand for aquaculture products. This brought environmental concerns on the effects of aquaculture systems on water quality and nearby ecosystems. In order to determine whether water quality can still support marine life and suitable for aquaculture purposes, assessment of eight aquaculture systems in Cebu was conducted. Water samples were collected within the aquaculture systems and fishpond outlets. These were brought to a water laboratory for analysis of BOD, Total Coliform, Nitrate, Phosphate, Ammonia and Total Suspended Solids. Water temperature, pH, D.O, conductivity, TDS and salinity were measured in-situ. Results showed that the pH within fish cages and brackish water fishponds exceeded the standard limit while dissolve oxygen falls below the minimum standard limit. However, these values falls within the desirable, optimum and ideal growth of species cultured. The total coliform count was found highest in freshwater ponds which also exceeded the standard limit. Sedimentation was higher in aquaculture systems than in fishpond outlets due to waves exposure, currents and fishermen activities. Biophysical assessment showed fair condition of live hard corals, high fish diversity, moderate fish density and high fish biomass in Badian fish cages. Poor seagrass cover was observed in Carmen fish cages. Mangrove species were found nearby fishponds while trees, palms and grasses were observed in upland fishponds. This study revealed that water quality of most fishpond outlets and aquaculture systems were within the water classification of DAO 34, 1990 and found to have a minimal effect on the environment particularly on water quality and the cultured species.

Keywords: Fishponds, water quality, total coliform, water classification, DAO 34, 1990, biophysical.

### INTRODUCTION

The rapid increase of human population in the Philippines has a corresponding pressure on the demand for food in which greater percentage can be sourced out from the fishery products. Due to this, a number of aquaculture industries are rapidly growing in fresh water and marine environments. The aquaculture industry is growing more rapidly than in any other segment of the animal culture industry (Gang et al. 2005). This is because the demands of aquaculture products as food, e.g, bangus, prawns, etc. are consumed either directly or as raw

materials in the production of processed products either for domestic or international markets. However, along the development, concerns are evoked about the possible effects of ever increasing aquaculture wastes both inside and outside the aquaculture systems. Inputs of artificial feeds and trash fish as food for the cultured species may result to environmental problems on the water quality condition and may pose pollution to the area.

Effluents from aquaculture that consist of faeces or uneaten food can cause oxygen depletion and ammonia toxicity when it decomposes. Ammonia together with other nitrogenous compounds such as nitrite and nitrate, are considered as major contaminants in aquaculture wastewater (Cao et al. 2007). Excessive sediment deposition beneath sea cages results in the release of H<sub>2</sub>S into the water (Beveridge 1987) may cause foul odor in the environment. Organic particulates from the aquaculture industry will be consumed by bacteria causing the said microorganism to multiply in excessive number posing pathogen to fish and other organisms. Changes in pH is lethal to fish that can be influenced by the high levels of ammonia and hydrogen sulphide due to the large amounts of nutrient load/ wastes from the aquaculture activities.

Aquacultural discharges may pose threats to the three major aquatic habitats, the seagrass, corals and mangroves. Seagrass requires less nitrogen compared to phytoplankton and algae. They thrive in clear and low nutrient waters. When human can released nutrients from aquaculture or any other waterways, phytoplanktons will shade the seagrass and algae begin to grow on seagrass blades. This will retards the growth of seagrass which may cause the seagrass to die, exposing the sediments and releasing more nutrients (Suthers and Rissik, 2009). Likewise sediments in water reduces light that reaches the corals in which zooxanthellae can no longer performs photosynthesis where the corals depend on for their food ( Castro and Huber 2010). Mangroves however will not be affected with effluents from the aquaculture, but their associated threats from aquaculture is its conversion to aquaculture farms. These three major habitats supported diverse form of life wherein their habitat deterioration may also mean deterioration in the supply of food to human.

Although aquaculture industries has been beneficial in terms of socio-economic, it could also pose threats to the environment such as its effect in relation to water quality particularly its physico-chemical, bacteriological, biophysical properties and others. Thus, there is a need to assess the status of the existing aquaculture industries, specifically cages/pens and ponds, to determine whether or not the quality of water in the area is suitable for aquaculture purposes and can still support the marine life and its nearby ecosystems.

As far as the researchers' knowledge are concerned, there has been no study yet conducted on the status of the existing land-based and offshore aquaculture industries that are found operating in the Central Visayas region, particularly, Cebu, Philippines. Thus, this study was directed towards this purpose.

Results of the study can serve as basis in policy determining options in regulating the aquaculture practices in Visayas region in order to avoid the possible occurrence of massive fish

kill that had happened in some regions in the country in particular, and to the global aquaculture industry, in general.

