

# **STATUS OF AQUACULTURE ENGINEERING IN THE PHILIPPINES<sup>1</sup>**

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## **INTRODUCTION**

Aquaculture accounts for 35 percent of the Philippines total fishery production of 2.8 million metric tons in 1998. An annual growth rate of 5.6 percent have been posted by the aquaculture sector in the Philippines for the last two decades. This has been primarily attributed to increased production of tilapia and prawns. The growth trend, however, was not sustained when the prawn sector, on one hand, was greatly affected by a disease outbreak that reduced its output from 90,000 MT in 1995 to 40,000 MT in 2000. The output from the tilapia sector, on the other hand, remains unchanged after reaching its peak of production in 1993.

If aquaculture is to be enhanced at a sustainable level, then the problem of production inefficiencies need be addressed focusing not only on the two major sources of growth, shrimps and tilapia, but on the other species as well.

The paper presents the status of aquaculture practices in the Philippines and the level of technology adapted or the lack of it. Highlights of the paper are the problems encountered, the strategies adopted to address them and the industry gaps still needing attention. Special focus is likewise given on areas of engineering implications.

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## **Aquaculture Management**

To date, the aquaculture industry is still limited to the kind of fish species it can cultivate. It is still confined to the culture of milkfish, tilapia, carp, shrimp, mussel, oyster and the seaweed Euchema.

### 1. Finfish

#### 1.1 Milkfish

Quality and sufficient supply of fry beset shifting of farming method from the traditional (extensive) to semi-intensive and intensive methods. Even with the ample fry produced by hatcheries, supply is still not satisfactory. Deformities in hatchery-produced fry have to be solved. The cost of fry is still expensive that many of the small farmers cannot afford it thereby limiting their operations to just one cropping a year. The costs of formulated feeds are also prohibitive.

Sustainable levels of stocking density in pens and cages have yet to be defined. Cognizant of carrying capacities, the same should be determined for ponds in light of farming intensification. Moreover, existing mangrove-carved ponds cannot accommodate intensive level without redesigning and modifying them.

Farmable areas of lakes and coastal waters have to be zonified accordingly to ensure sustainability of operations and soundness of the ecosystem. Experience have shown, and let this be a stern warning – that over-construction of pens and cages in such bodies of water has led to their fast deterioration.

## 1.2 Tilapia

Similar to that of milkfish, insufficient and quality supply of seeds confront the development of farming systems. Poor quality fry/fingerlings come from poor strain of breeders. In turn, this results to longer culture period, higher inputs, and lower production income.

Hatchery operators and farmers should have access to technologies of proper maintenance and management of quality breeders through periodic training. Genetically improved strains (GIFT, GMT, YY-male, sex-reversed) should be made available to reputable hatchery operators at reasonable cost to ensure fry availability.

Development of the saline strain should be pursued with more vigor. Breeding and farming techniques thereof should be appropriately disseminated to farmers. Likewise, periodic training should be conducted in order to guide farmers and hatchery operators.

Availability of seeds of the saline strain can well complement the shortage of milkfish for brackish water farming.

## 1.3 Carp

There seems to be a need for further refinement of the farming systems of the commercially cultured species, including the production of quality seeds.

## 2. Crustaceans

### 2.1 Shrimps

Production started to decline in 1992 when little attention was given to address the environmental impact of intensive shrimp farming, particularly the effects of effluent on waterways, where poor water quality led to disease outbreaks (Corre, 1995). The disease problem has yet to be licked soonest before expecting the industry to regain its lost good production level.

It is worth noting that some experiences show that the incidence of pathogens is greatly reduced under “sugpo-bangus” polyculture. The appropriate stocking ratio has to be determined, with consideration for sustainability of operation and better profit. Such polyculture system is not as highly profitable as that of the intensive method, but is much less risky, more sustainable and economical in the long term. Moreover, it does not pollute the environment.

Cultivation of the white shrimps (*P. merguensis*/*P. indicus*) should be explored as alternates to “sugpo”.

