Environmental Impact and Growth Performance of IMTA species in Marine Pen Culture System

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Introduction

Marine aquaculture as a potential solution to problems of overfishing and declining supply from capture fisheries is expanding worldwide. It offers various opportunities and benefits particularly to coastal communities, serves as a protein source, provides income and employment, and some areas entirely depend on it as a source of livelihood. However, its effect on the surrounding environment has been a growing concern in this industry particularly on the intensive use of commercial feeds. In the Philippines, the production of milkfish through aquaculture consistently tops the list among finfishes with an annual production of 411 metric tons in 2017 (PSA, 2017).

The grow-out of milkfish is dependent on the feeding of formulated feeds. Thus, uneaten feeds, aside from the fecal matter, were observed to cause deterioration of the environment in the culture enclosure and surrounding areas. In this context, the concept of Integrated Multi-Trophic Aquaculture (IMTA) emerged. It uses not only commercially-important commodities, but also environmentally sustainable species from different trophic levels. The wastes products, consisting of uneaten feed, fecal matter and metabolic excreta of one species become beneficial inputs for the growth of another species through natural self-cleansing mechanism (Chopin *et al*. 2001). This is an ecosystem approach in mariculture, particularly applied in temperate waters that has been proven to solve problems in sea pollution associated with fish culture (Troell 2009). However, although it is possible to adopt the IMTA system concept in tropical waters, it is suggested that site-specific practices be implemented because there might not be a universal system for IMTA (Lander *et al*. 2013).

In this study, locally available marine species were tested, milkfish (*Chanos chanos*) as the fed species, seaweed (*Kappaphycus alvarezii*) as inorganic-extractive species for the water column, and sandfish (*Holothuria scabra*) as organic-extractive species on the sediments. This study aims to verify and improve IMTA systems suitable for farm conditions in coastal areas in the Philippines, with emphasis on mitigating the environmental impacts of mariculture of milkfish.

Methodology

The IMTA study was conducted in the waters of Barangay Pandaraonan, Nueva Valencia Guimaras in the Philippines with a series of experimental runs from August 2015 to October 2018. The setup consist of pen enclosures for milkfish (150 and 162 m^2) and sandfish (25 m^2), while seaweed was cultured around these pens through the floating monoline method using polyethylene ropes.

The stocking density of the cultured species was dependent on their availability. Milkfish stocks were sourced from the local ponds in Guimaras. Seaweed seedlings during the initial runs were obtained from the laboratory of SEAFDEC/AQD. Some seedlings were also sourced out from seaweed farms in nearby Panobolon Island which is also in Guimaras province. Sandfish juveniles were provided by the sandfish hatchery in SEAFDEC/AQD. The growth and survival of the cultured species were monitored monthly. Meanwhile, monthly collection of water samples within the pens and at a control site (50 m and 200 m away from the pen) was done for nutrient analysis. Sediment samples were analyzed for acid volatile sulfides (AVS) and organic matter (OM) content through Loss on Ignition (LOI) menthod.

Results and Discussion

IMTA Species Culture

Milkfish was cultured in pens with an initial average body weight of 20 to 50 g. They reached the commercial size at an average weight of 300 to 400 g after 112 days from stocking in pens (**Table 1**). These results were obtained for all runs conducted from 2016 to 2018. The results were comparable to those that are grown in monoculture. The highest survival achieved was around 99 % but only for Runs 2 to 4 (April 2016 to August 2017) in only one pen. Runs 5 and 6 (October 2017 to October 2018) showed an average survival for both pens at <70 % due to high mortality and some unaccounted fish that was probably associated with social factors.

Table 1. Growth performance of IMTA species from 2015 to 2018.

Specification	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Culture Period	Aug–Dec 2015	Apr–July 2016	Sept–Dec 2016	May–Aug 2017	Oct–Feb 2018	May–Oct 2018
Days of Culture	124	95	108	54,96	121,121	103,160
No. of Pens						
Milkfish	3	1	2	2	2	2
Sandfish	3	1	2	2	2	4
Area (m^2)	25	144	150,162	150,162	150,162	150,162
Milkfish						
ABW (g)	261	384	378,403	329,342	228,277	313,329
Survival (%)	55	99	80,99	88,98	68,87	76,45
Sandfish						
ABW (g)	115	82	45	35	191,127	81,86,102,99
Survival (%)	6	5	1	5	14,38	62,53,55,59
Seaweed						
Biomass (kg)	76	244	1	2	0	0

Seaweed (*Kappaphycus alvarezii*) was cultured in surrounding areas adjacent to the milkfish pen thru the long line method using PE rope with floaters. Seaweeds were only successfully grown during Run 2 (April 2016 to July 2016). The seaweeds proliferated at the start of the milkfish culture period, from initial biomass of 10 kg to 244 kg in 100 days. This impressive growth might be due to factors such as the season (dry season) and the overnight soaking of the seaweed plantlets in a fertilizer bath prior to stocking in floating longlines. However, seaweeds stocks had very low survival, primarily because of grazing by herbivorous fish, such as rabbitfish which were abundant in the area. The small-scale nature of our experimental setup has made our seaweed stocks very vulnerable to predatorion. In addition, the remaining seaweeds became infected with what is known as the *ice-ice* disease. After this run, the culture of seaweed in the IMTA site was not sustained due to factors such as predation, and unavailability of sufficient quantity of seedlings from laboratory. In later runs, the seaweed seedlings were sourced from the nearby Panobolon Island where seaweed farming is practiced. However, growth performance of such seaweed was poor, compared with that of Run 2. Perhaps, the incompatibility of the seedlings sourced from another site was a factor for the poor growth, in additiona to predation and diseases.