## MATERIALS AND METHODS

### Site Description

Eight aquaculture systems located in the southern and northern part of Cebu were chosen for this study. These were shortlisted by the research team after the reconnaissance visit to the area and were chosen and recommended by the respective LGU's considering the size (has) and operational status. The study site include: Carmen, Badian, Alcantara, Moalboal, San Remegio, Lapu-lapu, Barili and Alegria as shown in Figure 1.



Figure 1. Map of Cebu Province showing the eight survey sites

### Conduct of Biophysical Assessment

Reconnaissance survey of fishponds, fish cages and fish pens were conducted in selected municipalities in Cebu. Information about the aquaculture systems were gathered as to: type of aquaculture system, area, species cultured, type of feeding, years in operation, type of ownership and others (Table 1). Inception meetings were conducted prior to field sampling. Field surveys were carried out by a team of researchers from the CTU-ICRM Center together with experts from DENR. Surveys were focused on the assessment of water quality, sediment load, mangroves and other vegetation in fishponds and fish pens. Corals, fish and seagrass assessment were also conducted within fish cages.

**Table 1. Site description of the study sites**

Barangay/ Municipality	Type of Aquaculture System	Sampled /Operational Area (has)	No. of Years operational	Species Cultured	Type of Feeding	Ownership
Luyang, Carmen	Fish cage	0.081 (18 cages)	1-14	Milkfish	Feeds	Private
Zaragosa, Badian	Fish cage	0.049 (5 cages)	4	Milkfish	Feeds	Private / Coop
Polo, Alcantara	Fish Pen	0.16	4	Milkfish, Rabbitfish	Feeds	LGU/P.O
Tuble, Moalboal	Fishpond	12.5	44	Milkfish	Natural & Feeds	CTU/Gov't.
Argawanon, San Remegio	Fishpond	1	30	Milkfish	Natural & Feeds	Gov't/FLA
Calawisan, Lapu-lapu	Fishpond	2.9	2-44	Seaweeds, Milkfish	Natural	Private
Campangga, Barili	Fishpond	0.35	10	Tilapia	Feeds	Private
Valencia, Alegria	Fishpond	0.113	2-4	Tilapia	Feeds	Private

Coordinates of the sampling sites were determined using a hand-held global Positioning System (GPS). First round of water sampling was undertaken last November to December 2013 while second round of water sampling was conducted last July to August 2014. Sampling was done at no particular time of the day and regardless of tide. Water samples were taken from the surface (upper 50 cm) of fishpond outlets (specifically on areas where freshwater and sea water meet or locally called “bukanas”) and nearby waters of fish pens and fish cages. Composite water samples were collected inside the aquaculture systems. Water temperature, pH, D.O, TDS and salinity were measured in-situ using Hannah multi-parameter meter and were recorded. Sealed and properly labelled water samples were taken to Ostrea Mineral Laboratories, Inc. for analysis of BOD (Dilution Technique), Total Coliform (Multiple Tube Fermentation Technique), Nitrate (Brucine Sulfate), Phosphate (Stannous Chloride), and Ammonia (Distillation/Titrimetric) within 6 hours after collection. Laboratory analysis followed the Standard Methods for the Examination of Water & Wastewater, 21<sup>st</sup> Ed. following the DENR Standard for Class C and Class SC waters (DAO 34, 1990).

Suspended solids were collected using an improvised sediment trap made of 3-plastic jar containers measuring 13 cm in length and 5.5 cm in diameter (English et al. 1997) securely fastened to a wood stake or pole. Three (3) traps in each site were vertically and firmly installed into the bottom of fishpond outlets and beneath cages and pens for 7 days. The mouth of the traps were covered with nets secured with rubber bands to prevent leaves and branches, molluscs, fish, crustaceans from entering. The traps were retrieved after 7 days and prior to retrieval, the mouths of the traps were covered before bringing it out to the surface. The samples were taken to the Laboratory for the analysis of Total Suspended Solids using the Gravimetric Method dried at 103-105°C).

Sedimentation rate (mg/cm<sup>2</sup>/day) was determined by dividing the dry weight (in mg) with the area of the sediment trap aperture width (in cm<sup>2</sup>) over the duration (in days) the sediment trap was placed under water.

The flora and fauna surrounding the fishponds including mangroves, trees, palms, birds as well as corals, fish, and seagrass observed within 50 meters from the fish cages and pens were also assessed using the method by English et al. (1997).