The use of probiotics and reservoirs is now adapted to control the growth of luminous bacteria as an alternative to antibiotic in shrimp farming.

#### 1. Probiotics

These are beneficial bacteria capable of repressing the growth of pathogenic organisms either through the production of inhibitory substances or by competition (Moriarty 1998, Corre, et al 1999). According to Corre, et al, the procedural modification are on water management and aeration. An initial dose of probiotics is applied 2-3 days before stocking to ensure the luminous bacterial population of the water is low if not negative. Regular application of probiotics improves water quality, thus, a

minimal water exchange is necessary. The use of paddlewheel aerators operated 24 hours is necessary to thoroughly distribute the probiotics in the pond and to hasten probiotic activities, added Corre, et al.

## 2. Reservoir Systems

This is used to supply all the water needed in the rearing pond after stocking where water is allowed to settle for at least 7 days in the reservoir in the process reducing the pathogens to a tolerable level before water is supplied to the rearing ponds. A 1:1 pond to reservoir ratio is recommended by Corre

### 2.2 Mudcrab

With the development of the hatchery technique, the technology should be appropriately packaged for dissemination and adoption into commercial scale. Likewise, grow-out practices and experiences need be further improved/refined for wide-scale adoption. If need be, training should be conducted for a more effective transfer of hatchery and grow-out technologies.

Feed formulations for different stages of growth, particularly in grow-out operations, have to be developed. The use of trash fish, the main feed stuff used in the present grow-out operation, has been noted to be unreliable and insufficient. An acute shortage in the stuff will be noted as more and more farmers will venture into crab farming. A good fattening ration should also be developed,

Lastly, appropriate stocking densities have to be determined. Ways on how to minimize cannibalism should be pursued to guide farmers in realizing higher recovery rate. Very importantly, a technique of redirecting the sex to all-female stock should be developed. It should be noted that fattened female crabs

command much higher price than males. Besides, males are more highly cannibalistic.

### 3. Molluscs

#### 3.1 Mussels and Oysters

The red tide menace limits mussels and oyster farming, to that of using bamboo as substrate. A number of the major mussel/oyster farming areas of the country are afflicted with the red tide problem so that attempts to improve production system of these two bivalves will be very nil, if it ever gains headway at all.

As we all know, the red tide scares entrepreneurs to invest in mussel and oyster farming. It is even a threat to exploring the cultivation of other species of bivalves. The precise prediction of the red tide occurrence in order to guide farmers of unnecessary harvesting as well as safeguard consumers from the dreaded PSP (paralytic shell poisoning) is what the sector badly needs. A potential researchable area to address this concern is the probable use of the product as toxicant during the peak of red tide infestation.

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### 4. Seaweeds

#### 4.1 *Eucheuma* (including *Kappaphycus*)

The genus constitutes the bulk of aquaculture production at over 50 percent in 1995. Latest farming experiences indicate that there seems to be a relatively slower growth rate of *Eucheuma* compared to those realized a few

years back, thus the need to work out genetic improvements of the farmed species. Nurseries and seed banks that will develop and improve the stock for planting materials will greatly enhance the performance of this sector.

#### 4.2 Gracilaria

For Gracilaria , the need is similar as better farming techniques have to be developed, including a study of strain improvement.

### **Pond Layout Design**

Though most aquaculture farms in Southern Mindanao are successful in their farm operations, there are problems encountered during the culture period on farm facilities and other support systems. The problems which the operators experience are related to the proper planning of the pond layout and design of the farm and most importantly, to the proper implementation of the project in accordance with design specifications. The following problems and solutions were encountered and applied, respectively, to the commercial aquaculture farm operated by Dole Philippines presented according to specific facilities and structures wherein problems are often encountered during culture operations:

- 1) Sea water supply intake system
- 2) Supply flume
- 3) Harvest gates
- 4) Drainage canals
- 5) Pond bottom
- 6) Pond dikes

## 1. Sea Water Supply Intake System

Generally, there are two types of SW intake systems that are used in the fish farms operations in Southern Mindanao, the open channel intake and the closed-conduit pipe intake systems. The open channel intake is commonly constructed in farms where the shoreline is relatively flat and the deeper portion of the sea is very far. The installation of pipeline intake is very expensive, hence, open channel was the option to lower the development cost of the project.