Sandfish (*Holothuria scabra*) cultured inside the milkfish pen during Runs 2 to 4 (April to July 2016) grew but at very low survival rates. This suggests that they may not withstand direct nutrient load from milkfish culture. With this observation, a separate pen enclosure was installed adjacent to the milkfish pen for sandfish culture from Run 5 (November 2017). This modification in the culture design allowed better growth and survival for sandfish. In Run 5, initial stocks with an average weight of 7 g reached 191 g after 15 months with an average survival rate of 26 %. In Run 6, initial stocks with an average weight of 16 g reached 90 g after 9 months with an average survival rate of 57 %. These results indicate that the size of sandfish at stocking may be an important factor for survival, as well as the nutrient load.

Environmental Impact

Environmental indicators such as dissolved inorganic nitrogen (DIN), comprised of nitrate, nitrite and ammonia, were analyzed monthly. These forms of nitrogen are readily available to phytoplankton and often are controlling the formation of blooms. These are the most bio-available and abundant forms of nitrogen that contribute to coastal eutrophication and should be monitored. The concentration at the control (50 m far from the pen) site ranged from 0.03 to 0.04 mg/L. The 2nd Control site (200 m far from the pen) measured at 0.01mg/L. DIN concentrations inside the milkfish pens ranged from 0.03 to 0.06 mg/L (**Figure 1**). These monthly monitoring results show that the IMTA practice did not create a significant impact in the water environment, based on nitrogen loading.

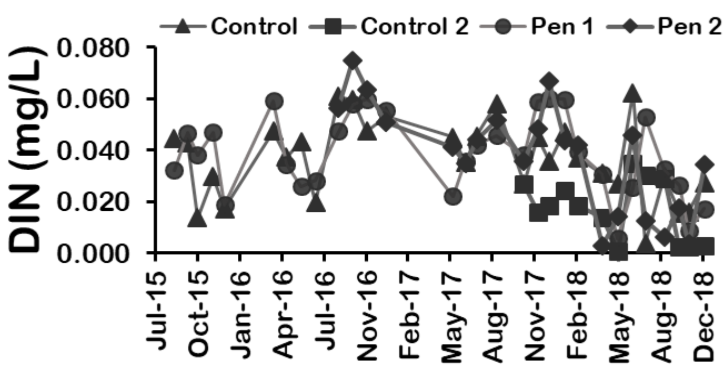

Figure 1. Monthly monitoring results of dissolved inorganic nitrogen (DIN) concentrations in IMTA site from Run 1 to 6 (2015 to 2018)

On the other hand, sediment quality was found to deteriorate as the intensity of culture increases. This was supported by the increase in acid volatile sulfide (AVS) levels (**Figure 2**). Organic matter content (**Figure 3**) had the same increasing trend with increasing farming intensity. From the results of these analyses, it is suggested that after two continuous culture periods of milkfish, a fallow period is recommended, wherein the pen will be left empty for 3–5 months to allow for the natural recovery of the sediments.

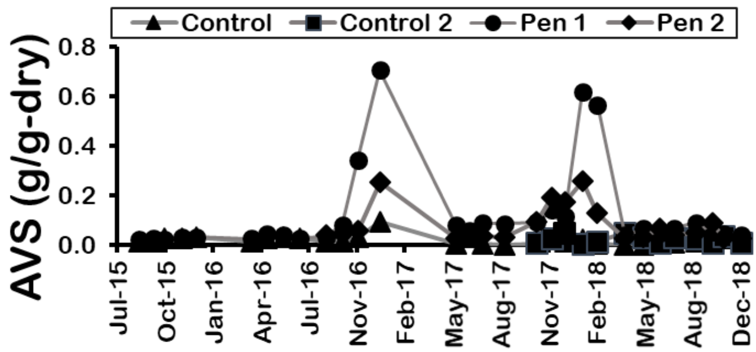

Figure 2. Monthly monitoring result of acid volatile sulfide (AVS) in IMTA site from Run 1 to 6 (2015 to 2018)

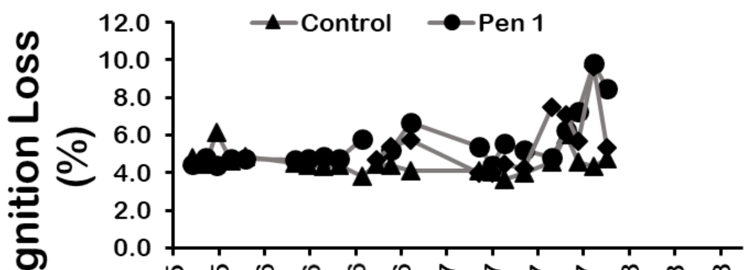

Figure 3. Monthly monitoring results of OM thourgh loss on ignition (LOI) in the IMTA site from Run 1 to 5 (2015 to 2018)

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