## RESULTS AND DISCUSSION

### Physico-chemical Water Parameters

#### A. Temperature

Temperature is important in plant photosynthesis and metabolic activities of aquatic organisms (USEPA, 1997). Water temperature in both outlets and within aquaculture systems ranged from 29.6-32.5°C and 26.0-31.4°C respectively as reflected in Figure 2. The outlets of the fishpond in Tuble, Moalboal obtained the highest mean temperature of 32.5°C. Almost all the sites obtained a mean water temperature that falls within the 25-31°C DENR water quality standards for class C and SC waters represented by the broken lines as shown in Figure 2. Only the fishpond outlets in Moalboal exceeded a little above the standard temperature. Warmer temperatures were observed in outlets than within the aquaculture systems. However, there is no typical temperature for water, but there is an optimal temperature which vary from one species to another (Kemker, 2014)

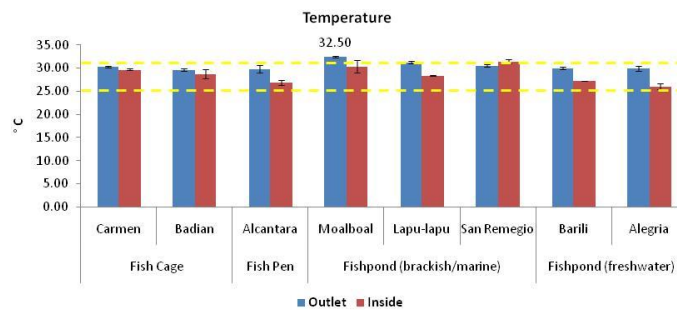


Figure 2. Mean water temperature of water samples in the study sites

#### B. Salinity

Salinity is simply a measure of the amount of salts dissolved in water (USEPA, 1997) and just like temperature, aquatic plants and animals have different tolerable salinity range. Water salinity ranged from 30-35 ppt in outlets and 29-35 ppt within the aquaculture systems excluding freshwater ponds as shown in Figure 3. Outlets of freshwater fishponds in Campangga, Barili and Valencia, Alegria had a salinity of 0.42-0.50 ppt and 0.16-0.22 ppt within the ponds. There is no water quality criterion set by DENR for salinity. Almost all sites obtained a salinity suitable for the species cultured. The salinity of the water in most of the sites are suitable and tolerable for the cultured species.

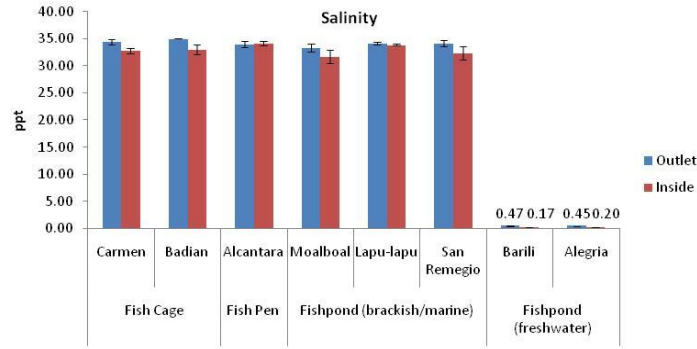


Figure 3. Mean water salinity of water samples in the study sites

### C. pH

Water pH in outlets and within the aquaculture systems varied from 7.36-8.32 and 7.47-8.84 respectively as reflected in Figure 4. It is a measure of how acidic or basic (alkaline) a solution is (Ohrel and Register, 2006). Most of the sites had mean pH values within the 6.5-8.5 DENR standards for Class SC waters (represented by the broken lines) preferred by most organisms. However, milkfish ponds in Moalboal, Lapu-lapu and San Remegio recorded a pH above the standard limit of DENR. The optimum pH level of Milkfish is 6.8 to 8.7. According to Food and Agriculture Organization (FAO), fish grows between 6.5 and 9 pH level. The desirable pH range for fish production is 6.5 – 9.0 according to Lawson (1995), and Tarazona and Munoz, (1995). Hence, an increase of pH beyond DENR standard did not have any adverse effect on the cultured milkfish species.

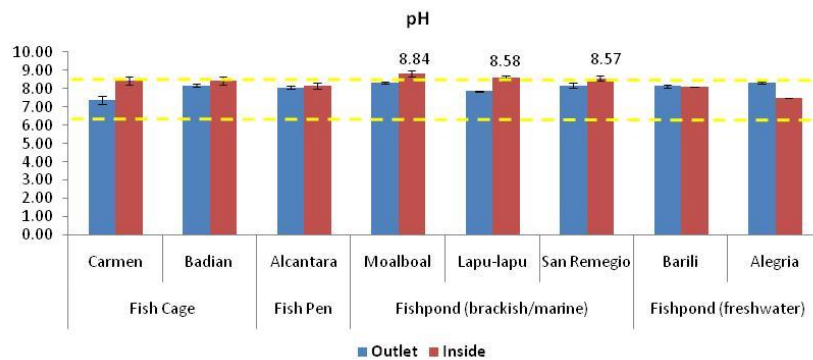


Figure 4. Mean water pH of water samples in the study sites

### D. Dissolved Oxygen

Dissolved Oxygen (DO) is oxygen in a dissolved state found in microscopic bubbles mixed in between water molecules (PHILMINAQ). It is needed by fish to respire and perform metabolic activities and considered as one of the most important aspect of aquaculture. Dissolved oxygen in outlets ranged between 2.07-6.30 mg/L and between 2.92-6.10 mg/L within the aquaculture systems. Results showed that 3 aquaculture systems had a mean DO values below 5.0 mg/L which is the minimum DENR standard limit for Class C and SC waters represented by the broken line as

shown in Figure 5. Cultured species in these aquaculture systems are milkfish and tilapia which can still grow well at DO level of 3-5mg/L and 1-3 mg/L, respectively.