During the early stage of culture operations, problems were encountered on water supply quality. The farm could not pump water during low tide due to the massive siltation of the channel. Pumping schedule and water exchange were very much affected during rainy days. It is impossible to avoid pumping of turbid water even during low tide.

Considering that good water supply is the lifeblood of aquaculture, the channel type intake system was redesigned and converted to pipeline intake system. Modified intakes are operating for more than four years now and problems encountered were lessened significantly.

## 2. Supply Flume

The supply flume system of every farm is usually designed without the provision of an end check or a by-pass structure. This type of structure is purposely used in conveying wastewater down to the drainage canal without passing through the pond.

Usually the problem stages are during dry-up and culture periods. At dry up periods, the cleaning of flume is a must. While during the culture period, when initially pumped water is turbid due to accumulated silt and other foreign materials from the water supply site, it is necessary to dispose of this water to the drainage canal until the pumped water is relatively clean and ideal for filling-up the pond.

A by-pass flume was also installed in one of the farms to discharge filthy and oily water supply to the drainage canal during the first 30 minutes of pumping. In other farms, end check and by-pass structures were installed purposely for conveying turbid water and for easy disposal of debris, silt and other suspended materials in the flume by flushing with water during clean-up.

In newly designed farms, provision and installation of these structures are highly recommended.

### 3. Harvest Gates

A common problem associated with the gate structure is excessive leakage which usually occurs during the mid-culture of operation period. Attributed to the shallow construction of cut-off-wall or even the absence of it, leaks are found underneath the flooring of the structure and at the winged-wall to dike connections. Improper compaction of back-filled soil was also observed to create a gap between the dike and the winged-wall where water could easily penetrate.

To address this problem, temporary repairs were made during operations by covering the hole passage with nets and piling of sandbags to control the leaks and stop the shrimps from coming out of the pond. Regular monitoring is likewise undertaken until harvest and repairs were properly made during dry-up period.

The foundation is the most important part of a concrete structure and as such should be well considered as early as the design stage. For a harvest gate, the strength is dependent on the cut-off-wall that resists against failure from sliding and overturning. It is suggested that design and proper implementation of harvest gate structure should be given emphasis. The ideal depth of cut-off-walls should be a minimum of 80 cm at the heel and 100 cm at the toe of the structure's flooring. Back-filled soil must be well compacted every 15 cm layer.

#### 4. Drainage canals

Drainage canal is one of the most important system in an aquaculture farm, as a poorly designed canal usually leads to unusual problems during culture operation . A concrete-lined drainage system is ideal, however, earthen channels are mostly in existence due to its relatively lower cost.

The rapid siltation and caving-in of dikes due to scouring in the harvest area are the most common problems associated with poorly designed drainage canal. Silt deposits affects and causes delay during harvest due to slow draining of water, while the turbulent flow of water from the harvest gate will cause scouring that usually damages the drainage canal and dike embankments.

Desiltation would entail substantial cost during maintenance period. Scouring incurs damage in the gate structure and contributes deposit of unnecessary soil in the drainage channel. Thus, design of drainage canal system must be well considered.

A suggested design of drainage section should have an element of velocity which is  $>0.30$  but  $<1.00$  meter per second. Lower than 0.30 m/s is considered

silting velocity and 1.00 m/s above is considered scouring velocity. To address the problem of scouring of canal at the toe of the harvest gate, a provision of stilling basin (of 50 cm minimum depth) is recommended to transform turbulent flow of water to laminar flow as it passes from the harvest gate to the drainage canal.

#### 5. Pond Bottom

There are some farms with pond compartments having very poor water holding capacity mainly due to the fact that the type of soil was observed to be sandy while some ponds have limy-loam and limestone with honeycomb-like holes. The percolation range is as high as 200 percent in which the filled water rises up to a maximum of 80 cm and will be empty in less than 12 hours.

Excessive seepage and percolation associated with the foregoing can be corrected by filling the pond bottom with clay soil lining of about 10 cm. The original bottom should be plowed at 15 cm depth in crisscross pattern to mix with the filled clay soil and then the plowed bottom can be compacted afterwards. The pond percolation problem and similar problems experienced during certain periods should be soled when culture is minimal. The farm, which adopted this strategy has now become one of the most productive farm in the area.

#### 6. Pond Dikes

There were observed cases where even if perimeter and partition dikes were properly compacted and constructed, seepage problems still occur, saturating top of embankments and destroying some portions of road surfaces. The seepage, in this case is mainly attributed to the orientation of pond dikes, being higher than the road

surface. The filled water in the pond have a higher surface elevation than the top of the road, thus the leakage.

Efforts undertaken to correct the seepage are long term solutions in nature. Saturated roads are back-filled with scraped black soil from the pond to level-of the road surface with the top of pond dike. Catch trenches were excavated on some portions leading to PVC pipes installed across the roadway to dry up the surface. Back-filling with gravel and other temporary measures were done to make the roadway dry and passable.

As observed in different farms, the layout of access road is ideal to be at the perimeter and central part of the farm area. It has to be a part of pond dike with a large section to accommodate service vehicles and trucks likely to pass during culture and harvest periods. The side slope of the main dike exposed to wind direction requires concrete lining or grouted riprap to prevent scouring.

Every farm is a designed in conformity with the actual site situation. The saltwater intake, pumps, supply flumes and electrical systems are well planned to technically conform to the pond layout and drainage system of the farm. These facilities must efficiently serve the life support needs of the farm and should afford assigned technicians the flexibility to utilize these built-in support systems in ensuring that the farm's requirements are met..

The saltwater intake is the most important system in this type of aquaculture. Without good water quality, it was observed that a series of failures were encountered. In 1995, most of the farms were fully operated with the modified SW intake made of pipes, delivering clean and clear saltwater from the deeper part of the

sea offshore. Culture operation is found to be successful having high percentage of recovery and minimal problems encountered.

### **Development of Pen and Cage Aquaculture in the Philippines**

It was in the early 70s, when the Laguna Lake Development Authority started introducing fishpen technology that led to its commercial adoption by the private fish farmers in the lake. It was not long after its introduction that the fish cage technology was adapted in other bodies of water nationwide.

Laguna Lake was the pioneering area where a pilot fishpen and cage were introduced. It was observed that due to its natural productivity, fish culture in this lake especially for milkfish, tilapia, carp, catfish and other cultured species can be done and produced at lesser cost. Laguna de Bay is surrounded by domestic, industrial and agricultural areas which are contributing to its highly productive water resource. However, its capacity to absorb organic and inorganic wastes in time led to problems particularly affecting the fish population. This was due to siltation and pollution which came to a critical point that led to failure of aquaculture in the area.

In the absence of municipal water resource planning, lake management became a problem. The issue of duplication in functions as well as the question on who has control of and responsibility for policy making and implementation to address lake problems are frequently raised. This led to misunderstandings between and among the shoreline municipalities, Bureau of Fisheries, Laguna Lake Development Authority and the Department of Environment and Natural Resources. The scenario is no different in areas where there bodies of water such as San Pablo Lakes, Buhi and Bato Lakes, Taal Lake, Manila Bay, where the introduction of fishpens and fishcages was also massive. This

shows that sustainable fish production is greatly anchored on sound and functional policies geared towards protecting local water resources from abuse and degradation.

### 1. Fishpen Aquaculture

Fishpen development is highly dependent on the availability of raw materials for pen structures. In the Philippines, indigenous materials like bamboo are perceived to be the most efficient and economical, however, in the long run this cost efficiency is eroded by the fact that the material is only good for two years.