D.O may change in a matter of hours since it is affected by physical, chemical, and biological factors making it difficult to assess the significance of any single DO value (Ohrel and Register, 2006).

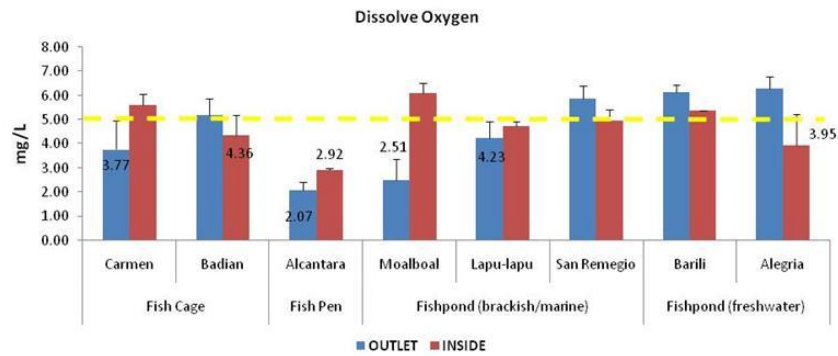


Figure 5. Mean water DO of water samples in the study sites

### E. Total Dissolved Solids (TDS)

Total dissolve solids includes materials dissolved in the water, such as, bicarbonate, sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. These ions are important in sustaining aquatic life. However, high concentrations can result to damage in organism's cell (Mitchell and Stapp, 1992) and can cause water turbidity, reduce photosynthetic activity and increase in water temperature. Total dissolved solids in outlets ranged between 430-489.30 mg/L and between 177.33-481 mg/L within the aquaculture systems as shown in Figure 6. The Philippines and ASEAN do not have a standard water quality criterion for TDS, (PHILMINAQ, Water Quality Criteria and Standards for Freshwater and Marine Aquaculture) and DENR does not also have a standard water quality criterion for TDS. Acceptable levels for total solids for Class C (freshwater) and SC (marine) waters in Kenya is 1,200 mg/L while Malaysia only have a standard for Class C waters which is 500-1,000 mg/L based on PHILMINAQ. Basing the results on the standards of Kenya and Malaysia, all sites falls within the acceptable levels for total solids.

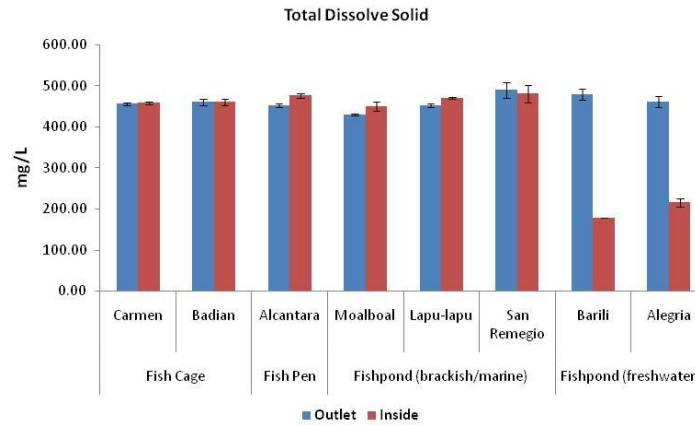


Figure 6. Mean total dissolve solids of the water samples in the study sites

## II. Biological Water Parameters

A one-time water collection within the aquaculture systems by means of composite sampling in three strategic locations/site was done for BOD, total coliform, nitrate, phosphate and ammonia.

### A. Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand or Biological Oxygen Demand (BOD) is a measure of how much oxygen is consumed by bacteria or microbes as they break down organic pollutant in water. It is useful in determining the degree of pollution in bodies of water (EMB, DENR, 2008). Biochemical Oxygen Demand (BOD) in outlets and within the aquaculture systems ranged from 1.67-4.17 mg/L and <1-9.00 mg/L respectively as shown in Figure 7. Almost all sampling sites had a BOD mean which fall within the DENR standard limit of 7-10 (maximum value) mg/L for Class C and SC water. All sites recorded a BOD level within the acceptable range which is optimum for normal activities of fishes. The sites do not show the presence of high concentration of biodegradable organic matter hence, unpolluted.

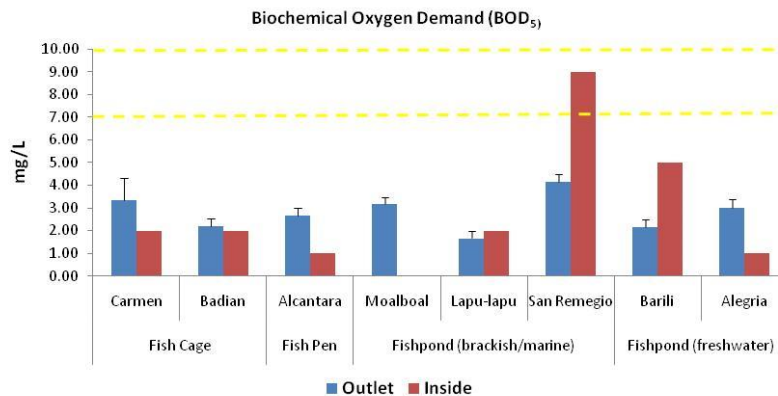


Figure 7. Mean biochemical oxygen demand of the water samples in the study sites

## B. Coliform

A very wide range of total coliform count was found in the outlets ranging between 17-1,489.68 MPN/100ml and inside the aquaculture systems between 2-35,000 MPN/100ml Figure 8. Total coliforms are present in all the sites but both freshwater fishponds in Campangga, Barili and Valencia, Alegria exceeded the maximum standard total coliform of DENR for class C and SC waters which is 5,000 MPN/100ml represented by the broken line. These ponds have a freshwater source from waterfalls and spring and may be contaminated by grazing animals, livestock and human excreta or by surface soils, land application of manure washed during heavy rains. Basically, bacteria are present in fishpond waters due to uneaten feeds, fecal matter, decaying fish and manure which are added into the ponds. One possible reason these freshwater ponds have high coliform count was they being enclosed and water exchange is slow. Moreover, coliform bacteria are not sensitive in low salinity level or reduced in numbers in waters with low salinity.

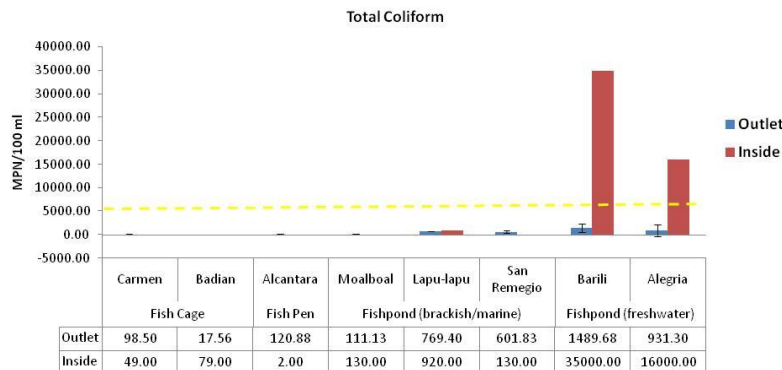


Figure 8. Mean total coliform of the water samples in the study sites

## C. Nitrate

Nitrate concentration in outlets and within the aquaculture systems ranged between <0.01-1.64 mg/L and <0.01-0.78 mg/L respectively (Table 2). All sites had a nitrate level below 7 and 10 mg/L which is the DENR standard for Class C waters (freshwater) not applicable to sampling sites with brackish and marine waters. Santhosh and Singh (2007) described the favorable nitrate range of 0.1 mg/L to 4.0 mg/L in fish culture water. Concentrations in excess of 5 mg/L usually indicate pollution by human or animal waste, or fertilizer or run-off (Chapman, 1992). The results showed that all areas had a nitrate concentration which did not exceed the DENR standards which means that all sites are free from human and animal waste or fertilizer run-off pollutants.

## D. Phosphate

Phosphate concentration ranged between <0.01-0.25 mg/L in the outlets and between <0.01-0.28 mg/L in within the aquaculture systems (Table 2). Low phosphate concentrations

were recorded in all sites. The sites had a mean phosphate level below the DENR standard for Class C and SC water which is 0.5 mg/L. Man made sources of phosphate in the environment include domestic and industrial discharges, agricultural runoff where fertilizers are used, and changes in land use in areas where phosphorous is naturally abundant in the soil (Belingham, 2012). The sites therefore are free from domestic, industrial and agricultural pollutants.

### E. Ammonia

All sampling sites obtained a mean ammonia concentration <0.2 mg/L (Table 2). DENR standard for ammonia concentration is 0.05 mg/L for both Class C and Class SC waters. According to Swann (1997) and OATA (2008) ammonia levels below 0.02 ppm is considered safe and ammonia level between 0-3 mg/L are considered unpolluted. The sites therefore were unpolluted and safe even with existing aquaculture industries.