In terms of engineering design, fishpens are usually big, either rectangular or square in shape while some may be oblong or circular . They are usually set-up at five meters water depth or less to be more efficient and strong enough to withstand environmental factors. Fish pens have to be situated in a cove to shelter them from big waves and strong winds.

The allotment of navigational area between fishpen modules to avoid disruption of small-scale fishermen activities is another design consideration. Not only will this help in the proper circulation of water but it will likewise avoid eutrophication attributed to high siltation of organic matter from feeds and fecal matters causing ecological imbalance that in turn leads to fish mortality. In the same manner the design must be suited for easy management especially during harvesting.

The concentration of the countries' fishpen development are in Laguna Lake and Lingayen Gulf which are also both utilized for milkfish culture. The said water resources are likewise used for other purposes such as tourism, subsistence fishing, agriculture and navigation and as such are open to over utilization. Thus, re-

engineering plan in terms of carrying capacity, design and zoning of the area must be built-in with the development plan of the respective local government units (LGUs).

Aquaculturists, environmentalists and biologists are needed as well as engineers to help plan and train the local fishery officers to oversee the needs of their natural water resource. At present, local fishery officers are usually wanting in resource management experience so that they need to be oriented for more efficient implementation of protection guidelines in the locality.

## 2. Fishcage Aquaculture

The fixed type Fishcage originated in Laguna Lake, the floating cages started in the San Pablo lakes, while the use of bamboo, plastic drums and styrofoam blocks as floats are popular in Taal Lake.

Recently, a plan to introduce imported typhoon-proof floating cages was suggested but its high cost, is anticipated to discourage would-be investors. Made of pneumatic control spars where nettings are attached, this US technology, could possibly be adapted in the Philippines through the use of more cost efficient indigenous materials and resources.

Given the magnitude of the fishcage industry than spans from north to south where there are bodies of water suitable for cage culture, the need for resource planning to avoid conflicts and prevent ecological imbalances and provide sustainable fish production cannot be overemphasized..

In the case of fish cage operation nutrient waste recycling offers alternative option as done in Thailand where a fish species is stocked at high densities and fed high protein diets in cages suspended in ponds while a filter feeding fish species is stocked outline the cages in the pond to utilize natural production derived from the

cage waste. Intensive culture means high protein fish diets where nutrient rich wastes are often directly or indirectly released to the surrounding environment and sources of environmental pollution. These wastes are potential fertilizers which can be reused to generate natural foods for culturing filter feeding fish species at low cost. The technology will likewise provide opportunities to make aquaculture more profitable to farmers at the same time minimizing environmental pollution.

## References

- Arado, C. O. 1996. Standing Committee Report on Pond Layout and Design. 11<sup>th</sup> Annual Scientific and Business Meetings of the Society of Aquaculture Engineers of the Philippines, Inc., 16 October 1996. Quezon City, Philippines.
- Cas, F. C. 1996. Standing Committee Report on Pens and Cages. 11<sup>th</sup> Annual Scientific and Business Meetings of the Society of Aquaculture Engineers of the Philippines, Inc., 16 October 1996. Quezon City, Philippines.
- Corre, V. L., et al. 1999. Sustainable Shrimp Culture Techniques: Use of probiotics and reservoirs with “green water”. Philippine Council for Aquatic and Marine Research and Development, Los Baños, Laguna.
- Fernandez, P. M. 1997. Standing Committee Report on Aquaculture Management. 12<sup>th</sup> Annual Scientific Meeting of the Society of Aquaculture Engineers of the Philippines, Inc., 21 November 1997, Intramuros, Manila, Philippines.
- Irz, X. and McKenzie, V. 2002. Profitability and Technical Efficiency of Aquaculture: A comparison of Intensive and Extensive Production Systems in the Philippines. International Forum on Tilapia Farming in the 21<sup>st</sup> Century, February 25-27, 2002, Philippines.

Wang, J. 2002. Sharp growth as aquaculture industry develops. Asian Aquaculture Magazine. Jan.-Feb. 2002 issues, pp. 32-34,