Table 2: Nitrate, Phosphate and Ammonia Concentration

		Nitrate		Phosphate		Ammonia	
		Outlet	Inside	Outlet	Inside	Outlet	Inside
Fish Cage	Carmen	<0.01	<0.01	0.04	0.02	<0.2	<0.2
	Badian	<0.01	<0.01	0.08	0.03	<0.2	<0.2
Fish Pen	Alcantara	0.02	<0.01	<0.01	<0.01	<0.2	<0.2
Fishpond (brackish/marine)	Moalboal	<0.01	<0.01	0.25	0.28	<0.2	<0.2
	Lapu-lapu	<0.01	0.03	0.04	<0.01	<0.2	<0.2
	San Remeg	0.34	<0.01	0.02	0.03	<0.2	<0.2
Fishpond (freshwater)	Barili	0.21	0.43	<0.01	<0.01	<0.2	<0.2
	Alegria	0.64	0.78	0.05	0.12	<0.2	<0.2

### F. Total Suspended Solids (TSS) and Sedimentation Rate

Total Suspended Solids in aquaculture systems such as cages and pens ranged from 75-478 mg/L (Figure 9) and its rate of sedimentation ranged from 0.183-0.958 mg/cm<sup>2</sup>/day (Figure 9). Total suspended solids in fishpond outlets ranged from 63-289 mg/L (Figure 10) and its rate of sedimentation ranged from 0.125-0.580 mg/cm<sup>2</sup>/day (Figure 10). DENR standard of TSS (AO, 2008) for SC waters is 80 mg/L.

Fishpond outlets of Moalboal and Barili also exceeded the TSS standard obtaining 289 mg/L and 101 mg/L respectively. Sites with high TSS had high sedimentation rate. Based on the results, mean TSS and sedimentation rate is higher in the aquaculture systems compared to fishpond outlets as the latter (particularly the fish pen in Alcantara) is less exposed to waves and currents thus, uneaten feeds and fecal matters not dispersed by water currents settles into the bottom of the fish pen resulting to higher amount of suspended solids.

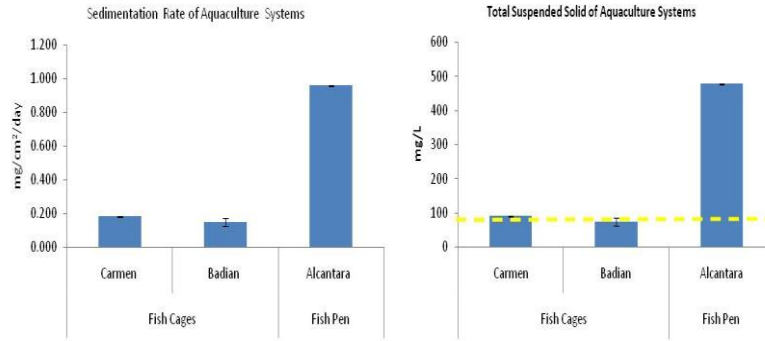


Figure 9. Mean total suspended solids and sedimentation rate of aquaculture systems

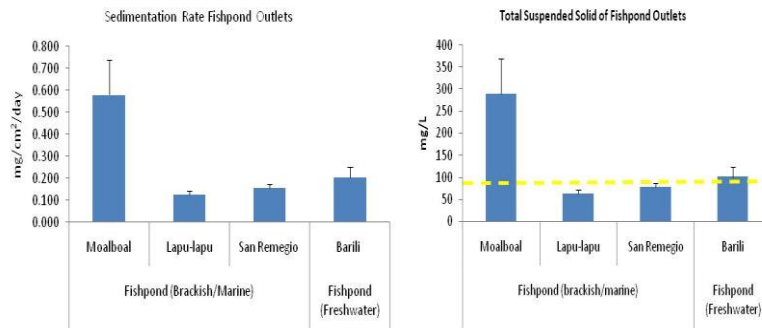


Figure 10. Mean total suspended solids and sedimentation rate of fishpond outlets

### III. BIOPHYSICAL ASSESSMENT

#### A. Corals

Among the sites, only the fish cages in Badian have the presence of corals in the area. Live hard corals were in fair condition (26%) based on Gomez et al., (1981). A total of 7 hard corals according to lifeforms were recorded. Branching type of corals were observed as dominant (8.67%) followed by digitate (7.33%) and massive forms (5.67%) (Figure 12). High Acropora / branching coral life forms suggest that the reef is exposed to high energy and strong wave action (Sorokin, 1993). A high percentage of dead corals with algae (31%) were observed which could be an effect of uneaten feeds that settles and cause nutrients producing algae in corals.

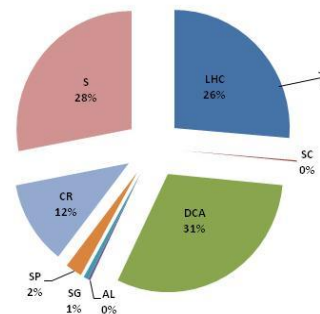


Figure 11. Percent Benthic Cover at Zaragosa, Badian Fish Cages

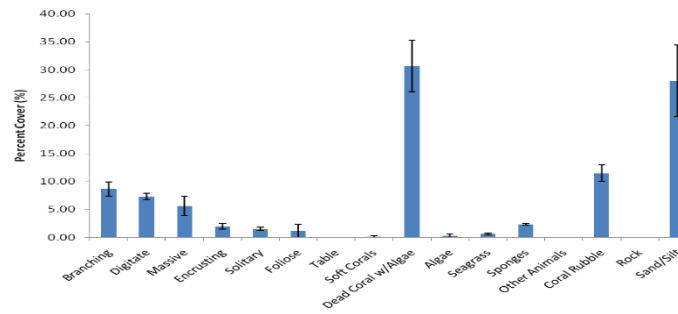


Figure 12. Percent Benthic Cover of Badian Fish Cages ( $\pm$  standard error, n=3)

## B. FISH

Indicator fish species from the family Pomacentridae, Labridae and Chaetodontidae were found in most numbers nearby Zaragosa, Badian fish cages. The presence of indicator fish such as Pomacentridae and Chaetodontidae indicate the presence of live coral cover and a healthy reef. The abundance of pomacentrids could also be due to the increase in algal cover on dead corals due to bleaching and pomacentrids mostly being algivores (Krishnan et al. 2013). This supported the result that corals with algae as well as live hard corals dominated the site. As shown in Figures 13, 14 and 15 the site had high fish diversity with 80 species/1,000m<sup>2</sup>, moderate fish density with 1,805 ind./1,000m<sup>2</sup> and high fish biomass with 28.36 MT/km<sup>2</sup> based on the categories described by Nañola et al. (2006) and Hilomen et al. (2000). Species from family Scaridae, Lutjanidae and Caesonidae contributed to the high fish biomass. Parrotfishes (Scaridae) are abundant on coral reefs, where they are often the largest component of the fish biomass. Scaridae are abundant in coral reefs and grows to bigger sizes (Westneat, 2002).

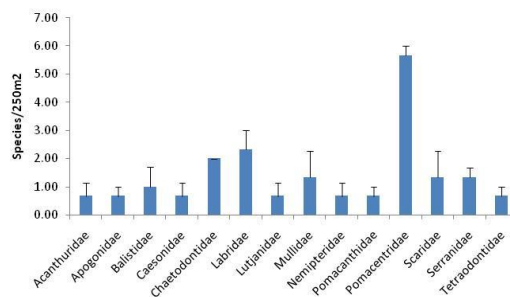


Figure 13. Mean fish species richness (species/250m<sup>2</sup>) near Zaragosa, Badian fish cages

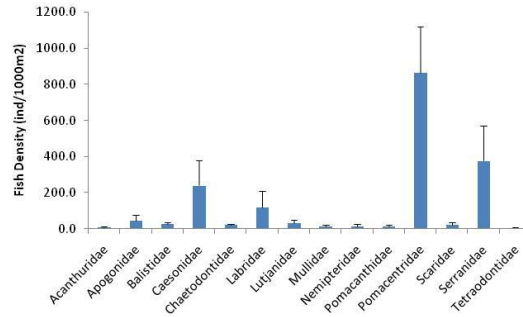


Figure 14. Mean fish density (ind./1,000m<sup>2</sup>) near Zaragosa, Badian fish cages

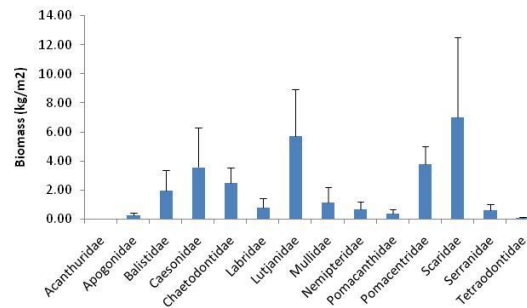


Figure 15. Mean fish biomass (kg/1,000m<sup>2</sup>) near Zaragosa, Badian fish cage

### C. SEAGRASS

Patches of *Enhalus acoroides* were found within the Luyang, Carmen fish cages. As shown in Figure 16, the site had a poor seagrass cover of 17 percent based on the criteria set by Fortes, (1989). Epiphytes observed in the leaves of *Enhalus acoroides* probably is due to nutrient load from feeds. Rich nutrient load could be the result of muddy and silted water observed in the area. The Local Government Unit in Luyang, Carmen together with the Bureau of Fisheries and Aquatic Resources assessed the area and made sure that there were no corals and seagrass in the area where the fish cages was established. Other invertebrates observed in the area were jellyfish, oyster, sea cucumber, crab and few branching corals.

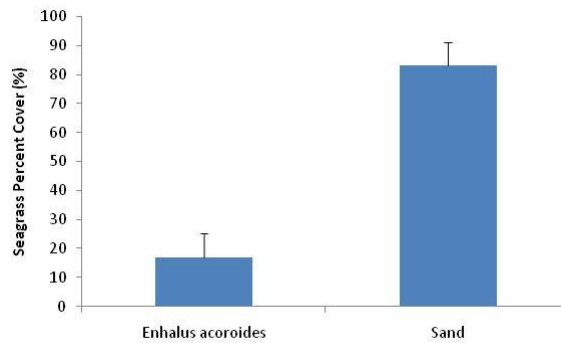


Figure 16. Seagrass percent cover within Carmen fish cages ( $\pm$ standard error, n=3)

## D. MANGROVES

Species of *Avicennia marina* were commonly found surrounding the aquaculture systems. Other common species were *Rhizophora apiculata* and *Sonneratia caseolaris* (Table 3). The presence of mangroves helps protect the pond from damage caused by strong winds, waves and storms. Moreover, mangroves are capable of absorbing pollutants such as heavy metals and other toxic substances as well as nutrients and suspended matter (UNEP, 2006) which may enter the fishponds. They could also be source of wild fry and juvenile fish for the aquaculture systems.

Mangrove communities within fishponds will prevent soil erosion of fishpond dikes and provides shades. Aside from that mangroves within the aquaculture systems helps collects silt, protect the ponds from waves and serve as buffer from storm surge (Menasveta, 1982).

Table 3. Mangrove composition in nearby aquaculture systems

Species	Local Name	Carmen	Alcantara	Moalboal	San Remigio	Lapu-lapu
		(cage-360 sq.m)	(pen-160 sq.m.)	(pond-160 sq.m)	pond (440 sq.m.)	(pond-360 sq.m.)
<i>Avicennia marina</i>	Bungalon	*	*	*	*	*
<i>Avicennia officinalis</i>	Api-api				*	
<i>Lumnitzera racemosa</i>	Kulasi			*		
<i>Xylocarpus granatum</i>	Tabigi				*	
<i>Xylocarpus moluccensis</i>	Piagao				*	
<i>Aegiceras floridum</i>	Tinduk-tindakan	*				
<i>Osbornia octodonta</i>	Tawalis	*				
<i>Bruguiera gymnorhiza</i>	Busain	*				
<i>Bruguiera cylindrica</i>	Pototan-lalaki				*	
<i>Ceriops tagal</i>	Tangal	*		*		
<i>Rhizophora apiculata</i>	Bakauan-Lalaki	*	*	*	*	*
<i>Rhizophora stylosa</i>	Bakauan-bangkau	*				*
<i>Sonneratia caseolaris</i>	Pedada	*	*	*	*	*

## E. Other flora and fauna

For fishponds without mangroves, its vegetation which includes common trees, palm or grass and other flora and fauna surrounding the ponds were noted. Common plants found in the freshwater ponds of Barili and Alegria were Coconut, Cogon grass, Manzanita, Guava, Mahogany, Devil weed “Hagonoy”, Moringa, Amber seed “Dalupang” and Talisay tree while common crops observed were Sweet potato, Cassava. The upland fishpond in Alegria had the most number of species of trees/palm and grass observed (41 species). Common birds and insects observed in the fishponds were Egret and Kingfisher “Tikarol”. Six (6) species of birds were found in the fishponds of Barili and Alegria. Although mangroves provides habitat for birds, it is not known if the species found are permanent residents or transient visitors of the mangrove communities.

## CONCLUSION

Results of the study showed that water quality of most fishpond outlets and aquaculture systems were suitable for its designated use or classification. The aquaculture sites were found to have a very minimal effect on the environment particularly on water quality wherein results of the water parameters showed a more or less the same environment within the aquaculture systems and that of the fishpond outlets and nearby waters of pens and cages. However, in terms of coliform count upland fishponds had the highest counts compared to the other sites.

Therefore, it is clear that the operators of the aquaculture system and related industries are observing the proper protocol in managing their businesses.

### **RECOMMENDATIONS**

Continue the periodic water quality test monitoring of pond waters in certain depths.

Conduct further studies to determine the source of high total coliform in freshwater fishponds and apply precautionary measures to reduce contamination.

Fish sourced out from ponds with high level of coliform above the DENR Standard should be properly cooked.

Observed proper pond management.

Ponds must have continuous water overflow for proper water exchange.

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